Confederation of Indian Industry

Best Practices Manual in Paper Sector

Volume 13

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DISCLAIMER

While every care has been taken in compiling this manual, Cll-Godrej GBC accepts no claim for any kind of compensation, if any entry is wrong, abbreviated, omitted or inserted incorrectly either as to the wording space or position in the manual.

The manual is only an attempt to create awareness on Energy, Water and Environmental management and sharing of best practices being adopted in Indian Paper industry and the international cleaner production technologies and how the paper manufacturing units can reach the Best Available Specific Energy Consumption figures in the industry.

Published by Confederation of Indian Industry

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FOREWORD

It is with great pleasure that I introduce this Best Practices Manual, an extensive guide devoted to the pulp and paper industry's continuous efforts to improve energy efficiency. As the Chairman of Papertech 2025, I have the honour of addressing the introduction of this crucial resource at our conference, where professionals and executives from the industry come together to talk about and influence the direction of this important industry.

Innovation and economic expansion have always been anchored by the pulp and paper sector. However, our industry faces hitherto unheard-of difficulties as sustainability and environmental responsibility become increasingly demanded. As a result, we need to keep changing, implementing best practices and cutting-edge technology that not only increase our output but also lessen our environmental impact.

This handbook is evidence of our industry's combined efforts to confront these issues head-on. It compiles several case studies that showcase the best energy-saving techniques and innovations being used in the industry now. In addition to demonstrating the creativity and commitment of our sector, these real-world examples offer priceless guidance on attaining energy management excellence.

This manual's inclusion of the best specific energy consumption values—both thermal and electrical—attained by some of our top paper mills is one of its most notable aspects. These numbers provide a clear path for others to follow, encouraging ongoing development and establishing new benchmarks for energy efficiency.

Going ahead, we must keep exchanging knowledge and working collectively on best practices. We will ensure that the pulp and paper sector continues to lead the way in environmentally friendly industrial practices, advancing development and protecting the environment for coming generations, through initiatives such as this.

To everyone who helped make this manual possible, I want to express my profound gratitude. Because of your commitment and knowledge, this industry is excellent and I have no doubt that this handbook will be a useful resource for many years to come.

Mr. Ganesh Bhadti

Chairman, Papertech 2025 And

Executive Director-Operations and Project, Seshasayee Paper and Boards Limited

MESSAGE FROM PRESIDENT- IPMA

I am delighted to present the "Best Practices Manual in Pulp and Paper Sector in India Volume 13," a comprehensive manual that highlights the commitment, ingenuity, and collective wisdom of the sector. This manual is the result of the hard work, dedication, and teamwork of numerous professionals and stakeholders in the Indian pulp and paper industry. India's Pulp and Paper Industry has long been an important part of the country's economy, supporting livelihoods all throughout the country and producing necessary goods. However, as environmental impact and sustainability gain more attention worldwide, our industry must simultaneously retain production while drastically lowering its ecological footprint.

Modern technology, eco-friendly procedures, and ethical sourcing have all been adopted by the Indian Pulp and Paper industry to ensure that it not only thrives but also helps create a cleaner, more sustainable India.

This handbook, which gathers industry-wide case studies and best practices, acts as a beacon for what can be accomplished with creativity and teamwork. It demonstrates the observable advantages of the best energy-efficient methods and technology that have been used in different paper mills. The handbook also includes best available information describing the best specific energy consumption levels, both thermal and electrical, attained by top mills, establishing new benchmarks for others to strive for.

Let's keep collaborating to attain energy efficiency excellence and establish our sector as a sustainable beacon.

Mr. Pawan Agarwal

President, Indian Paper Manufacturers Association (IPMA), and

Managing Director, Naini Papers Ltd

ACKNOWLEDGEMENT

We wish to express our sincerest regards to all the stakeholders for their invaluable contributions for this manual.

We deeply express our sincere thanks to the following organizations for sharing the technical information for the identified best practices:

Chandpur Enterprises Ltd.

- Good Enough Energy
- ITC-PSPD, Kovai Unit
- Khanna Paper Mills
- M/s Piller De
- Seshasayee Paper And Boards Ltd, Erode
- Seshasayee Paper And Boards Ltd, Tirunelveli
- Tamil Nadu Newsprint and Papers Limited, Unit-II Trichy

We also sincerely thank the following technical committee members of Papertech 2025 for their contribution to bringing out the “Best Practices Manual for Pulp and Paper sector, Volume 13”.

- Mr. Ganesh Bhadti (Chairman, Papertech 2025 and Executive Director- Operations and Projects, Seshasayee Paper and Boards Limited)
- Mr. S.V.R. Krishnan (Executive Director, Khanna Paper Mills Limited)
- Mr. Mukesh Jain (Executive Director Andhra Paper Ltd.)
- Mr. C.S. Kashikar (Chief Operating Officer, Orient Paper & Industries Ltd.)
- Mr. Sidhartha Mohanty (Vice President, ITC Ltd. PSPD)
- Mr. Mahesh Gandhi (Director Venkateshwara Tirumala Paper and Board Pvt. Ltd)
- Mr. Mukesh Kumar Tyagi (Director, Naini Paper Ltd.)
- Mr. Anuj Kumar Tayal (Sr. Vice President, West Coast Paper Mills Ltd.)
- Dr. B.P. Thapliyal (Secretary General, Indian Agro & Recycled Paper Mills Association)
- Mr. Nandakumar D.M. (President Elof Hansson India Pvt. Ltd.)
- Mr. Saurabh Mittal (Director-Sales and Technology, Ivax Paper Chemicals Pvt. Ltd.)
  Mr. D. Radhakrishnan (Chief Manager, Seshasayee Paper and Boards Limited)

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EXECUTIVE SUMMARY

The Indian pulp and paper industry stands at a decisive crossroads, where the imperative for sustainable transformation has never been more acute. This Best Practices Manual has been crafted with precision to serve as a definitive guide, equipping industry stakeholders with a consolidated reference to the most impactful energy efficiency strategies currently being deployed within the sector. As the industry strives to reconcile expansion with environmental stewardship, the manual emerges as a cornerstone resource for advancing energy performance. By distilling real-world examples into actionable knowledge, it aspires to accelerate the sector's progression toward a future defined by sustainability and operational efficiency.

Developed from empirical data drawn from energy-saving initiatives undertaken by the Indian paper industry, the manual presents 11 case studies sourced from leading, high-performing paper mills, technology providers, and select cross-sectoral applications with strong replicability potential. These studies illuminate the varied methodologies employed by mills in addressing their unique energy challenges, thereby offering practical insights into the effective implementation of advanced technologies.

Beyond the case studies, the manual consolidates benchmark data on best-in-class Specific Energy Consumption (SEC) values—both electrical and thermal—achieved by India's most efficient mills. These figures provide not only a benchmark but also a directional pathway for mills aspiring to strengthen their energy efficiency performance. They underscore the vast, untapped potential for energy savings and establish a demanding yet attainable standard of excellence for the industry at large.

Some of the best SEC values achieved are:

Table 1 Some of the Best SEC figures for different category of Paper mills[1]

	Raw material	Paper product	Best Electrical SEC	Best Thermal SEC
			kWh/Ton FNP	MT steam/MT FNP
Plant 1	Wood	Packaging	**930**	**4.85**
Plant 2	Agro	Packaging	**1018**	**2.53**
Plant 3	RCF	Packaging	**285**	**1.25**
Plant 4	Imported Pulp	Packaging/Speciality	**537**	**2.01**

By embracing the best practices and drawing on the insights of industry leaders documented in these case studies, mills across the sector can replicate proven successes, thereby advancing the collective pursuit of a more sustainable and energy-efficient industry.

Intended as a reference for professionals and stakeholders throughout the pulp and paper value chain, the

1 Based on CII data

manual seeks to catalyse continuous improvement in energy efficiency and environmental stewardship. In doing so, it reinforces the industry's long-term sustainability objectives. As the Indian pulp and paper sector undergoes ongoing transformation, this Best Practices Manual stands as an essential guidepost, directing the industry toward greater efficiency and a more sustainable future.

How To Use The Manual

The primary objective of this manual is to document and benchmark the lowest specific energy consumption values attained by leading Indian paper manufacturing units, thereby establishing a performance trajectory for other mills in the sector to achieve comparable Energy-related Key Performance Indicators (KPIs). This publication further serves as a catalytic instrument to stimulate continuous improvement initiatives within the Indian pulp and paper industry, driving units towards global benchmarks in energy, water, and environmental management.

To define a structured pathway for performance enhancement and alignment with international standards, the manual consolidates best practices implemented across select Indian pulp and paper mills along with advanced technological solutions offered by equipment suppliers. These practices and technologies are presented as reference frameworks, to be adapted and fine-tuned according to the operational requirements of individual plants.

Emerging and state-of-the-art technologies highlighted herein merit consideration for both retrofits in existing facilities and deployment in greenfield projects, with the objective of achieving world-class energy efficiency. Their applicability, however, necessitates further technical assessment against site-specific process conditions.

It must be emphasized that the identified best operating parameters and practices do not represent an absolute ceiling; instead, they serve as demonstrative benchmarks. Superior energy efficiency levels and advanced operation and maintenance paradigms remain attainable through sustained innovation and optimization.

Accordingly, Indian pulp and paper mills are encouraged to approach this manual as a constructive opportunity—leveraging the collective knowledge embedded within it to accelerate their journey toward performance excellence and to contribute to the overarching vision of making the Indian pulp and paper industry truly world-class.

The details in the Benchmarking section are compiled from CII energy award, energy audit and other reliable government sources. Benchmarking is dynamic and changes based on the adoption of technologies. There might be few plants operating at lower SEC than the values mentioned in this publication.

Chapter 1: Paper Sector

1.1 Sectoral Overview of Paper Industries

Scale & Raw Material Mix

There are 510 Paper mills in India. Out of these non-wood sectors (agro + RCF) collectively contribute around 70% of the country's paper and board production while the rest of the production takes place from wood-based paper mills.[2]

Production, Economic & Employment Impact

The Indian industry accounts for about 2% of global paper production. In terms of composition by volume the 30 % of the units are wood based mills while 48% are Re-cycled Fibre based mills and 22% are employing Agro residue as the raw material in their mills for production purposes.

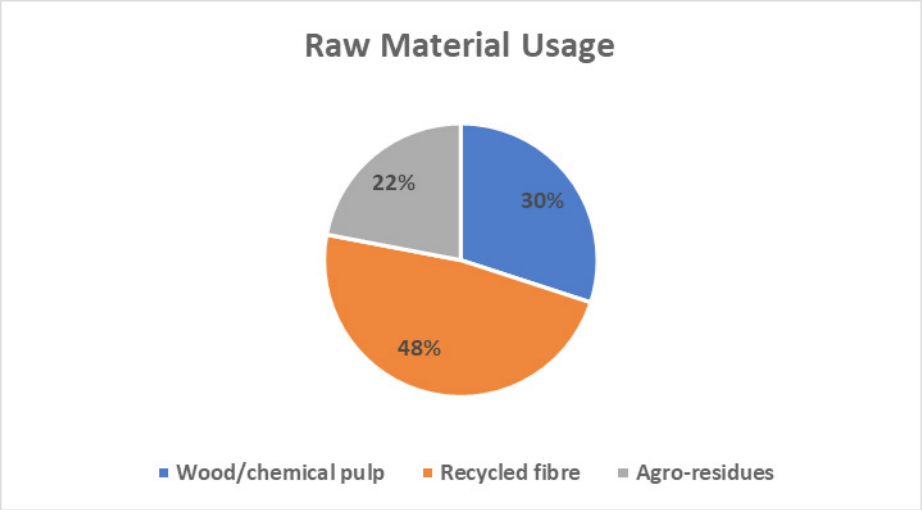


Figure 1 Raw material usage

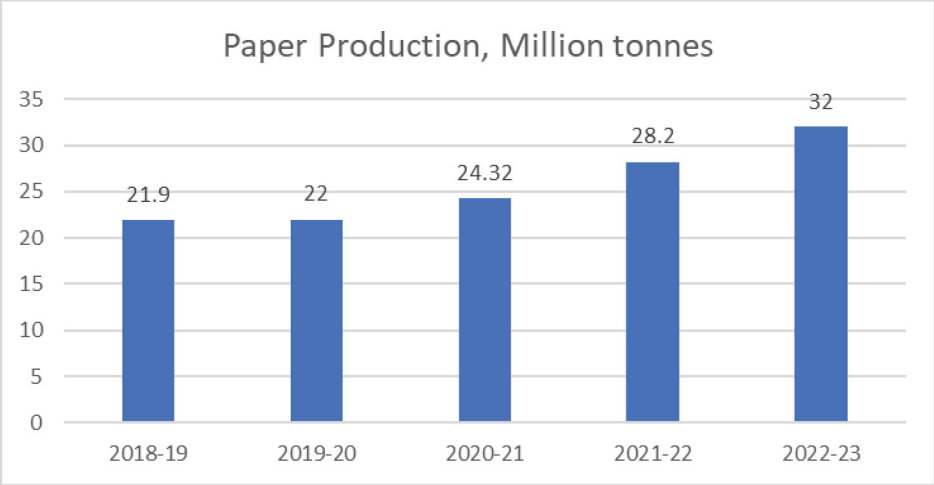


Figure 2 Growth in capacity of paper production

[3]

2 iarpma.org

3 Indian Paper Industry a journey well-travelled

The type of raw material, GSM produced, and type of pulping process adopted has a deep impact on the energy consumption of the paper mills. Hence, in the case of paper sector, it is important to compare the Energy performance of the Paper mills against each other while considering the different raw material mix being deployed by them.

The next section showcases the Energy performance of the different Paper mills in the country based on the raw material mix, in terms of the over-all performance and the electrical and thermal Specific Energy Consumption levels.

