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Energy Efficient Technologies in Paper sector and their impact on the sectoral Low carbon roadmap

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Abstract:

As per studies conducted by CII-GBC, the CO2 emissions from the Indian Pulp and Paper sector was estimated to be approx. 30.5 million tonnes in 2019, contributing to 1.09% in the total net GHG emissions . The previous paper by CII-GBC, had highlighted the potential for decarbonization in the Indian Pulp and Paper sector and had gone on to briefly describe the impact of various levers on emission reduction. In this paper, we will focus on the impact that two of the levers i.e. the "Latest energy efficient technologies" and "Fuel mix change" have brought about in sample units and the potential impact that they might have on the Low Carbon roadmap, for the Pulp and Paper sector, in the country. The extensive experience of CII-GBC team in the paper sector served as the foundation for identification of energy saving options mentioned in the paper. Energy saving opportunities identified are from areas like Pulp mill, paper machine, effluent treatment plant, vacuum pumps, etc.

The technologies included in the paper are as follows:

- *High Nip Press*
- *Turbo Vacuum Blower*
- *Regenerative Braking Motor*
- *Microturbine*
- *Turbo Oxy Jet Aerators*
- *White Liquor Heater*
- *Use of Biofuel in Coal Boiler*

Keywords: *Energy efficiency, Energy reduction, Decarbonization, Low Carbon technology, Best practices.*

Introduction

Pulp & Paper industry is among the most energy-intensive industries globally. With the growing worldwide push for sustainability, there is pressure on the paper industry to improve operating efficiency while reducing its environmental impact. The average emission intensity for the Indian Pulp and Paper industry is 1.58 MTCO2e/MT of paper while the per capita consumption of paper in India (15.75 kg) is significantly low compared to global per capita paper consumption (57 kg) . As paper production is projected to increase, significant efforts must be made to reduce the emission intensity of production. This paper delves into cutting-edge advancements within the sector, examining key technologies that can play a vital role to reduce energy consumption and carbon emissions. This research aims to shed light on how the use of latest developments in Paper machine, Cogeneration systems, Effluent treatment plants, and integration of renewable sources of energy is altering the ecological footprint of the business. All these technologies are technically feasible and viable and have a high replication potential.

1. High Nip Press

Mechanical pressing is a critical stage in the papermaking process, employed to remove water from the paper sheet after the forming and wet pressing stages. The quality and characteristics of the finished product are greatly influenced by this phase. Mechanical pressing serves two primary purposes: dewatering and consolidating the paper web. Effective dewatering ensures the removal of excess water, facilitating subsequent stages in the papermaking process. Consolidation involves improving the paper's density and

Figure 1 High Nip Press

surface smoothness. Traditionally solid press rolls with rubber coating were used for mechanical dewatering of water before the thermal drying process in the dryers. There is a limitation on the size of the press rolls being used due to lack of reliable suppliers and the stress that can be taken by the rubber coating.

TABLE 1 COMPARISON BETWEEN SPC AND SSC BEFORE AND AFTER IMPLEMENTATION

S.no.	Description	Before	After
1	Specific Power Consumption, kWh/T	360	330
2	Specific Steam Consumption, T/T	1.55	1.4

In one of the units, after making an effort to locate and select the appropriate suppliers, the company was able to import 1650 mm press rolls which were installed along with Polyurethane (PU) coating. The unit observed a reduction in moisture in paper after Press rolls from 49 to 44%, as a result of which the unit was able to increase the speed of the machine from 360 to 390 mpm, leading to a reduction in specific steam consumption and specific power consumption. The investment for the entire project was INR 3.5 Cr while the Simple Payback Period incurred was just 11 months. The total GHG emission reduction potential in the sector for this technology is 10.29%.

2. Turbo Vacuum blower

Vacuum dewatering in the wire part of paper machines is a fundamental process integral to the papermaking industry. Vacuum dewatering in the wire part of paper machines is a fundamental process integral to the papermaking industry. Vacuum dewatering involves the application of negative pressure to remove water from the paper stock as it traverses the wire part. Achieving the best possible paper quality, including strength, forming, and surface qualities, requires effective vacuum dewatering.

Figure 3: Liquid ring vacuum pump

Figure 3 Turbo vacuum blower

Traditionally Liquid ring Vacuum Pumps have been in use for this purpose. Liquid ring vacuum pumps are rendered inefficient depending on the temperature of sealing water which in turn depends on the ambient temperature.

In a paper mill during the process of upgradation of capacity of the unit, Turbo vacuum Blowers were installed for dewatering in the wire part and felt part conditioning. In, Turbo vacuum Blowers, no sealing water is used so capacity derating is avoided, in addition to which they are driven by Variable Frequency Drives (VFD) which regulate the rpm and hence the vacuum levels supplied by the equipment based on the requirement set by the operator and hence work in a more optimized manner.