Chapter- 2. Benchmarking

2.1 Overall Plant Level Benchmarks

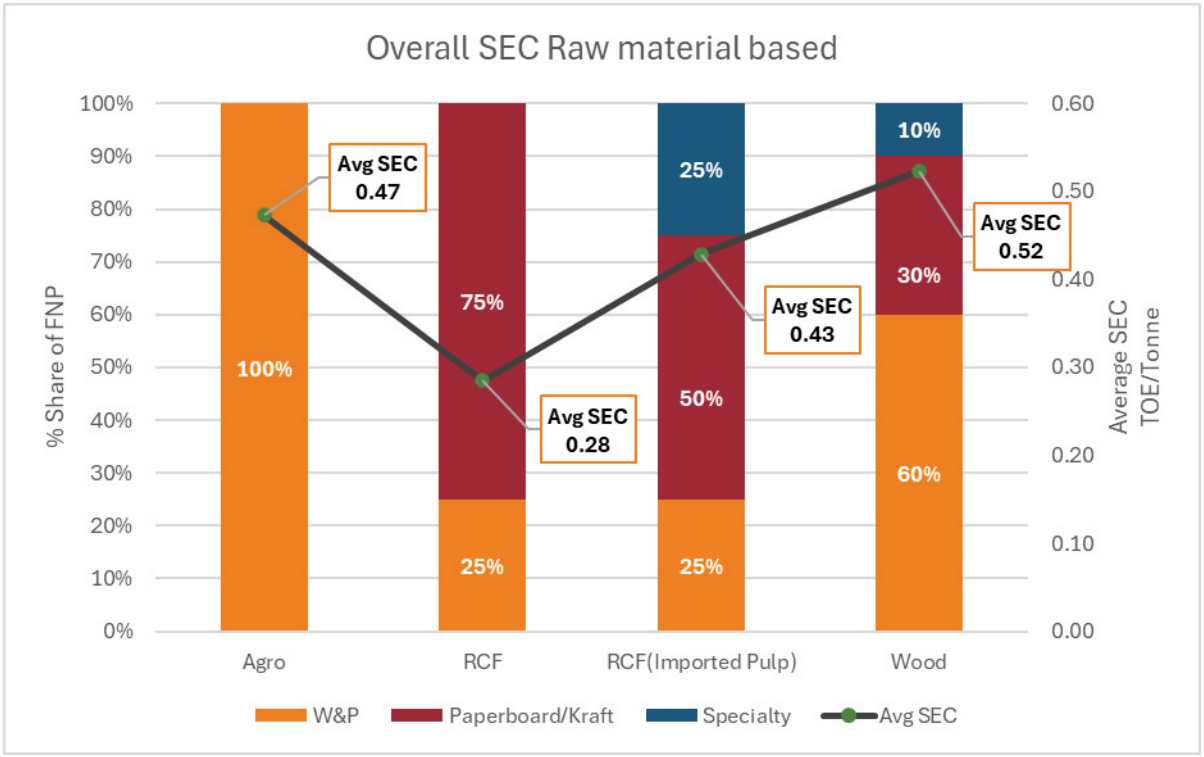


Figure 3 Overall SEC raw material based

Above graph shows the average specific energy consumption (SEC) of paper mills using different types of raw materials. It can be clearly seen from the chart that the SEC of wood-based paper mills is highest among the 4 major categories of paper mills while Re-cycle Fibre (RCF) or wastepaper-based Paper mills have the lowest SEC.

This disparity in energy consumption levels is because the wood-derived pulping systems are inherently more energy-intensive owing to the energy intensive process of lignin removal from the woody biomass. Wood typically comprises 25–35% lignin[4], a polymer that forms linkages with cellulose and hemicellulose, imparting rigidity and structural integrity. Effective delignification in wood-based mills necessitates high-intensive thermochemical treatments, such as kraft pulping employing sodium hydroxide. These processes are operated under elevated conditions of temperature (150–170 °C) and pressure, thereby imposing high specific energy demands. Moreover, the energy footprint is increased by requirements for steam generation, liquor circulation, pressure maintenance, and the operation of chemical recovery units essential for process sustainability and chemical economy.

Conversely, agro-residue–based raw materials, such as bagasse, wheat straw, and rice straw, are characterized by a lower lignin fraction (15–30%)[5] with comparatively less condensed and structurally simpler linkages. The reduced recalcitrance of lignin in these substrates enables delignification at milder operating severities (130–150 °C) and shorter residence times within the digester, significantly diminishing thermal energy requirements. Additionally, due to the inherently porous and less consolidated fibre matrix of agricultural residues, fibre liberation and separation proceed with reduced mechanical and thermal resistance, leading to a substantially lower specific energy consumption compared to conventional wood pulping operations.

Also, the wood-derived fibres exhibit greater fibre length and intrinsic tensile strength, but their separation and fibrillation demand elevated mechanical specific energy input during refining. The refining of wood pulp therefore incurs higher electrical energy consumption to induce the requisite degree of fibre fibrillation and bonding potential. In contrast, agro-residue fibres, owing to their shorter morphology and higher processability, necessitate comparatively lower refining energy intensity, though they may require supplementary additive

4 Journal of the American Institute of Conservation

5 Potential of lignin as biofuel substrate - ScienceDirect

incorporation to attain equivalent paper performance characteristics.

In the Recycled Fibre, that is used as raw material in paper mills, the absence of lignin becomes an advantage on the energy front, as there is no requirement of cooking for delignification. Hence, the Specific Energy Consumption in the pulping process is drastically lower when compared with wood and agro based mills leading to an overall lower SEC for the RCF based mills.

2.1.1 SEC of Wood Based Mills

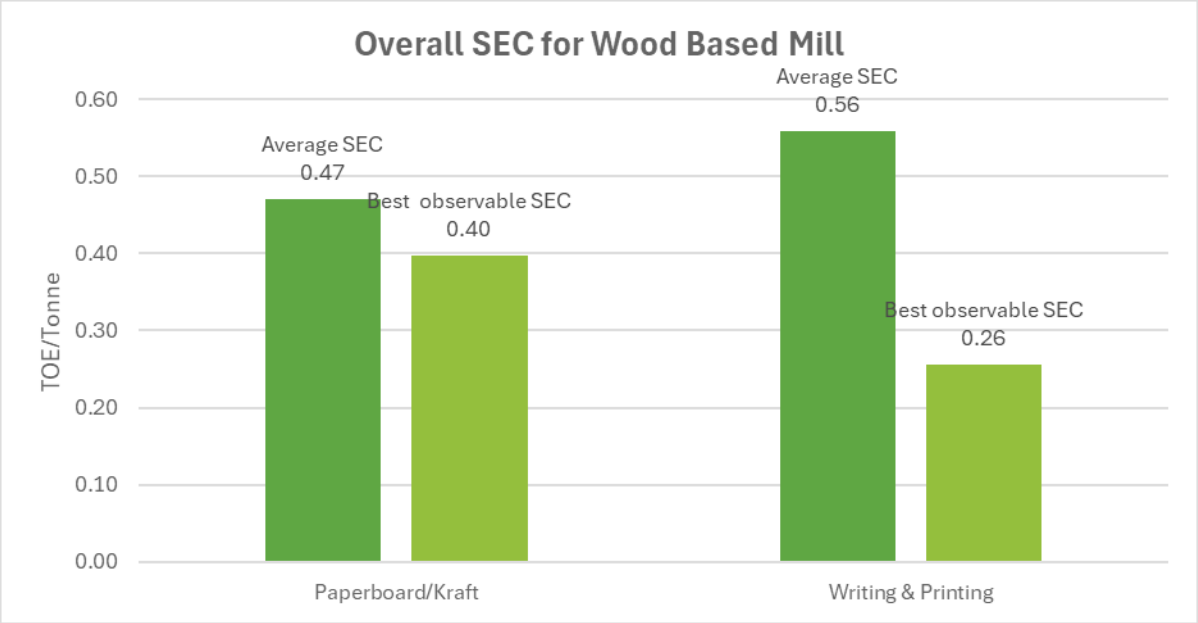


Figure 4 Overall SEC of wood-based mills

From the above chart, the average Specific Energy Consumption (SEC)[6] of Paperboard/kraft manufacturing wood-based mills are lower compared with the Writing and printing grade of paper manufacturing wood-based mills. Wood-based paper mills engaged in paperboard and kraft paper manufacture exhibit comparatively lower Specific Energy Consumption (SEC) than writing and printing paper mills, primarily due to intrinsic differences in product performance specifications and process intensity. Kraft paper production requires only moderate optical properties, particularly in terms of brightness, which limits the bleaching sequence to 2–3 stages, in contrast to the 4–5 bleaching stages typically necessary for writing-grade papers. This reduction directly translates into decreased bleaching energy demand.

Furthermore, the energy efficiency advantage in kraft production is reinforced by the relatively relaxed quality assurance tolerances associated with packaging grades. Kraft papers permit broader process variability and defect acceptance, thereby lowering rework and rejection rates when compared with writing and printing grades that impose stringent quality thresholds. This clearly establishes that product specifications are a primary determinant of energy intensity.

6 PAT Notification

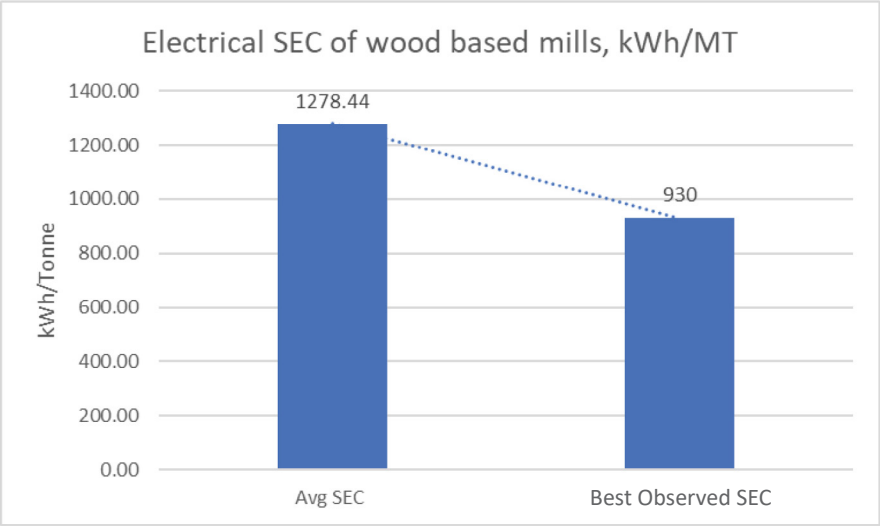


Figure 5 Electrical SEC of Wood based mill

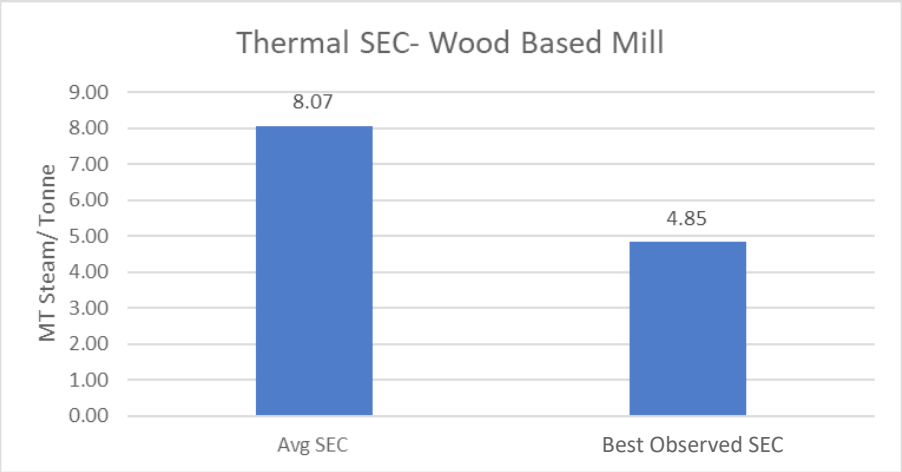


Figure 6 Thermal SEC of wood-based mills

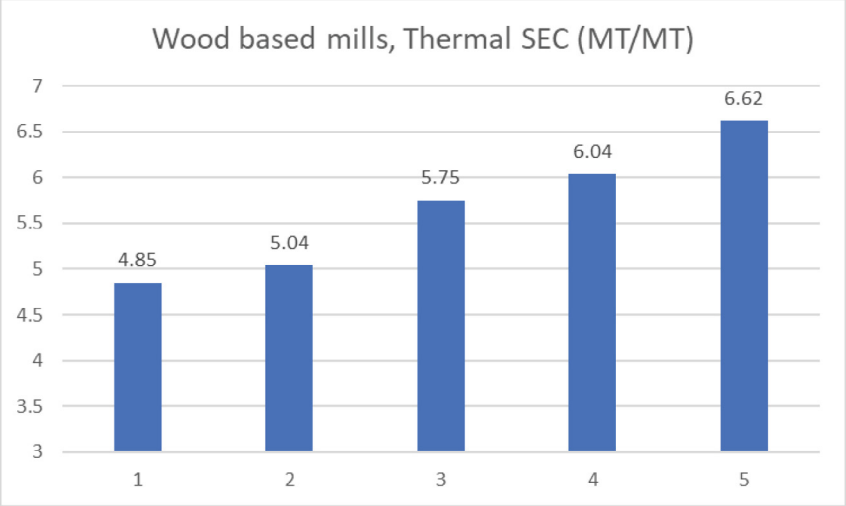


Figure 8 Thermal SEC of top wood-based mills

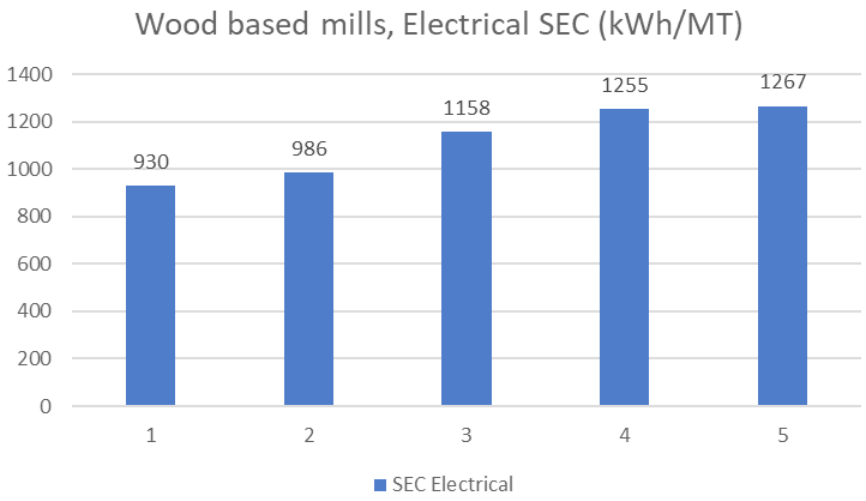


Figure 7 Electrical SEC of top wood-based mills

The difference in average and Best available SEC among wood-based mills primarily stems from product mix differences and technology gaps. The unit which achieves the best electrical and thermal SEC primarily has its strategic focus on 82% kraft production, which requires minimal energy for refining and finishing compared to writing papers or specialty grades. In contrast, the paper mill with highest SEC produces around 63.65% specialty papers requiring intensive processing, combined with outdated equipment and poor capacity utilization (56.8%).

The unit with the Best Observable SEC has implemented projects like installation of Centrifugal compressor in place of Screw compressor, installation of energy efficient Vacuum pump, installation of VFDs, identifying opportunities to optimize running time of equipments like broke refiner and HW refiner, implementing logics and automation to reduce the run time of idle equipments, etc which have yielded significant savings in terms of electrical energy consumption. While projects like installation of Thermocompressors in the paper machine section, installation of heat exchanger for heat recovery from secondary condensate of Evaporator, usage of digitization to improve the Evaporator steam economy have had a deep impact on the performance of the mill to reduce the thermal energy consumption.

Equipment age also significantly impacts performance - modern mills showcase excellent efficiency (930-986 kWh/Ton) while legacy operations suffer from inefficient refiners, old motors, and process control systems[7].

7 CII Database

2.1.2 SEC of Agro Based Mills

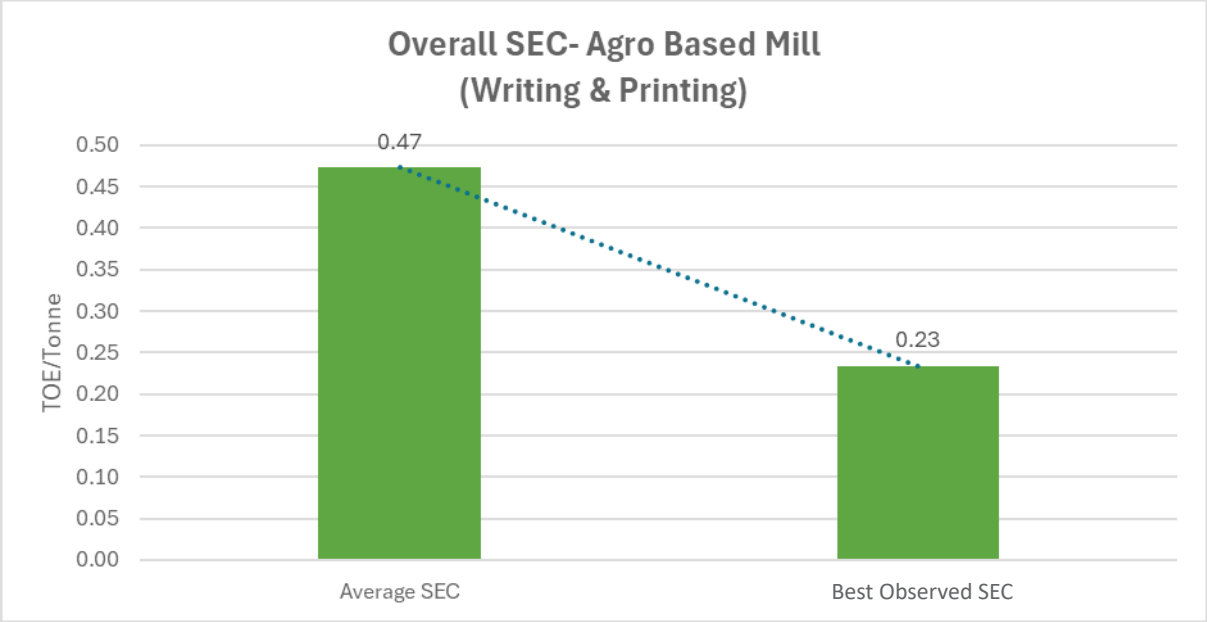


Figure 9 Overall SEC for Agro based mill (W&P)

The deviation in SEC between the average and the Best Agrobased writing and printing paper manufacturing units, primarily results from raw material processing complexity and product mix differences[8]. The unit with Best SEC achieves superior efficiency through focused agro-processing (96.82% single feedstock) enabling optimized cooking conditions - agro-residues require lower temperatures (130-150°C vs 150-170°C for wood), shorter cooking times (2-3 hours vs 4-6 hours), and have 15-25% lignin content compared to 25-35% in wood. Their balanced product mix (48% kraft, 52% specialty) also reduces steam requirements compared to energy-intensive writing papers. In contrast, units with comparatively poor performance stem from managing different raw materials (43.4% agro, 38.2% wood, 18.4% RCF) requiring process compromises, combined with 100% writing & printing paper production demanding intensive multi-stage bleaching and high brightness targets[9].

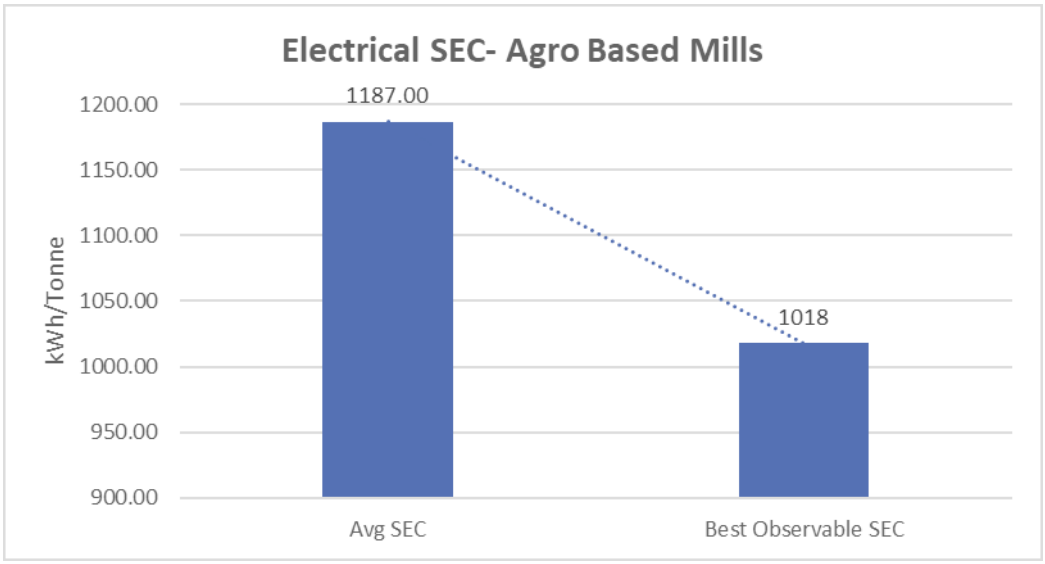


Figure 10 Electrical SEC for Agro based mills

8 PAT Notification
9 CII Database

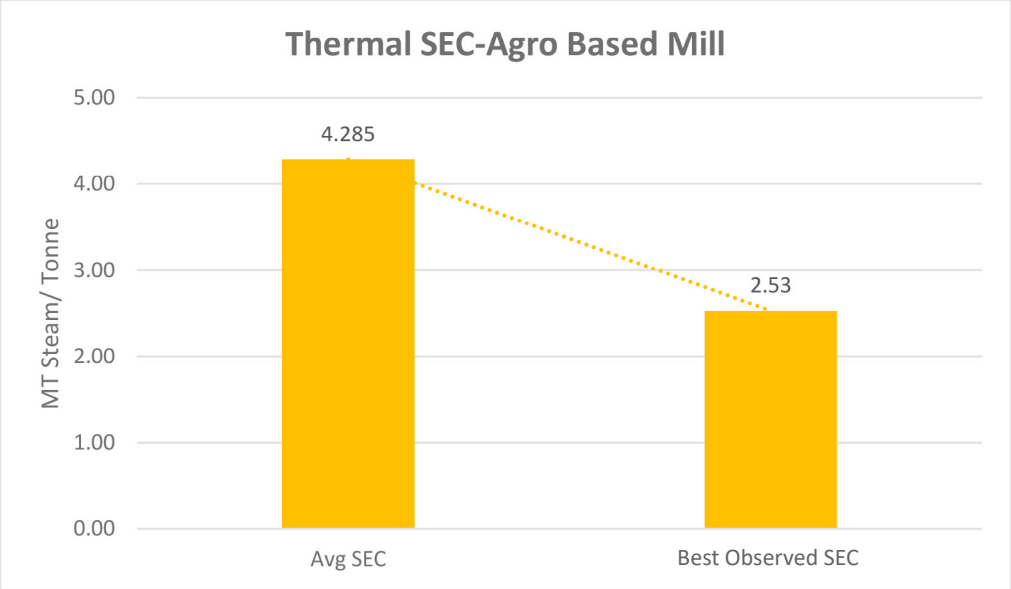


Figure 11 Thermal SEC for Agro based mills

For improvement in Agro based Mills, implementation of feedstock segregation with separate processing lines optimized for each raw material type may be considered. Steam system optimization through advanced heat recovery, cascade utilization, and improved insulation could reduce the SEC even further. Enhanced biomass utilization by maximizing agro-residue burning and optimizing boiler efficiency for agro-fuel could reduce energy consumption. The key strategy is leveraging agro residues' inherent processing advantages through specialized equipment, consistent feedstock management, and integrated biomass energy recovery systems.

The unit with the Best Observable SEC has implemented electrical energy saving projects like installation of Microturbine, installation of VFDs on equipments like Vacuum pumps and Boiler feed pump, ensuring proper sizing of equipments, replacing metallic blade of fans with FRP blades. While thermal energy saving projects like installation of VFD on hood air blowers to maintain the relative humidity and temperature of the hood air, installation of online oxygen analyser to optimize the excess air, recovery of steam line condensate which have resulted in energy saving which have led to lower thermal SEC levels.

2.1.3 SEC of RCF Based Mills

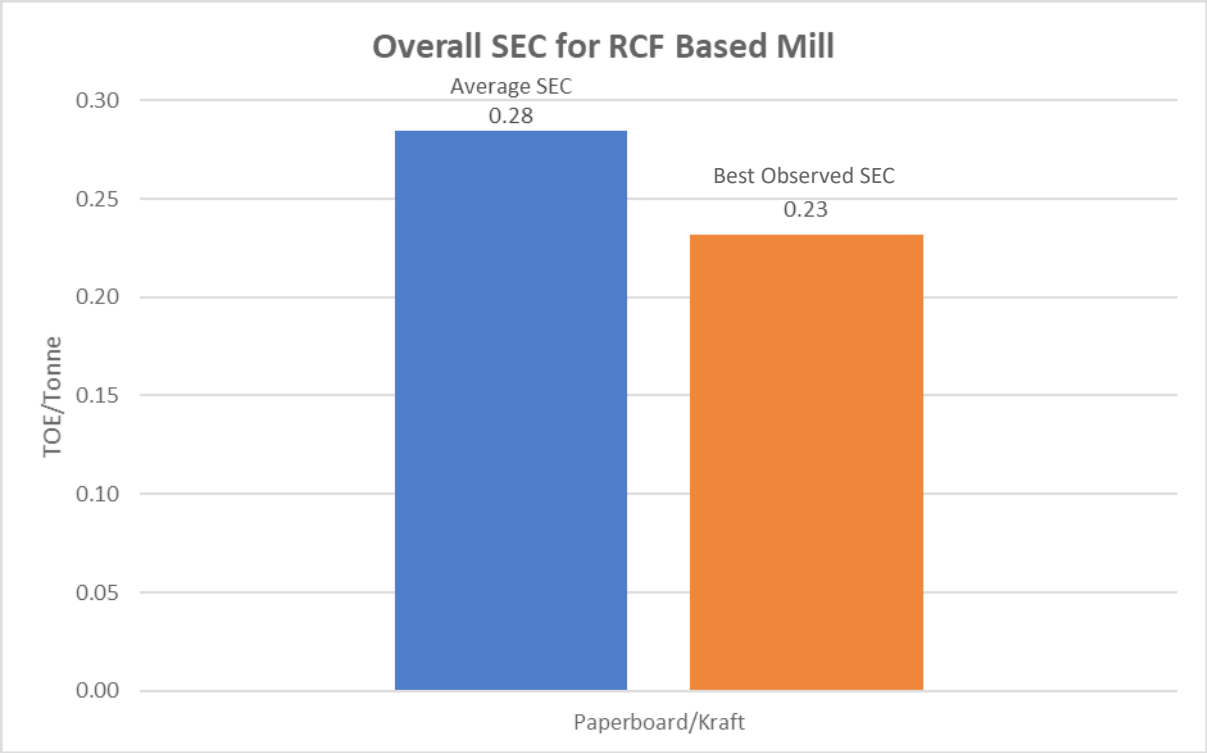


Figure 12 Overall SEC for RCF based mills

The above chart reveals significant variations in Specific Energy Consumption (SEC) among paperboard and kraft paper manufacturers across India, ranging from a best-case scenario of 0.232 TOE/MT of FNP to 0.396 TOE/MT of FNP, representing a 71% difference between the most and least energy-efficient operations. The primary driver of SEC variations lies in the technological sophistication and age of manufacturing equipment. Companies with lower SEC values likely employ modern, energy-efficient machinery including advanced pulping systems, optimized heat recovery mechanisms, and computerized process control systems.

In the data set, the paper mill with the smallest capacity exhibits the highest SEC (0.396 TOE/MT), while the paper mills, with the largest capacity has achieved the best SEC (0.232 TOE/MT). This suggests that larger facilities can indeed leverage economies of scale for better energy efficiency through shared infrastructure costs and optimized utility systems.

The 71% variation in SEC values among these manufacturers indicates substantial potential for industry-wide energy efficiency improvements. Best-performing companies demonstrate that achieving SEC values around 0.23-0.24 is feasible with appropriate technology investments, operational excellence, and process optimization. The data suggests that strategic upgrades in technology, improved process integration, and enhanced operational practices could help underperforming facilities significantly reduce their energy consumption, contributing to both cost savings and environmental sustainability in the Indian paper manufacturing sector[10].