TABLE 2 COMPARISON BETWEEN LIQUID RING VACUUM PUMP AND TURBO VACUUM BLOWER COMBINATION

Equipment name	Installed Capacity, kW	Liquid ring vacuum pump combination, kW	Turbo Blower combination, kW
Turbo Vacuum Blower	550		248
Liquid Ring Vacuum Pump	340	136	127
Liquid Ring Vacuum Pump	250	137	
Liquid Ring Vacuum Pump	250	136	114
Liquid Ring Vacuum Pump	180	131	
Centrifugal Blower	55	23	23
Centrifugal Blower	22	7.1	7.1
Centrifugal Blower	18.5	11.8	11.8
Total		**581.9**	**530.9**

The reduction in power consumption of vacuum system was from 582 to 531 kWh, while the reduction in specific power consumption of the vacuum system was from 1.94 kWh/Ton of paper for Liquid ring vacuum pumps to 1.77 kWh/Ton of paper for Turbo vacuum blower and with increase in vacuum intensity even the specific steam consumption was observed to have reduced from 2.1 to 2.0 Tonnes/ Tonne of Paper. The investment made for this installation was INR 400 Lakhs while a monetary benefit of INR 226 Lakhs/annum was achieved by the plant resulting in a Simple Payback Period of 22 months. The total GHG emission reduction potential in the sector for this technology is 2.42%.

3. Regenerative Braking Motor

In the Rewinder section of a Paper machine, the large parent rolls of paper are sliced into smaller rolls or sheets, so they are more suitable for distribution and further processing. After being unwound from the parent roll, the paper is cut to the necessary width, then rewound onto smaller cores. In this process, the tension and speed of the paper being rewound are controlled by a braking mechanism. Conventional braking mechanisms of traditional rewinding systems lose energy as heat generated due to friction, resulting in inefficiencies and increased energy consumption. Thus, there is an opportunity to harness this loss in energy by using a Regenerative braking motor.

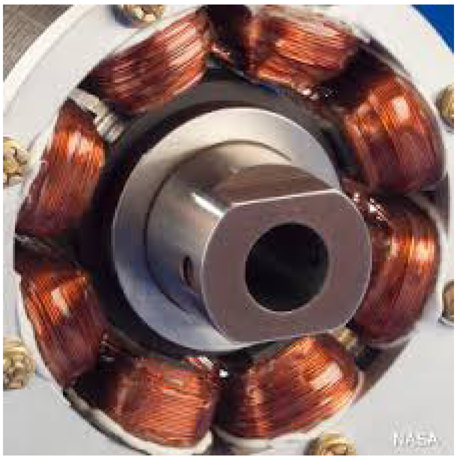

Figure 4: Motor Winding

In a paper manufacturing unit, while an old paper machine was being transferred from another unit, during installation stage itself a Regenerative Braking motor was installed in the unwinder roll of the Rewinder section. The front drum and rear drum motors were consuming close to 130 kWh of electrical energy. The Unwinder regenerative braking motor was generating close to 110 kW of power and supplying to the PCC panel leading to significant power savings. In addition to this, even the replication potential for this installation is very high. The energy saving potential of this technology is estimated to be 1-1.5% of the entire plants energy consumption. The total GHG emission reduction potential in the sector for this technology is 0.45%.

4. Microturbine

For a Paper machine dryer, steam is conventionally supplied at 3.5-4.0 ksc pressure for drying the paper. This steam is generated from a Boiler at 8 ksc or higher pressure. The pressure and temperature of steam generated in the boiler is reduced in a Pressure Reducing and Desuperheating Station (PRDS). This process of reducing the pressure and temperature of steam results in a drop in Enthalpy of steam leading to losses in energy and becomes an opportunity loss for generation of power. This loss in heat energy can be converted to electric power by installing a Microturbine.

Figure 5: Microturbine

A microturbine is a comparatively small capacity back pressure turbine which is to be installed in the bypass line of the existing PRDS system. The steam which was passing through the PRDS system previously will now pass through the Microturbine for reduction of pressure and temperature and exit the Microturbine at the pressure required by the paper drying process, during which time the Microturbine will be generating electrical power. The size of a Microturbine can range from 20 kW to 5500 kW. These types of Turbines are available for both Superheated and Saturated steam. In one of the Paper mills, it was found that the estimated potential for power generation was as high as 220 kWh with an investment of INR 200 lakhs and a payback period of 30 months. The total GHG emission reduction potential in the sector for this technology is 5.13%.