10 PAT Notification

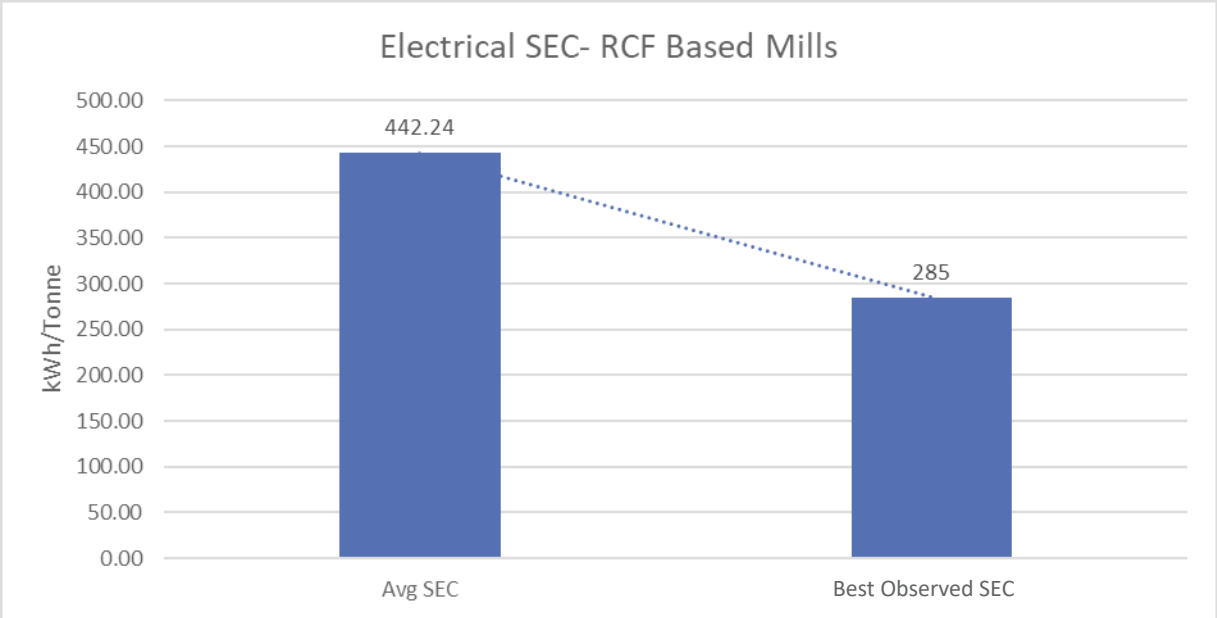


Figure 13 Electrical SEC for RCF based mills

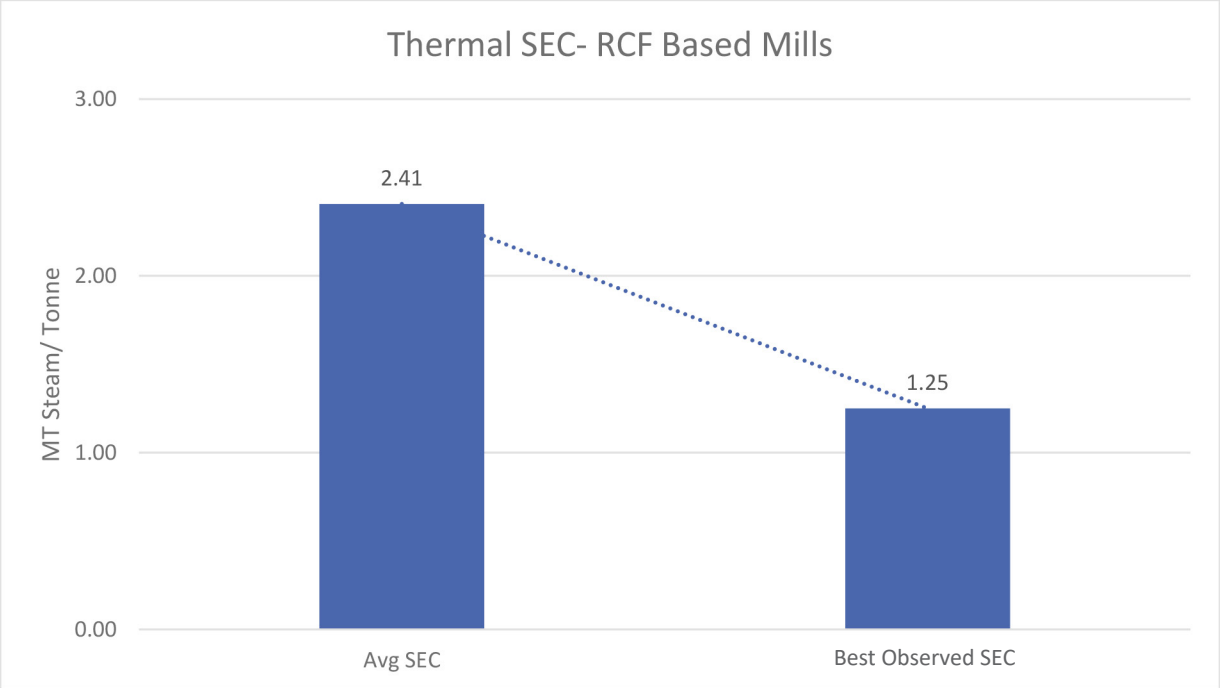


Figure 14 Thermal SEC for RCF based mills

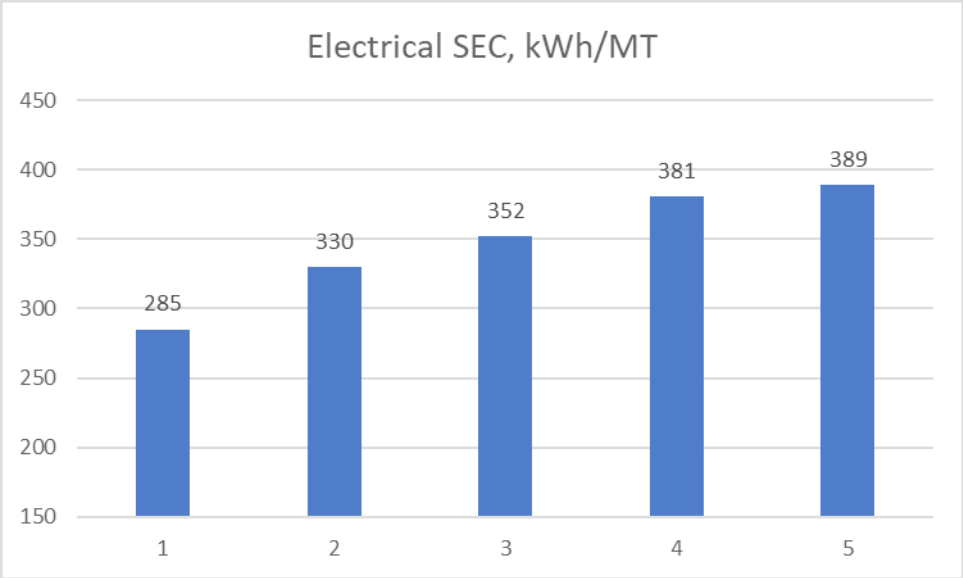


Figure 15 Electrical SEC of top RCF based mills

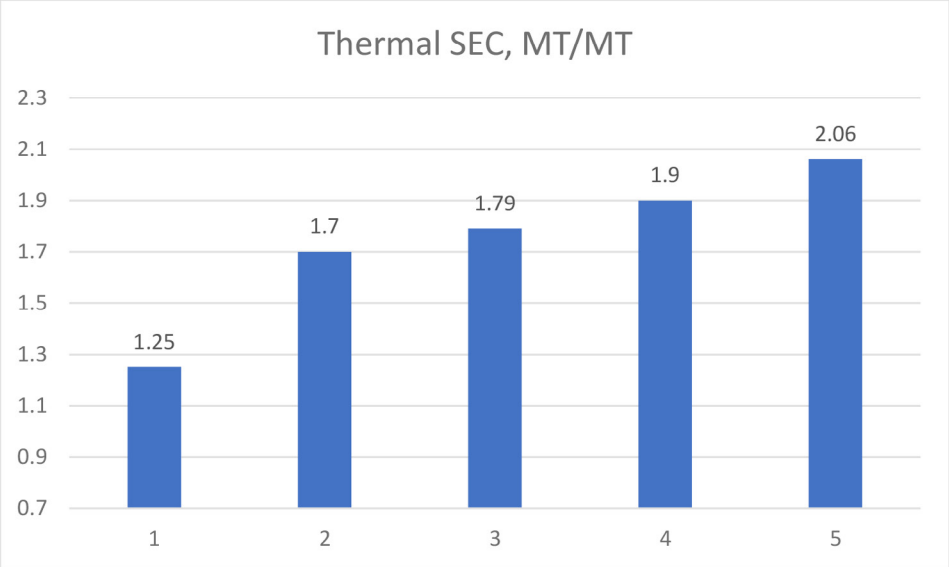


Figure 16 Thermal SEC of top RCF based mills

The collected data further reveals significant energy efficiency gaps in RCF (Recycled Card and Fiber) based Indian paper mills when compared to industry benchmarks. The electrical energy consumption shows a substantial 55% deviation from best practices, while thermal energy consumption exhibits an even more concerning 93% gap above optimal performance levels.

The 55% electrical energy overconsumption in RCF mills stems from several interconnected factors. Older motor systems operating at suboptimal efficiencies contribute significantly to this gap. Many facilities continue using standard efficiency motors instead of upgrading to IE3 or IE4 premium efficiency alternatives. Furthermore, oversized or improperly maintained equipment operates outside optimal efficiency curves, while inadequate automation leads to manual operations that fail to optimize energy consumption patterns.

The 93% thermal energy excess represents the most critical efficiency challenge. Poor heat integration between process stages means substantial waste heat from paper drying sections isn't recovered for preheating incoming process air. Many RCF mills lack sophisticated heat exchanger networks that could capture and redistribute

thermal energy throughout the facility. Steam system inefficiencies compound the problem through inadequate insulation, steam leaks, and condensate losses. Older boiler systems operating at lower efficiencies, combined with poor combustion air preheating and stack heat recovery, result in substantial fuel waste. The absence of cogeneration systems means facilities miss opportunities to simultaneously generate electricity and process steam, leading to separate energy generation inefficiencies[11].

The paper mill with the Best Observable SEC has implemented electrical energy saving projects like installation of Tri-disc refiner, installation of VFDs on Vacuum pumps, installation of screw compressors with VFDs on FD fans and ID fans, etc. while for thermal energy saving projects like installation of hot air hood, installation of online Quality control system have been undertaken by the plant.

2.2 Process-Wise Benchmarking

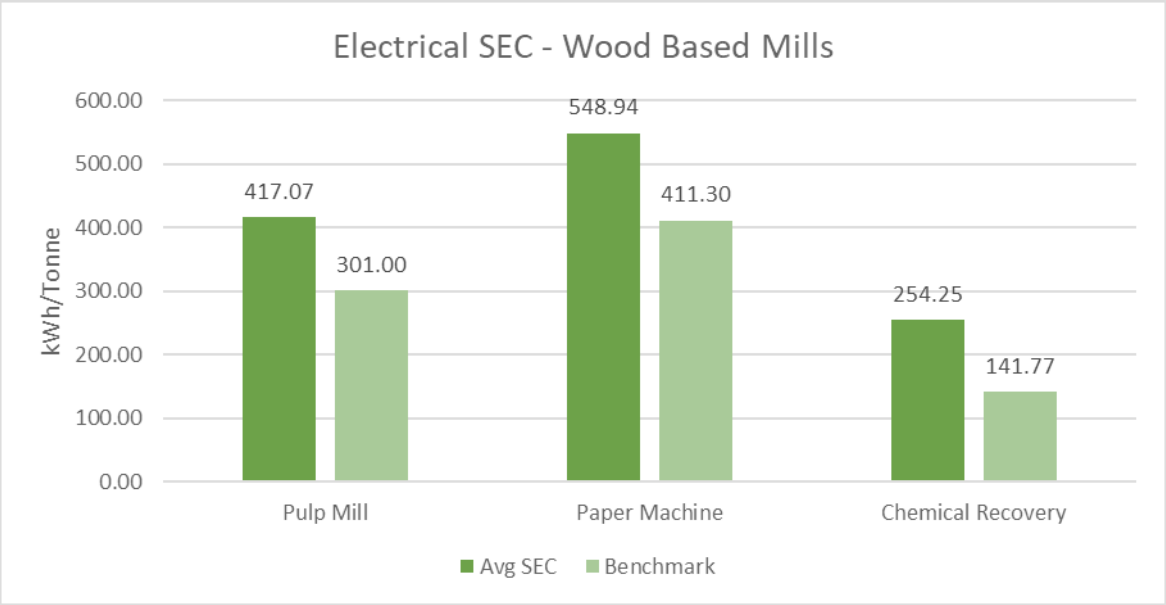


Figure 17 Electrical SEC-Wood based mills

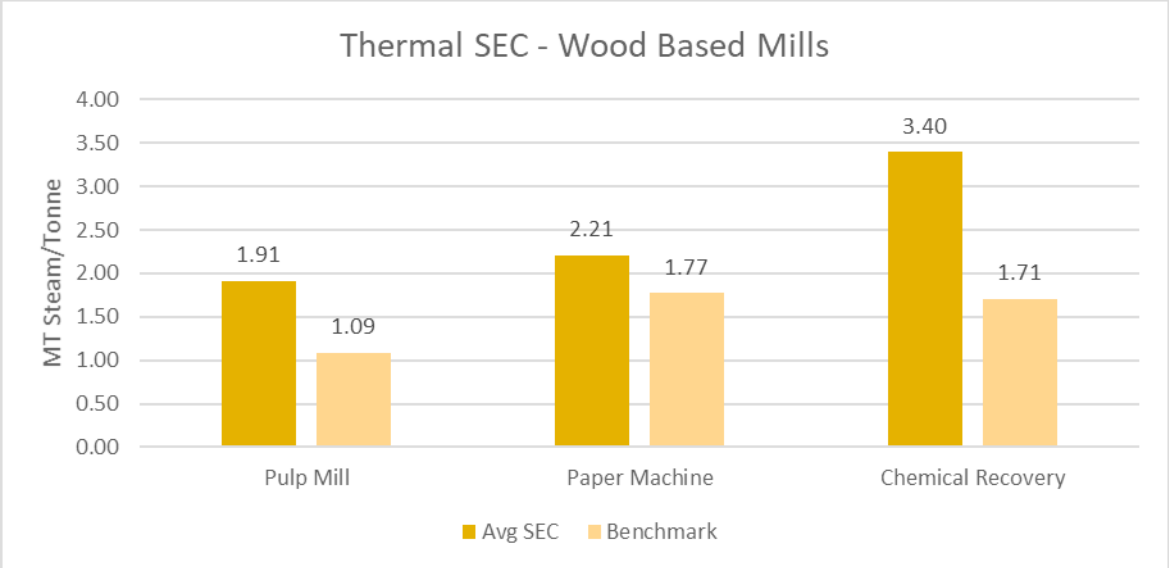


Figure 18 Thermal SEC-Wood based mills

11 CII database

Pulpmill:

The pulp mill section shows moderate electrical consumption primarily due to inefficient chip handling systems, outdated refiners, and suboptimal screening equipment. Wood preparation processes, including chipping, screening, and chip washing, likely operate with oversized motors and inadequate variable frequency drive implementation.

Significant thermal energy waste occurs in digester operations, pulp washing, and oxygen delignification stages. Poor heat recovery from cooking liquor and inadequate steam utilization in continuous digesters, contribute to the 75% thermal overconsumption. Modern pulp mills should recover substantial heat from hot black liquor and reduce the thermal energy consumption levels.

Paper Machine:

While still above benchmark, the paper machine shows the lowest electrical efficiency deficit. This suggests relatively modern drive systems, adequate process control, and properly sized equipment. The usage of Turbo Blowers instead of Liquid Ring Vacuum pumps, installation of Hot air hood systems, etc. have been imperative in achieving the lowest SEC in the Paper machine. However, opportunities exist in optimizing approach flow systems and improving press section efficiency.

The paper machine demonstrates the best thermal efficiency among the three sections, indicating reasonably effective heat recovery from drying sections and adequate steam system management. The moderate thermal gap suggests opportunities in improving hood heat recovery, optimizing steam and condensate systems, and enhancing heat integration between drying sections.

Chemical Recovery:

Chemical recovery systems exhibit the most electrical efficiency deficit. This stems from energy-intensive operations including black liquor concentration, recovery boiler auxiliaries, causticizing processes, and lime kiln operations. Outdated evaporator systems operating at suboptimal efficiency require excessive electrical power for black liquor concentration from 15-18% to 65-80% solids.

The chemical recovery section shows the most alarming thermal energy waste, consuming nearly double the benchmark steam requirement. This indicates fundamental heat integration failures in the recovery cycle. Modern chemical recovery systems should be net energy producers through efficient black liquor combustion and steam generation, but the data suggests significant heat losses, poor combustion efficiency, and possible inadequate heat recovery from hot caustic liquor.

Improvement Priorities:

Chemical recovery system represents the highest impact opportunity, with significant potential energy savings across electrical and thermal consumption. This should include recovery boiler efficiency improvements, evaporator system upgrades, and comprehensive heat integration. Chemical recovery presents with potential to transform from energy consumer to energy producer through proper heat integration and equipment upgrades.

Chapter 3: Best Practices in Paper Manufacturing Units

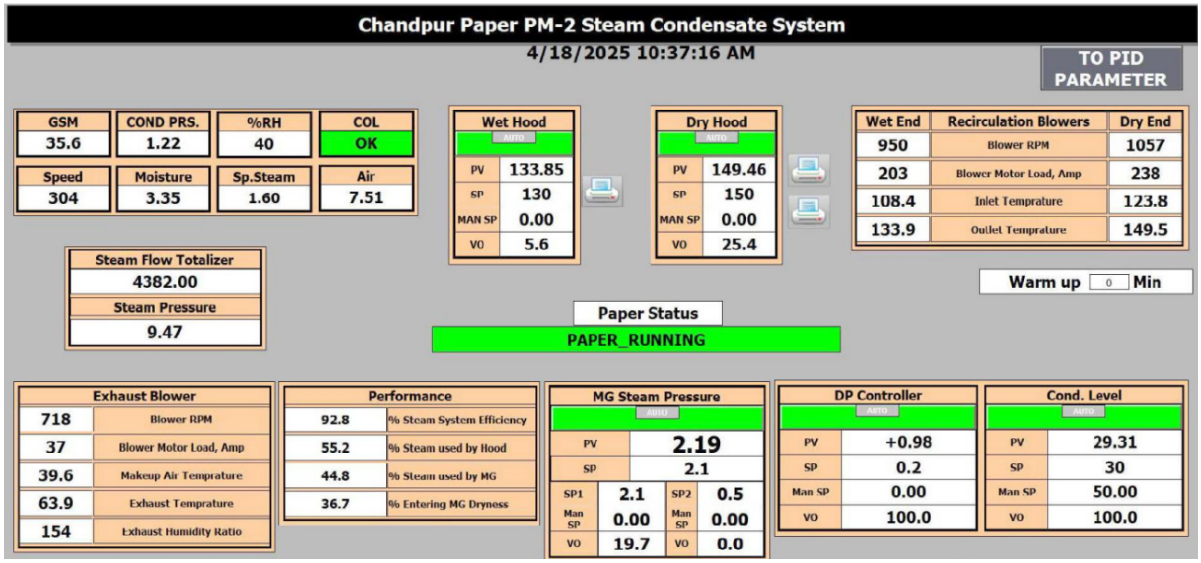
Case Study 1: Data Visualization and Online Energy Audit for Steam & Condensate System

Name of the project: Data Visualization and Online Energy Audit for Steam & Condensate System

Company Name/Plant: Chandpur Paper (A unit of Chandpur Enterprises Ltd.)

Background / Baseline Scenario: Chandpur Paper (A unit of Chandpur Enterprises Ltd.) located in Uttar Pradesh, is into manufacturing Poster Paper and Chromo (C1S) Paper. The unit produces an impressive 120 Tons Per Day (TPD) using the top-notch machinery sourced from global leaders, ensuring precision and efficiency. The mill uses electricity from grid as well as rooftop 850.98kW solar plant. Bagasse and biomass are the main fuel for boiler, which provides steam for drying paper on the paper machine.

Proposed System: In place of existing PID controller based, a PLC based system was used for process control of MG drying cylinder and hood. While developing the PLC system, the calculations for performance of steam and condensate system, energy efficiency etc. were included and all the relevant data was displayed on the process monitor.



Reference Case Study: After a new hood was installed in the year 2024, the operating parameters were manually collected and using Excel energy efficiency was calculated on a daily basis, just to have an idea about the performance of the same. As the mill manufactures paper in different basis weights (36-70 gsm), and also the operators were frequently juggling with operating parameters (like blower rpm, temperature set-points, MG pressure etc.) to ensure desired production rate and quality; significant variation in hood efficiency was being observed on different days. That gave a clue that if all calculations are made available online; maybe operators can operate system in efficient way.

So, all calculations were included in the PLC programming, and finally the system was installed on PM-2.

Outcome: The proper optimization after this resulted in reduction in steam consumption from 1.85 T/T to 1.64 T/T, or nearly 9%. Here, it must be noted that many mills producing similar grades on MG paper machines claim to achieve 2.0-3.0 T/T steam consumption. In addition to reduction in steam consumption, there was a reduction of nearly 30kW of electricity. Further reduction of 1-2% steam saving and another 30kW is expected in future. Overall, the present savings results in approx. 3500MT of steam and nearly 200,000 kWH of electricity annually. Later in March 2025, the same system was implemented on PM-1 also.

Replication Potential: This technology can be implemented on all paper machines without any problem. For bigger MF machines, having several hood exhausts and condensate cascading etc., the capex may be higher.

Cost of project: Approx. INR 10.0 Lakh (Including field instruments)

Payback: approx. 3 months.

Year of Installation: 2025 (PM-2), 2025 (PM-1)

Case Study 2: Vent Gas Waste Heat Recovery of drying section in paper industries. (Development of Core Technology for Large-Capacity and High-Temperature-Difference Heat Pump)

Name of the project

Vent Gas Waste Heat Recovery of drying section in paper industries. (Development of Core Technology for Large-Capacity and High-Temperature-Difference Heat Pump)

Technology Supplier: Piller De

Introduction to the technology:

- Mechanical Vapor Recompression (MVR) is an advanced energy-efficiency technology widely used in evaporators, dryers, and distillation systems in industries such as pulp & paper, sugar, food processing, and chemicals. It works on the principle of recovering and reusing the latent heat of vapor by compressing it to a higher pressure and temperature, thereby reducing the need for fresh steam.
- While a heat pump is a thermodynamic device that transfers heat from a lower-temperature source to a higher-temperature sink using mechanical work, typically powered by electricity. Instead of generating heat by combustion or direct electrical resistance, it leverages the refrigeration cycle in reverse to achieve very high energy efficiency.

· Installation capacity

- 5.5 ton/h Steam Generation through the Heat Pump & MVR

· Key performance indexes (Heat Pump)

- COP = 3.0
- Capacity = 3.5MW
- Temperature-Difference = 70℃

Background/ Baseline Scenario:

- Existing System:
  - In this European Paper mill, most of the thermal energy is supplied to the drying process from the steam boiler.
  - In the drying chamber, the thermal energy of the high-temperature steam dries the pulp and is converted into moist air, which is then exhausted through the stack.
- New Technology / Improvement:
  - Producing low-pressure steam from waste heat sources that would otherwise be released into the atmosphere through a heat pump system.
  - Recovering latent heat from wet steam during the process of waste heat recovery to reduce visible plume formation.
  - Utilizing recovered heat by converting it into compressed steam through a steam boosting system.

Project Details:

- There are three systems (Hood Heat Recovery, Heat Pump, Flash Vessel & MVR).
- A 3 layered pillow-plate heat exchanger is installed on the vent gas duct to recover waste heat using

water as the medium.

- The recovered waste heat is supplied to the heat pump system to heat-up the condensate to generate steam.
- The condensate heated by the heat pump flows to the flash vessel, where low-pressure steam is generated.
- The low-pressure steam is pressurized by the MVR system and then supplied to the consumer via steam header.

Schematic diagram

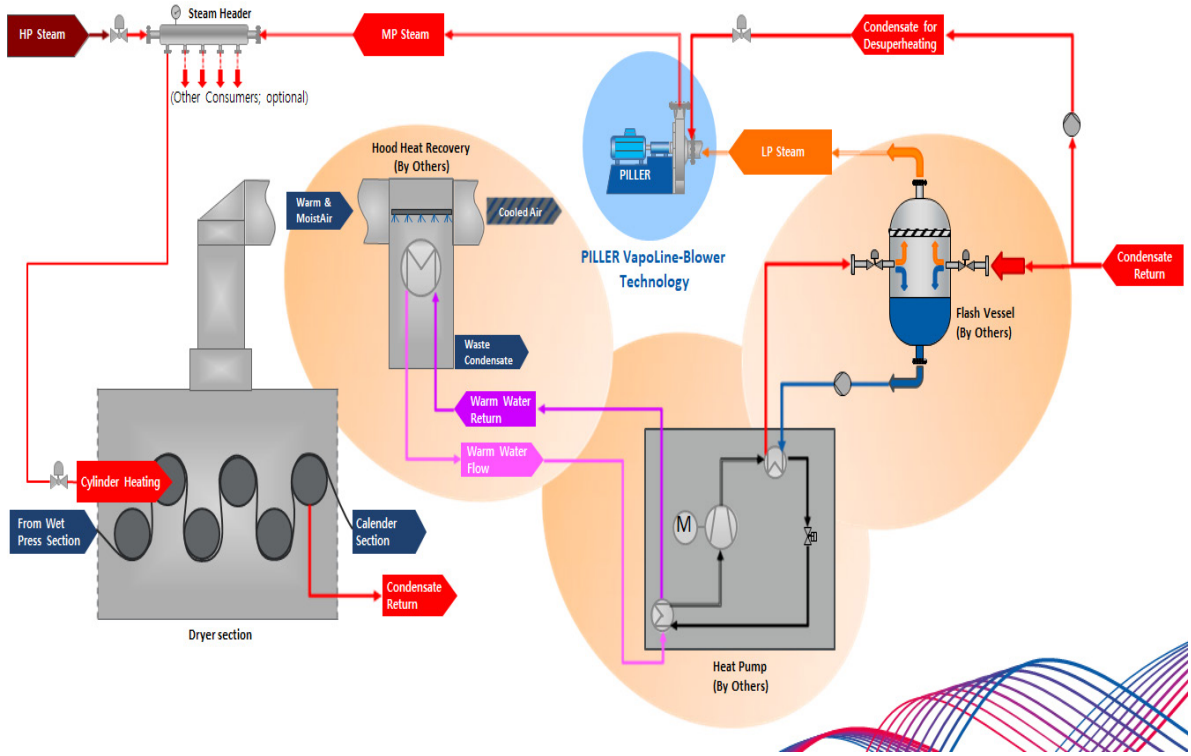


Table 2 Details of Energy saving

Sr. No.	Parameters	Unit	Before	After
1.	Drying Section Vent Gas Temperature at Stack	°C	85	51
2.	Net Waste Heat Recovery	kWh	0	2,300
3.	Steam generation	Ton/hour	0	5.5

Case Study 3: Strategic Re-purposing of Standby First Effect Calandria for Enhanced 7-Effect Evaporation Plant Efficiency and Sustainable Energy Management

Name of the project

Strategic Re-purposing of Standby First Effect Calandria for Enhanced 7-Effect Evaporation Plant Efficiency and Sustainable Energy Management

Company Name/Plant: Seshasayee Paper and Boards Ltd, Erode

Background:

This project focused on the strategic conversion of a standby first-effect Calandria into a fully operational second effect. The goal was to eliminate the necessity of operating on a reduced number of effects during crucial maintenance, thereby consistently upholding the design steam economy of 6.4. By creating redundancy, plant can now perform maintenance on one second-effect unit without interrupting the plant's overall operation.

Project Trigger:

The project was triggered by a critical need to address operational inefficiencies within the 7-effect evaporation plant. The plant's second-effect Calandria was highly susceptible to fouling, which required frequent and extended cleaning cycles. During these periods, the plant was forced to either reduce the evaporation feed rate or, more detrimentally, operate the entire system on a less efficient six-effect configuration. Both scenarios led to a significant drop in the steam economy, forcing the mill to burn more black liquor and valuable biomass fuel to compensate. This increased the paper mill's operational costs and negatively impacted the sustainability metrics. The availability of an underutilized, standby first-effect Calandria presented an ideal opportunity to solve this problem.

Challenges & Solutions:

The primary challenge was operational inefficiency and its downstream effects on cost and resource consumption. The constrained layout of the plant also presented a challenge for the physical modifications required.

The project provided a clear solution by:

- Re-purposing an underutilized asset: The plant transformed "dead capital" into an active part of their energy optimization efforts.
- Providing operational flexibility: The new setup allows for a sequence changeover, enabling one second-effect unit to be taken offline for cleaning while the other remains in service.
- Sustaining efficiency: This ensures the plant consistently maintains its design steam economy, eliminating the need to burn excess black liquor.

The Scheme Details & Approach

The project involved a comprehensive approach that began with a layout feasibility study. The core work included:

- **Piping Modifications**: Re-routing and integrating steam, condensate, feed, and vapor lines to seamlessly incorporate the converted unit. This included laying new pipes and relocating existing MOVs.
- **Instrumentation**: Calibrating and integrating new temperature, pressure, and flow sensors into the mill's existing DCS for optimized control.
- **Procedural Development**: Creating robust changeover protocols and training the operations team to ensure a smooth transition between units.

Envisaged Benefits

This project has yielded significant benefits:

- **Improved Heat Transfer**: Allows for thorough descaling, maintaining optimal heat transfer coefficients.
- **Enhanced Plant Availability**: Eliminates interruptions and allows for consistent processing of 250-260 m^3/hr feed rates.
- **Significant Steam Savings:** The project is projected to save 2,430 tons of steam per year, translating to approximately Rs. 34 lakhs in cost savings.
- **Sustainable Energy Management**: It ensures every unit of black liquor generates its maximum potential steam, aligning with the mill's energy independence and environmental goals.