5. Turbo Oxy Jet Aerators

An essential component of wastewater treatment in paper mills is aeration, which helps to effectively remove organic contaminants. For Effluent Treatment Plants (ETP) to operate sustainably and effectively, energy-efficient procedures, process parameter optimization, and appropriate aeration system selection are essential. Conventionally, ETPs were equipped with Floating aerators and Diffused aeration system which have limited capability up to certain depth or limited membrane life.

Figure 6: Turbo Oxy Jet Aerators

With superior mixing, the sophisticated, high-efficiency Oxy Jet Aerators/Mixers significantly boost oxygen transfer efficiency. A high-efficiency regenerative blower is used to pressurize and drive air down the hollow shaft. After that, the air is forced downward by the big mixing propeller and sheered into tiny bubbles. In waste-water systems, it combines better mixing with a higher fine bubble oxygen dispersion to optimize and regulate biological nutrient removal.

Oxy Jet Aerators cum Mixers can improve the mixing thereby increasing the oxygen transfer capacity. Electrical power can be saved while maintaining the dissolved oxygen content by running all or some of the system's units in mixing only mode during off-peak loading. As per the project details in one of the units the total investment for the project was INR 77.6 lakhs while a saving of INR 21 lakhs/year was achieved for a payback period of 40 months. The total GHG emission reduction potential in the sector for this technology is 0.002%.

6. White Liquor Heater

A critical process in the making of pulp is cooking, which involves subjecting raw materials like wood chips to a chemical process that breaks down lignin and extracts fibres making these fibres accessible for subsequent processing. For this purpose, White Liquor is used, at around 140-170 °C. To raise the temperature of this process steam is used directly resulting dilution of cooking liquor due to direct contact with steam condensate and also a higher heating and cooking time, also there is no condensate recovery from the process as it is a direct heating process.

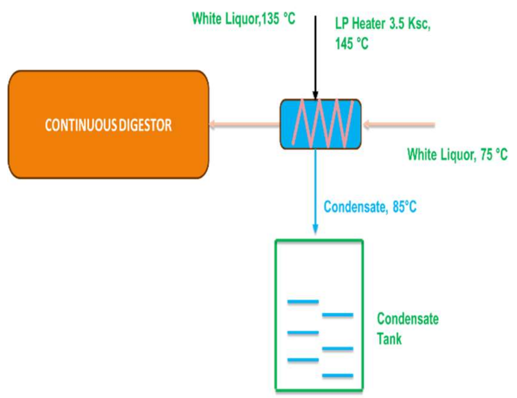

Figure 7: White Liquor heater configuration

To overcome the above disadvantages, some Paper mills have installed an indirect shell and tube type heat exchanger. The purpose of this heat exchanger is to heat the White Liquor to required temperature, by using steam, before the white liquor enters the Digestor. Being a shell and tube heat exchanger, the heating is indirect and hence issues of dilution of liquor and higher cooking time are addressed, at the same time being an indirect heating process condensate is also recovered which can be pumped back to the Boiler resulting in improved condensate recovery and saving in steam used for deaeration in the Deaerator. In one of the units the potential for saving was around INR 64 lakhs while the estimated investment was of INR 90 lakhs resulting in a Simple Payback Period of 19 months. The total GHG emission reduction potential in the sector for this technology is 1.78%.

Figure 8: Paddy Husk

7. Use of Biofuel in Coal Boiler

Most of the energy in a paper mill is consumed in the form of thermal energy i.e. steam. This steam is used in process like cooking, drying, generation of electricity in captive power plants, etc. For generation of this steam there are mills which are still dependent on Coal as a fuel, rendering high GHG emissions. Some of the mills that have access to agro based fuels have started using these fuels to substitute for some amount of fossil fuel in their boilers.

Paper mills have started moving towards greener more sustainable sources of energy. Replacing the existing completely may not be financially viable for most of the units so they have started blending renewable biomass-based fuels with the existing fossil fuels. However, some modifications need to be done in the fuel firing system for successfully implementing this. As per data shared by one paper mill was able to substantial quantity of their coal consumption with Chipper dust, Paddy Husk, saw dust, etc. which resulted in Coal savings of 27650 Tonnes Per annum, an increase in green energy by 7.46% and an annualized cost savings of INR 1123 lakhs. The total GHG emission reduction potential in the sector for this technology is 1.4%.

Decarbonization roadmap

As per the studies, the estimated emission from the Paper sector in India is 30.5 million MT CO2 equivalent per year. Appropriate implementation of the above-mentioned technologies can reduce the GHG emission in the Paper sector by around 12-18%. This would bring down the emission from the sector by 3-6 million MT of CO2 equivalent per year. Thus, a timely implementation of the latest technological developments mentioned in the paper can go a long way in contributing to GHG emissions reduction in the India Pulp and Paper sector.