Why It Is Innovative

This project's innovation lies in its resourceful approach. Rather than purchasing new equipment to solve the problem, the paper mill **creatively re-purposed an existing asset** to build redundancy into a critical part of the process. This proactive solution ensures continuous, optimal performance by addressing the root cause of the inefficiency—the need for maintenance—without compromising production or increasing costs. It is a prime example of sustainable engineering that maximizes internal resources to achieve both economic and environmental benefits.

Case Study 4: Water Management

Name of the Project:

Water Management

Company Name/Plant: Tamilnadu Newsprint & Papers Limited, Unit 2, Mondipatti

Water is a very critical and increasingly becoming a scarce resource. The sustained availability of water is threatened by climate change and other anthropogenic factors. Being aware of that, TNPL initiated various water management activities to improve ground water availability and to conserve water. Renovation of depleted water bodies and other structures for rain water harvesting, etc are being done to improve ground water level.

The newly installed Fiberline has very low water consumption (5.5 m^3/MT of pulp) with the state of the art pulping technology. Also TNPL Unit-2 has installed air cooled condenser for cooling water saving huge amount of water. Effluent generated in the board making process is treated with modern treatment facility assisted by Moving Bed Biofilm Reactor (MBBR), Biological Activated Sludge (BAS), and Dissolved Air Flotation (DAF) Processes designed to control the out let water within the norms as stipulated by Pollution control board. The treated effluent water is irrigated, through modern drip irrigation technology, to company owned plantation lands. This greatly minimizes the quantum of water requirements for inland irrigation as compared to conventional irrigation system.

The Wastewater treatment plant consists of the following

- Equalization Tank and EQT Pumps
- Bar Screen (Manual and Mechanical)
- Flocculator
- Primary Clarifier and Sludge pump cooling Tower and Sump
- Moving Bed Biofilm Reactor (MBBR 1 and 2)
- Basic Activated Sludge process(BASP)
- Secondary Clarifier and Pumps
- Dissolved Air Floatation(DAF)
- Online Filter
- Pressure Sand Filters and Pumps
- Sludge Thickener
- Sludge handling System consist of Belt press, Screw Conveyors ,Screw Press ,Belt Conveyor , Bellmer Press and Centrifuge etc

Table 3 Design Basis of Raw Effluent and Treated Water Parameters

Parameters	Units	Raw Effluent	Treated Water
pH		6.5-8.5	7.0-8.0
Biochemical Oxygen Demand (BOD 3@ 27°C)	mg/L	650	<10
Chemical Oxygen Demand	mg/L	2000	<200
Total Suspended Solids	mg/L	800	<50
TDS	mg/L	1650	<1650
Oil & Grease	mg/L	10	<10
Odour	mg/L	Odourless	Odourless

The effluent generated is treated in the modern high efficiency effluent treatment plant and treated water is sent for on land irrigation. The entire treated water is utilized for irrigating of 574 acres of TNPL land, effectively conserving the freshwater requirement for irrigation.

The quality of treated water, soil health & ground water are being monitored by Tamilnadu Agricultural University (TNAU), Trichy.

Water Bodies Protection

Protection and renovation of water bodies in and around unit 2 was initiated by TNPL. A study on "Micro Watershed Development in and around Anycut areas of TNPL U2" in consultation with Society for Social Forestry Research & Development Tamil Nadu (SSFRDT), Chennai was done to assess the water bodies around TNPL, unit-2.

Renovation of depleted water bodies and extension of retaining wall (about 70 meters) of the Mondipatti pond with the existing 250 meter wall to conserve water and protect soil erosion was also undertaken by the paper mill.

Case Study 5: Emission Reduction

Name of the Project:

Emission Reduction

Company Name/Plant: Tamilnadu Newsprint & Papers Limited, Unit 2, Mondipatti

Air pollution discharges such as SOx and NOx are well within the limit by adopting latest technological intervention, process optimization, and using low sulphur content imported coal and also substitution of biofuels such as saw dust. Control of Non-Condensable Gases (NCGs) is done with latest technological intervention. Approx 10 crores of investment is made to control NCGs emission. Online stack emission monitoring system installed and hooked to GLENS server to closely monitor the emission and any deviation is immediately communicated through SMS or e mail to take timely action on any deviation. Capital outlay for environmental expenditure for captive co-generation power plant & ETP is Rs. 5746.59 lakhs.

1. Two sheds and automatic water sprinkling system is provided at coal stock yard and coal handling area to suppress dust emission.

Closed Coal Shed

2. Closed belt conveyors were installed to transport coal from stock yard to boiler house.

Closed hoods for coal conveyors

Closed transfer of coal between conveyors

3. Three (3) No's of CO detection system is installed and in operation. Further the CO detection mechanism is provided along with online monitoring system and also connected with Care Air Centre of TNPCB.

4. The fly ash generated was collected in dry form and being supplied to TNPL's cement plant & other Cement plants for manufacture of Cement.

Eco Restoration and Conservation Measures

TNPL has raised plantation in about 574 acres of company's own lands in the villages viz., Mondipatti, K.Periyapatti, Chettichathiram in Manapparai taluk which is at an altitude of 150m above MSL. Before taking the land, the area was totally barren and sporadic rock-out crops. The soil was highly degraded with high amounts of soil erosion and devoid of any nutrients. Before taking up the plantation, green manure seeds were sown and incorporated into the soil in the entire plantation area. Planting operations were started during September 2015 and completed by January 2016. 680000 trees were planted with 68 different tree species such as Timber like Teak, Rose wood, Red sander, Sandal, Vengai, Neermaruthu, Kumil, Vagai, Neem, Silver oak, Sisoo, etc., Fruit trees like Mango, Guava, Pomegranate, Sappota, Amla, Jack, Athi etc., different Coconut varieties etc.

The people around 5 kilometer radius (32 villages on all the four directions) of the TNPL UNIT - II factory were given awareness regarding the habitat restoration for conservation of biodiversity, floral and faunal observations. Similarly, the School & College students nearby TNPL Unit II, Employees of TNPL Unit II were also given awareness regarding the habitat restoration for conservation of biodiversity, floral and faunal observations. Erection of sign boards indicating the conservation of flora and fauna, biodiversity conservation, etc. were carried out. Biodiversity Management Committee (BMC) was formed with the help of local village people, TNPL officials and students for effective conservation of resource in TNPL Unit II and nearby villages.

An area of 300 acres of Green Belt Plantation was converted into biodiversity conservation zone, with very less human interaction and restoring the damaged ecosystems enhancing the productivity and resilience of the ecosystems.

By the systematic ecosystem restoration projects, the key species such as Grey Slender loris and Peacock population have been witnessed to be increasing progressively.

- Grey slender loris 14 No's (2018-2019) and now 34 No's (2024- 2025),

- Indian peafowl - 400 No’s (2018-2019) and now 570 No’s (2024- 2025).

About 50 school students, 165 college students, 450 TNPL employees and 200 village people in and around TNPL Unit II was trained on biodiversity conservation.

This provided knowledge on biodiversity status and its importance and the flora & fauna availability around them.

Case Study 6: Boiler modification to suit new fuel mix, reduce the Specific power consumption, improvement of steam fuel ratio and increase of Bio-fuel

Name of the Project:

Boiler modification to suit new fuel mix, reduce the Specific power consumption, improvement of steam fuel ratio and increase of Bio-fuel.

Company Name/Plant: ITC PSPD Unit Kovai

Introduction of the plant:

The capacity of Board machine is 1.2 LPA Recycled board. Unit has 60TPH boiler for cogeneration (Capacity: 8MW).

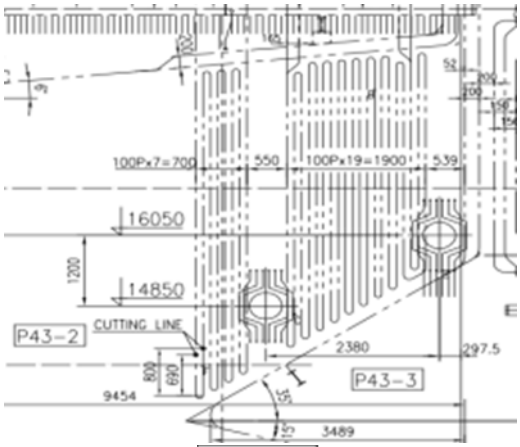
Background/ Baseline Scenario:

Cogen Boiler designed for firing lignite with biofuel. In view of non-availability of lignite supply, imported coal used in place of lignite. This resulted in shoot up of bed temperature up to 950 deg celcius & requirement of excess air to reduce the bed temperature. Specific Power consumption of Utility is 86 kWh/MT (Absolute power consumption from 94 lakh kWh).

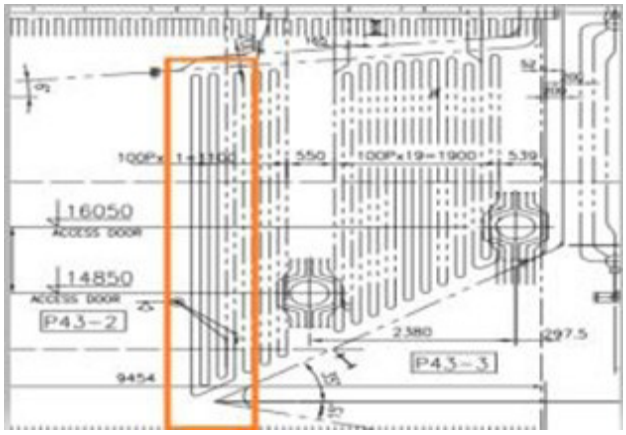
Project Details:

- Ø Installation of Double row bed coil in place of existing single row bed coil. This leads to an increase in the heating surface area of Furnace Panel and in bed evaporator from 672 sq mt to 847 sq mt. Increase of 172 sq mt.
- Ø Existing Convection Superheater is converted to “Platen Superheater” which increased the heating surface area by 95 sq mt.

Additional loop in Super heater coil :



Before



Before

Photographs:

Double row bed coil

Super heater coil

The following modifications were carried out

- Addition of refractory at furnace to achieve superheater steam temperature at convection zone.
- Addition of tertiary air nozzles to minimize the carryover of fines by providing blanketing effect over at combustion zone
- Addition of Suit blowers 3 nos to enhance the cleaning of soot deposit over super heater coils.

Results:

- Excess air reduced from 29.6% to 20%.
- Increase in Boiler Efficiency by 1.2%

Table 4: Details of energy saving

S No	Description	UOM	Qty
1	Air nozzle diameter increased	Lac KWH per annum	3.6
2	Unit level intervention (ID, FD Fan tuning, ESP Leakage arresting)	Lac KWH per annum	7.8
3	Total Power savings	KW	144
4	Total Energy savings	Lac KWH per annum	11.4

Technology Supplier: Themax Limited

Case Study 7: Boiler Air Pre Heater Replacement

Name of the Project:

Boiler Air Pre Heater Replacement

Company Name/Plant: Seshasayee Paper & Boards Unit: Tirunelveli

Company Profile

Seshasayee Paper and Board Limited, (SPB) Unit-II near Tirunelveli belongs to ESVIN GROUP, which operates its main plant in Erode, Tamil Nadu. This unit was acquired by SPB in 2011. The plant has a bleached pulp production capacity of 109500 Tonne per year from RCF. However, its capacity is not fully utilized due to unavailability of RCF. Hence, most of the required pulp is sourced from Unit-I in Erode. The plant is having paper production capacity of 90,000 Tonne per year. The plant produces only writing and printing paper. Special grade printing paper is also produced for export purposes.

Background/ Baseline Scenario:

.The existing APH had deteriorated over years of operation, leading to:

- Increased flue gas outlet temperature
- Reduced heat recovery efficiency
- Higher auxiliary power consumption
- Increased specific fuel consumption

This negatively impacted the overall boiler efficiency and energy consumption.

Project Details:

Details of the energy saving project:

- Detailed description of the project
    - The old type, tubular APH was replaced with a new APH. As a result, the heat transfer area was increased and the flue gas heat energy recovery improved considerably. Before the replacement of APH, the air handling systems- PA, FD and ID fans were forced to run in excess load over the required operation (ID sucks FD air too) where after the project implementation it settles to normal.
- Project timelines (duration & process downtime)- **Ten days planned shutdown for replacement of APH units.**

<u>Improvements achieved</u>

Table 5 Parameters before APH replacement

Old APH unit performance				
	Value	**Units**	**Value**	**units**
Mass of inlet airflow to the APH /hr	45	Tons	45000	Kgs
Specific heat of air	1.005	KJ/Kg-K	0.24	kcal/kg °C
APH Inlet Temperature of air	27	°C		
APH outlet Temperature of air	63	°C		
Temperature dt	36	°C	36	°C
Heat energy in the APH output			389125	kcal/hr

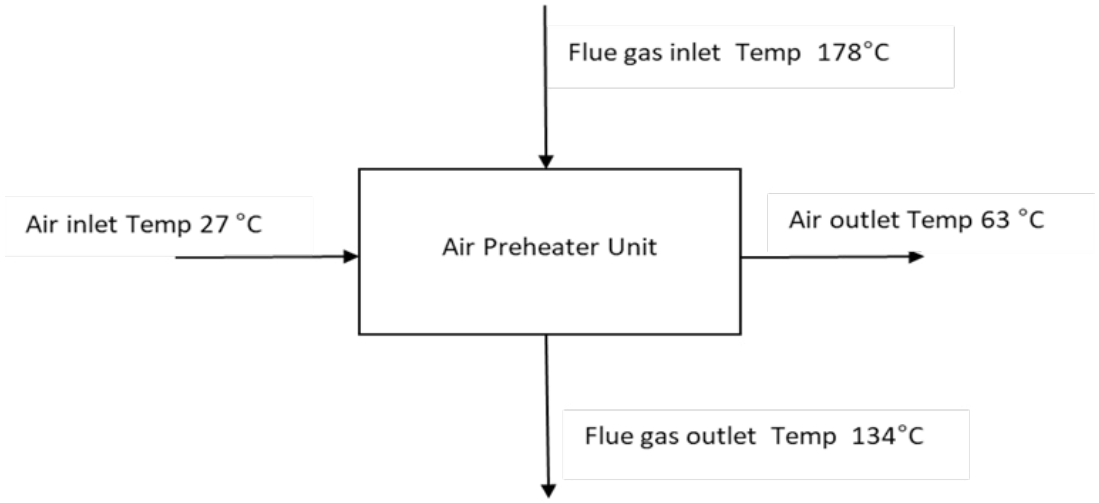
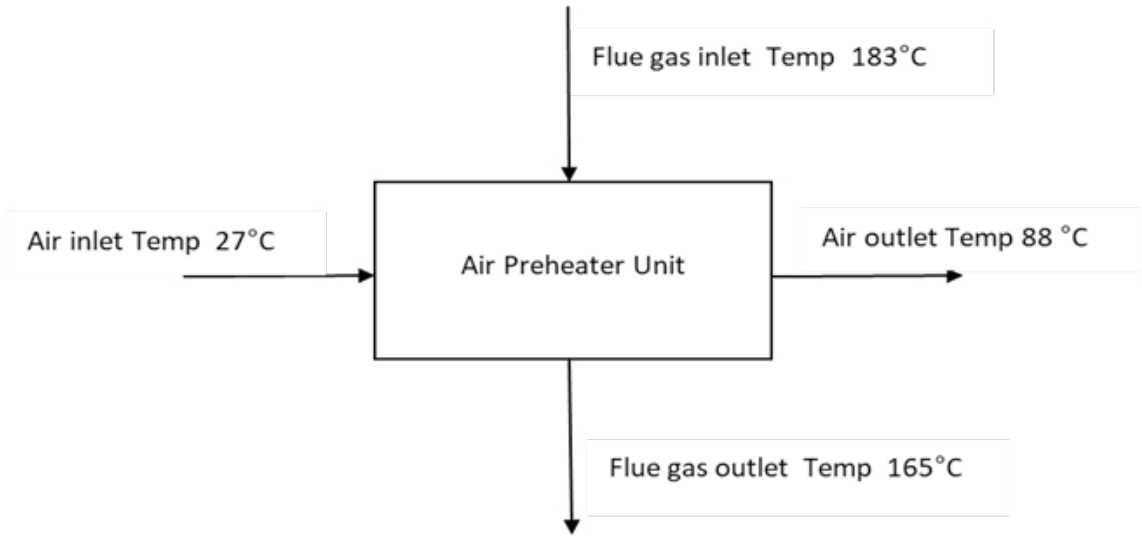


Table 6 Parameters after APH replacement

New APH unit performance				
	Value	**Units**	**Value**	**units**
Mass of inlet airflow to the APH /hr	50	Tons	50000	Kgs
Specific heat of air	1.005	KJ/Kg-K	0.24	kcal/kg °C
APH Inlet Temperature of air	27	°C		
APH outlet Temperature of air	86	°C		
Temperature dt	59	°C	59	°C
Heat energy in the APH output			**708592**	kcal/hr



CUSUM Analysis – Overview

CUSUM (Cumulative Summation) is a statistical technique used for monitoring small shifts in process performance over time.

- It works by accumulating deviations of measured values from a target or mean value.
- Especially useful in detecting gradual changes those traditional charts might miss.

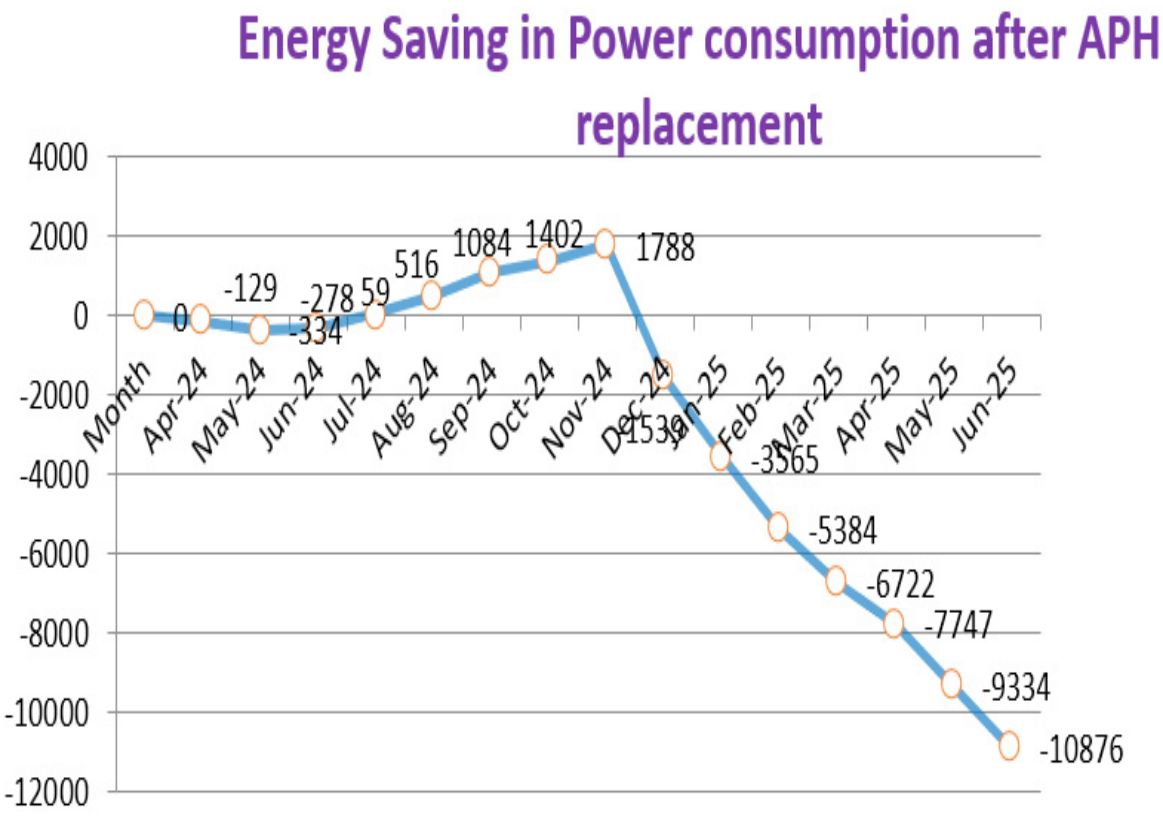
- Helps in early identification of process inefficiencies, equipment drifts, or operational anomalies.
- Valuable for continuous improvement and performance tracking in power plant operations.

To calculate the exact energy saving from the project, the CUSUM analysis methodology was carried out. For the CUSUM analysis the data from April 24 to June 25 was considered and it was normalized by regression analysis method by which a straight-line equation was formed.

y=12.4X+1472

Table 7 Energy saving calculation using CUSUM analysis

Steam Production Vs Power consumption					
Month	**Production**	**Actual Power in Kwh**	**Normalized power in Kwh**	**Energy saving**	**CUSUM**
Apr-24	853	13671	13800	-129	-129
May-24	845	13522	13727	-205	-334
Jun-24	830	13644	13587	56	-278
Jul-24	886	14440	14103	337	59
Aug-24	873	14436	13979	457	516
Sep-24	825	14107	13539	568	1084
Oct-24	809	13715	13397	318	1402
Nov-24	760	13333	12947	386	1788
Dec-24	844	10385	13712	-3328	-1539
Jan-25	888	12095	14121	-2026	-3565
Feb-25	840	11859	13678	-1818	-5384
Mar-25	904	12927	14265	-1338	-6722
Apr-25	891	13120	14146	-1026	-7747
May-25	864	12312	13899	-1587	-9334
Jun-25	861	12329	13871	-1542	-10876



Over and above this there are reasonable savings in fuel consumption (absolute) based on the heat energy value. The plant calculated the energy recovered (Kcal) in both cases and comparative results show that there is a coal savings of 2.4 Tons/days. The detailed workings as follows

Performance Improvement			
Improvement in the heat energy recovery	319467	kcal/hr	**As per the observed value, there is a saving of 2.4 Tons of coal per day**
GCV of coal	4650	kcal/kg	
Savings in coal due to improvement in heat energy recovered from flue gas in APH	98.14655	kg/hr	
	2355.517	**kg/day**	

- **Environmental or other benefits**
  - As a result of the replacement of the new APH, the heat recovery from the flue gas has improved by which the CO_2 emission was reduced considerably.

Table 8 Details of Energy saving

Sr. No.	Parameters	Unit	Before	After
1.	Temperature (if applicable) or any other parameters	Deg Celcius	63	88
2.	Pressure (if applicable) or any other parameters		NA	NA
3.	Power	kWh	13600	12300
4.	Steam consumption	Tonnes	NA	NA
5.	Energy saving	Kcal/hour	**389125**	**708592**
6.	Monetary benefits	INR Lakhs/annum	1300kwh x 8.50 Rs x350 days = 38,67,500 Rs per annum	
7.	Investment	INR Lakhs	48,23,000	
8.	Payback	Months	15 Months	
9.	Any other benefits (related to environment), if any		116592.3 tCO_2 emission	114931.44 tCO_2 emission

Case Study 8: Energy-Efficient Turbo Blower installed in place of conventional Vacuum System.

Name of the Project:

Energy-Efficient Turbo Blower installed in place of conventional Vacuum System.

Company Name/Plant: Khanna Paper Mills

Background/ Baseline Scenario:

The paper industry is energy-intensive, with vacuum systems consuming substantial power and water. Traditional liquid ring vacuum pumps are maintenance-heavy and inefficient. This project retrofits oil-free turbo blowers in low-to-medium vacuum areas, improving energy efficiency, reducing maintenance, and enhancing reliability while ensuring uniform vacuum throughout the machine. Additionally, heat recovery from turbo blower exhaust reduces the steam demand of the paper machine, saving fossil fuel and lowering emissions.

The trigger for implementing this project was:

- High energy consumption, excessive maintenance, and water usage associated with liquid ring vacuum pumps.
- Frequent breakdowns were impacting machine runnability due to non-uniform vacuum and reduced production efficiency.
- Reduced power consumption by replacing 20 vacuum pumps with two energy-efficient turbo blowers.
- No water consumption
- No chemical consumption
- Lower power transmission losses by switching from 415 V to 11 kV

Reduced steam consumption in the drying section

Project Details:

- **Detailed Description of the Project:**

  The wire and press section of the paper machine were originally equipped with conventional vacuum pumps that operated with high power consumption and higher pulsation, resulting in frequent vacuum fluctuations. These variations led to complex operations, reduced runnability, and overall inefficiency in the paper machine.

  To address these issues, the conventional vacuum pump system having installed capacity of 1825 kW was replaced with an energy-efficient turbo blower system with installed capacity of 1560 kW. Turbo blowers operate with constant pulsation, significantly reducing vacuum variation and enabling smoother, more stable machine operation. Additionally, turbo blowers consume less power, contributing to direct energy savings.

  One key advantage of the turbo blower system is the hot air exhaust, which offers an opportunity for waste heat recovery. This heat is now being utilized in the PV hood system, leading to an estimated steam saving of 15-18 tonnes per day. The improved consistency in turbo blowers enhances process reliability, improved wet end stability and reduces water consumption as compared to the conventional vacuum pump technology.

- **Modifications Made for Upgradation:**

  Replacement of single-stage separator with two-stage separator system

- MS separator upgraded to SS separator
- Addition of a concrete separator

Integration of turbo blower exhaust heat recovery into the PV hood system for steam savings

- **Project Timelines:**

  Total Project Duration: 45 days

  Process Downtime: 15 days

- **Replication Potential:**

  The solution has already been successfully implemented in two paper machines, resulting in measurable improvements in energy efficiency and operational performance. Based on these proven results, plans are underway to replicate this solution on the remaining two paper machines within the plant.

Before Pic

After Pic

Table 9 Details of Energy saving

Sr. No.	Parameters	Unit	Before	After
1.	Pressure	mmHg	-244 to -454	-244 to -454
2.	Power	kW	1,795	1,413
3.	Steam consumption	Tonnes/Tonne of paper	2.2	2.16
4.	Energy saving (Thermal+Elecrical)	Kcal	7.9 lakhs	
5.	Monetary benefits	INR Lakhs/annum	770	
6.	Investment	INR Lakhs	1150	
7.	Payback	Months	18	

Technology Supplier: Senfang

Case Study 9: Replacement of Conventional Cooling Tower Fans with HeCTA fan

Name of the Project

Replacement of Conventional Cooling Tower Fans with HeCTA fan

Company Name/Plant: Khanna Paper Mills

Background/ Baseline Scenario:

The existing cooling tower system was equipped with conventional axial flow fans that operate with relatively lower efficiency. These fans typically have higher energy consumption, limited controllability, and generate more noise during operation. Additionally, due to their older design and technology, they often lead to higher maintenance requirements and reduced overall system reliability.

To address these challenges and improve energy performance, the proposed project involves replacing the conventional fan with a High Efficiency Cooling Tower Aerodynamic (HeCTA) fan. HeCTA fans are specifically engineered for cooling tower applications, offering superior aerodynamic design, higher static efficiency, and lower power consumption. They also provide better airflow characteristics and enhanced corrosion resistance, resulting in improved cooling performance, reduced operational costs, and lower noise levels.

This upgrade aligns with the objectives of energy efficiency, reliability, and sustainability, making it a valuable improvement over the existing setup.

Project Details:

The energy saving project involved replacing conventional axial fans in the cooling tower of the turbine generator (TG) with High Efficiency Cooling Tower Aerodynamic (HeCTA) fans. The cooling tower consists of four cells, each equipped with a 37-kW motor-driven fan. The objective was to enhance energy efficiency by improving the aerodynamic performance of the cooling tower fans without making major mechanical changes. A total of three fans were planned for replacement under this initiative—two have already been successfully replaced, and the third is currently in progress.

Earlier, each fan assembly consisted of nine blades and a larger hub diameter. These were replaced with new high-efficiency FRP (Fibre Reinforced Plastic) blades in a six-blade configuration with a smaller hub diameter. This modification has increased the effective traverse area of the cooling tower from 13.28 m^2 to 14.11 m^2, allowing for improved airflow and enhanced thermal performance. Despite the change in fan assembly, the existing 37 kW motors were retained, avoiding the need for additional electrical modifications and keeping the capital investment minimal.

Each fan replacement was executed with minimal operational disruption, as only one cell was taken offline at a time. The process downtime per fan was approximately 8 hours, and the installation work was completed within a day for each cell. This phased approach ensured continuous cooling tower operation throughout the project duration.

The newly installed HeCTA fans offer several operational benefits. Their aerodynamic design enables higher air delivery at reduced power input, resulting in significant energy savings. The smaller hub and improved blade design also contribute to lower noise and vibration levels, enhancing the reliability and service life of the cooling tower system.

Before Pic

After Pic

Table 10 Details of Energy saving

Sr. No.	Parameters	Unit	Before	After
1.	Power (2 fans)	kW	49.3	31.1
2.	Energy saving	Kcal	15,652	
3.	Monetary benefits	INR Lakhs/annum	13.69	
4.	Investment (2 fans)	INR Lakhs	14	
5.	Payback	Months	12.2	

Case Study 10: Replacement of Root Blower with Energy Efficient Screw Compressor in ETP Area

Project:

Replacement of Root Blower with Energy Efficient Screw Compressor in ETP Area

Company Name/Plant: Khanna Paper Mills

Background/ Baseline Scenario:

The existing system in the Effluent Treatment Plant (ETP) area utilizes a conventional Roots blower for supplying air to the aeration tank. While Roots blowers are widely used for such applications, they operate at a constant speed regardless of process demand, leading to excess air delivery, higher energy consumption, and inefficient operation. Additionally, they generate more noise and have higher wear-and-tear due to their mechanical design.

To improve energy efficiency and process control, the proposed project involves replacing the existing Roots blower with a high-efficiency screw compressor. These advanced technologies offer better isentropic efficiency, smoother operation, and reduced energy consumption. Moreover, the system is integrated with a Dissolved Oxygen (DO)-based sensing and feedback control mechanism. This enables real-time monitoring of DO levels in the aeration tank and dynamically adjusts the compressor frequency through a Variable Frequency Drive (VFD), ensuring that only the required amount of air is delivered.

This upgrade not only enhances energy performance and reduces operational costs but also ensures optimal biological treatment efficiency by maintaining DO within the desired range.

Project Details:

The project involved the replacement of the existing aeration system in the Effluent Treatment Plant (ETP), which originally consisted of five Roots blowers, each rated at 55 kW. These conventional blowers operates at a fixed speed, supplying air continuously regardless of the actual oxygen demand in the aeration tank. This led to inefficient energy usage, excessive airflow, and limited control over the biological treatment process.

To improve energy efficiency and optimize process control, the system was upgraded by installing two energy-efficient Low Pressure (LP) blowers, each rated at 132 kW. These new blowers are equipped with Variable Frequency Drives (VFDs), enabling dynamic adjustment of air supply based on real-time requirements.

Additionally, the system is now integrated with Dissolved Oxygen (DO)-based sensing and feedback control. DO sensors installed in the aeration tank continuously monitor oxygen levels and provide real-time signals to the blower VFDs, allowing automatic regulation of blower speed and airflow. This ensures optimal DO levels are maintained, enhancing treatment performance while minimizing energy consumption.

Project Timelines:

Total Duration: 1 month

(Including civil, mechanical, instrumentation work, and pre-dispatch inspection)

Process Downtime: 1 day

(Required for decommissioning old blowers and commissioning the new system)

Challenges Faced During Implementation:

A 1-day downtime was required for installation and switchover activities.

To avoid disruption in the aeration process and maintain adequate DO levels during this period, fresh water was supplied continuously for 2–3 hours in the aeration tank.

The successful completion of this project has resulted in:

- Significant energy savings
- Improved process control
- Reduced equipment footprint
- Enhanced reliability and maintainability of the ETP aeration system

Before Pic	After Pic
	

Table 11 Details of Energy saving

Sr. No.	Parameters	Unit	Before	After
1.	Pressure		0.75-0.78 kg/cm2	0.8-.84 kg/cm2
2.	Power	kWh	270	177
3.	Energy saving	Kcal	79980	
4.	Monetary benefits	INR Lakhs/annum	56.24	
5.	Investment	INR Lakhs	90	
6.	Payback	Months	19	

Technology Supplier: Atlas Copco

Case Study 11: Energy Efficiency and Reliability Enhancement through Solar-Ready 250 kW Battery Energy Storage System in Paper Manufacturing

Name of the Project

Energy Efficiency and Reliability Enhancement through Solar-Ready 250 kW Battery Energy Storage System in Paper Manufacturing

Company Name/Plant: Doghat Paper Mills Pvt. Ltd

Background / Baseline Scenario

Before the project, the mill relied on a mix of grid power and diesel generators during peak load or outage periods. Peak tariff charges and frequent voltage fluctuations disrupted production and damaged sensitive drives and motors.

The facility also has a rooftop solar plant, but its output is often curtailed during low-load periods or when production lines run at reduced speed, leading to underutilization of available renewable energy.

The need for a cleaner, more reliable, and cost-effective backup and peak shaving solution prompted the adoption of a Battery Energy Storage System (BESS). While the current installation is charged primarily from the grid, it has been designed for seamless future integration with the rooftop solar system.

Project Details

Description:

The project involved installing a 250kW lithium iron phosphate ($LiFePO_4$) BESS integrated with the plant's grid supply. The system is paired with an intelligent Energy Management System (EMS) to:

- Shift peak demand to off-peak hours.
- Provide seamless backup during outages (UPS mode).
- Stabilize voltage and frequency for critical paper-making machinery.
- Be solar-ready for capturing excess solar power in the near future.

Operating Principle:

- **Charge (Current):** BESS charges from the grid, primarily during off-peak tariff windows.
- **Charge (Future):** System architecture is designed for rooftop solar integration, enabling daytime solar charging once coupled.
- **Discharge:** Automatically supplies power during evening peak demand, outages, or voltage dips.
- **EMS:** Predictive algorithms optimize charge/discharge cycles based on real-time plant load curves and will include solar integration logic.

Required modifications:

- Integration of BESS with main LT panel (solar-ready connections provided).
- Addition of load management relays.
- Minor civil foundation for containerized BESS unit.

Timelines:

- Project approval: Jan 2025.
- Installation & commissioning: 6 weeks.
- Downtime: <2 hours for switchover integration.

Improvements Achieved:

- Reduced diesel consumption by ~90% during outages.
- Lowered monthly energy cost by ~8–10% through peak load shifting.
- Improved power quality (voltage sag reduction by ~80%).
- Reduced CO_2 emissions by ~160 ton/year.

Improvements Expected (Post-Solar Integration):

- Increased solar utilization by ~20–25%, eliminating curtailment.
- Additional cost savings from self-consumption of renewable energy.
- Further CO_2 reduction of ~50 ton/year.

Environmental Benefits:

- Reduced diesel generator dependence.
- Lower noise and air pollution.
- Compliance with emerging emission regulations.
- Solar-ready design ensures future scalability of renewable energy use.

Challenges Faced:

- Optimizing load profiles to maximize storage benefits.
- Future task: EMS configuration for hybrid solar + grid charging.

Replication Potential

This project demonstrates that a solar-ready BESS can immediately deliver savings and reliability benefits while being future-proofed for renewable energy integration. The model is highly replicable for paper mills with existing or planned rooftop solar, especially those with high peak tariffs, unstable grid supply, or diesel dependence.

With modular scaling, similar systems can be adapted from 250 kW to multi-MW capacities across the pulp and paper sector.

Table 12 Details of Monetary benefits

S No.	Parameters	Unit	Before	After
1.	Power Source	kWh	Diesel Generators (2*250kW)	BESS + Diesel Generator (1*250kW)
2.	Monetary benefits	INR Lakhs/annum	NA	52
3.	Investment	INR Lakhs	50	
4.	Payback	Months	**7**	
5.	Any other benefits		ESG compliant	

Conclusion and Way Forward

The compilation of benchmarked specific energy consumption (SEC) values and the compilation of best practices across Indian pulp and paper mills represents a pivotal step in driving the sector toward operational excellence. The data, case studies, and technological pathways highlighted in this manual demonstrate that energy efficiency is not merely a function of equipment efficiency, but a systems-level outcome, shaped by the interaction of raw material characteristics, process integration, operational discipline, and management practices.

Key Conclusions

Variation in SEC by Grade and Raw Material

The benchmark SEC values clearly reveal that kraft paper and packaging grades achieve lower electrical and thermal intensities than writing and printing grades, primarily due to reduced bleaching requirements, broader product tolerances, and lower demands on brightness development. Mills utilizing wood fibers demonstrate superior strength properties of pulp, enabling lower refining intensity compared to agro-based or recycled fibers. Conversely, recycled and agro-based mills, while facing inherent material limitations, have innovated through process modifications, chemical optimization, and water-energy integration.

Process Integration and Energy Synergies

Mills that achieved world-class SEC values have moved beyond isolated equipment efficiency measures and adopted holistic process integration strategies. Examples include recovery boiler and turbine cogeneration optimization, heat recovery through multiple-effect evaporators, closed water loops reducing pumping loads, and utilization of non-condensable heat streams for secondary applications. These integrated approaches are critical in reducing both electrical and thermal SEC simultaneously, as opposed to achieving partial improvements.

Technology Deployment and Best Practices

Benchmark mills have demonstrated that state-of-the-art technologies—ranging from high-consistency refining, advanced vacuum system optimization, distributed VFD controls, shoe press technology, and energy-efficient drying cylinders—can transform SEC profiles when applied systematically. However, the evidence also indicates that technology adoption alone is insufficient without disciplined operation and preventive maintenance regimes. For instance, vacuum system efficiency gains were maximized only in mills where piping layouts, seal water systems, and monitoring protocols were simultaneously upgraded.

Benchmarking as a Performance Driver

By collating the best SEC values across multiple grades and mills, this manual establishes reference baselines for both electrical and thermal energy intensities. These benchmarks provide quantifiable targets for lagging units, create competitive pressure for continuous improvement, and establish a transparent yardstick for policy and financing institutions. Importantly, the manual demonstrates that the Indian sector is capable of approaching international best-in-class levels, thereby dispelling the perception of inherent inefficiency in Indian operations.

Energy Efficiency as a Sustainability Lever

Beyond cost reduction, the improvements in SEC directly translate into lower greenhouse gas (GHG) emissions, reduced freshwater withdrawal (via lower thermal load), and improved resource circularity. In this sense, energy efficiency serves as the single most effective lever for aligning the sector with India's national commitments under the Paris Agreement and evolving ESG (Environmental, Social, and Governance) disclosure frameworks.

Collectively, the manual validates the premise that energy performance is a function of design, operation, and innovation—and that best-in-class performance is replicable, scalable, and improvable.

Way Forward

While the benchmarks and best practices documented herein provide a robust foundation, the trajectory of the Indian pulp and paper sector must now extend toward next-generation performance paradigms. The future vision for the sector can be framed across four interlinked dimensions.

Deepening Energy Efficiency Beyond Current Benchmarks

Refining Process Optimization: Advances in real-time fiber morphology sensors offer the potential to further minimize specific refining energy while achieving target tensile, tear, and burst indices.

Drying Section Innovation: Given that drying accounts for over significant amount of thermal energy demand, deployment of technologies such as infrared pre-dryers, and heat pump integration could redefine SEC benchmarks.

Advanced Cogeneration Systems: Biomass-gasification integrated combined cycle (BIGCC) systems and high-pressure recovery boilers (>105 bar) with back-pressure turbines can push power self-sufficiency and reduce grid dependence.

Digitalization and Industry 4.0 Integration

Smart Energy Management Systems: IoT-enabled meters, predictive analytics, and AI-driven optimization algorithms allow real-time monitoring of SEC deviations, anomaly detection, and automated corrective actions.

Digital Twins: Plant-wide digital replicas enable simulation of energy flows under different raw material and product scenarios, facilitating proactive decision-making.

Predictive Maintenance: Condition-based monitoring of critical energy-intensive equipment such as vacuum pumps, refiners, and fans can minimize unplanned shutdowns and sustain optimal SEC values.

Raw Material and Fiber Strategy

Agro and Recycled Fiber Efficiency: Since agro-residues and recycled fiber will continue to form a substantial fraction of India's furnish, future research must prioritize refining chemistries, enzyme-assisted pulping, and advanced fillers to offset the inherent SEC disadvantages of shorter fibers.

Sustainable Wood Fiber Utilization: Expansion of farm forestry and genetically improved plantations can ensure long-term wood availability, while high-yield pulping technologies reduce specific cooking energy and chemical loads.

Decarbonization and Circular Economy Alignment

Carbon-Neutral Energy Pathways: Greater utilization of biomass residues (black liquor, pith, bark) coupled with carbon capture, utilization, and storage (CCUS) in recovery boiler systems will position mills as net-zero energy hubs.

Water-Energy Nexus: Closed water systems reduce both pumping energy and thermal loads on evaporators, aligning energy efficiency with water stewardship.

Waste-to-Energy Integration: Sludge gasification and anaerobic digestion of effluents can provide biogas for lime kiln substitution, creating closed-loop energy cycles.

Final Perspective

The manual, by presenting the best available SEC values achieved by Indian mills and the practices underpinning them, provides a dynamic framework rather than a static reference. It demonstrates that excellence in energy performance is not a fixed destination, but a dynamic continuum shaped by innovation, learning, and adaptation.

As Indian paper mills internalize these benchmarks and practices, they must simultaneously embrace the forward-looking imperatives of digitalization, decarbonization, and circular economy integration. The ultimate aspiration is not only to reduce kilowatt-hours or gigajoules per ton, but to redefine the energy paradigm of the industry itself—where each ton of paper produced embodies global standards of efficiency, resilience, and sustainability.

By rigorously applying the insights documented here, the Indian pulp and paper sector can establish itself as a global exemplar—world-class in energy performance, uncompromising in sustainability, and unyielding in its pursuit of operational excellence.

NOTE: Benchmarking is dynamic and can change with adoption of best technologies. The data for benchmarking has been collected from CII energy award and energy audit and there might be some plant operating at lower SEC than mentioned in this publication. We request paper mill to share the information with CII for further refining/updating the publication.

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About CII:

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering Industry, Government and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, with around 9,000 members from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 365,000 enterprises from 294 national and regional sectoral industry bodies.

For more than 125 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness, and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

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For 2024-25, CII has identified "Globally Competitive India: Partnerships for Sustainable and Inclusive Growth" as its Theme, prioritizing 5 key pillars. During the year, it would align its initiatives and activities to facilitate strategic actions for driving India's global competitiveness and growth through a robust and resilient Indian industry.

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CII-Sohrabji Godrej Green Business Centre (CII-Godrej GBC) was established in the year 2004, as CII's Developmental Institute on Green Practices & Businesses, aimed at offering world class advisory services on conservation of natural resources. The Green Business Centre in Hyderabad is housed in one of the greenest buildings in the world and through Indian Green Building Council (IGBC) is spearheading the Green Building movement in the country. The Green Business Centre was inaugurated by His Excellency Dr. A. P. J. Abdul Kalam, the then President of India on 14 July 2004.

The Services of Green Business Centre include- Energy Management, Green Buildings, Green Companies, Renewable Energy, GHG Inventorization, Green Product Certification, Waste Management and Cleaner Production Process. CII-Godrej GBC works closely with the stakeholders in facilitating India emerge as one of the global leaders in Green Business by the year 2025.

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