ENERGY CONSERVATION IN PAPER SECTOR – A STEP TOWARDS DECARBONISATION

By

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Indian Paper Industry – A Snap Shot

- The Indian paper industry is the fourth largest among global producer with production of 23.46 million tons in 2022-23.

- There are 538 operating units of pulp and paper with operating installed capacity of 25.65 million tons, having yearly output of 23.46 million tons.

- The sector provides direct employment to more than 0.33 million people in the country's rural areas. Further, nearly 2 million persons find indirect employment with the sector.

- Indian paper industry is highly fragmented in terms of per day ton paper manufacturing capacity and it is started from 5 TPD and moved upto 1650 TPD

Indian Paper Industry – Key Statistics

Total No. of paper mills	~912
Operating Mills • Wood based -18 • Agro based - 21 • Recycle fiber (RCF) based – 499	~538
Total Installed capacity, million tons	29.11
Operational Installed Capacity, million tons	25.65
Idle Capacity, million tons	5.51
Import (in million tons)	2.51
Export (in million tons)	2.16
Per capita consumption, kg	15.75
Global Share	5.57%

Energy consumption scenario

Type of raw material	Total Production in ton/year	Average Mkcal/ton of paper	Total Energy consumption in Mkcal	Equivalent Coal consumption in tons	Average equivalent coal consumption per ton of paper
Wood based	3385147	10.77	36458033	13138030	3.88
Agro based	1630020	9.698	15807939	5696555	3.49
Recycled paper based (W/P)	2230362	4.153	9262693	3337908	1.50
Recycled paper based (Packaging)	14227787	2.263	32197482	11602696	0.82

Paper Industry Clusters

Paper industry in India is driven by water and raw material availability and therefore many micro and small scale industries are found in clusters. There are 21 clusters in India.

S. No.	Name of the cluster	No of mills in clusters	S. No.	Name of the cluster	No of mills in clusters
1	Bangalore	4	12	Morbi	20
2	Chennai	5	13	Valsad	4
3	Coimbatore	4	14	Vapi	34
4	Erode	6	15	Amritsar	5
5	Godavari	17	16	Ludhiana	11
6	Mysore	5	17	Patiala	7
7	Pondhicherry	3	18	Meerut	13
8	Rajamundry	4	19	Moradabad	2
9	Shiva Kashi	4	20	Muzaffarnagar	30
10	Tirunelveli	5	21	Kashipur	27
11	Mehsana	6			

Major Issues & Challenges of Indian Pulp and Paper Sector

Despite a positive demand outlook, there are several barriers to the growth of the paper Industry. Some of these are :–

- **Raw material constraints**
- **High cost of basic inputs (raw material, energy, water, chemicals)**
- **Low economies of scale**
- **Technological obsolesce and cost of implementing new technologies**
- **Wastepaper collection/recovery mechanism**
- **Stricter emission norms**
- **Lack of Skilled manpower**

Decarbonization in Pulp & Paper Industry

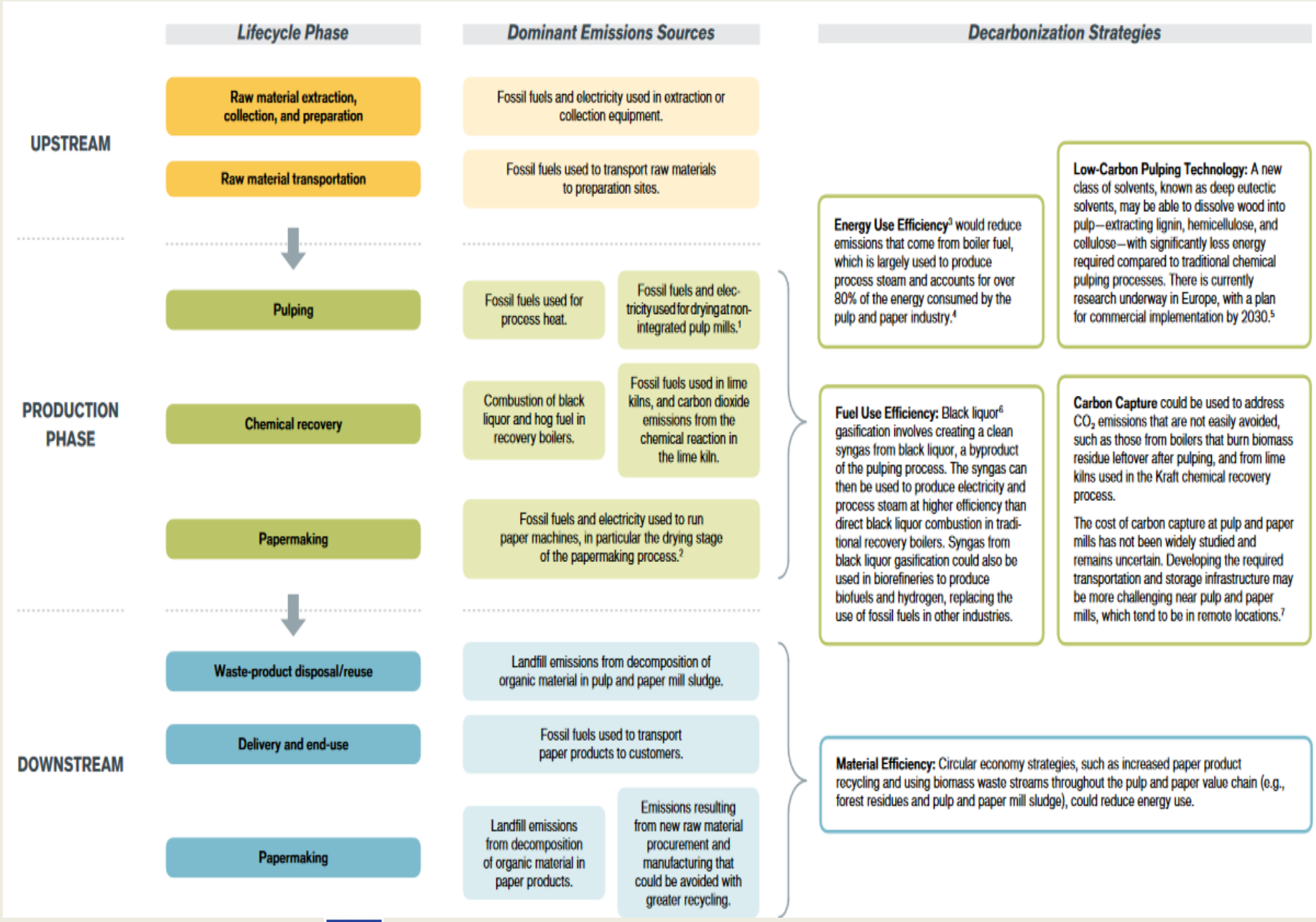
Greenhouse gas (GHG) emissions takes place throughout the life cycle of any product. In Pulp and paper sector major emissions takes place during the manufacturing process. Potential emission areas are:

1. Raw material transportation
2. Transportation of chemicals for process
3. Pulp production
4. Paper production
5. Transportation of final products
6. Effluent treatment - as water usage is extensive
7. Landfills
8. Power/Steam production

Areas of potential emissions can be well managed by various technologies or management measures. Thus, decarbonization of pulp and paper sector is viable and can be achieved if managed effectively.

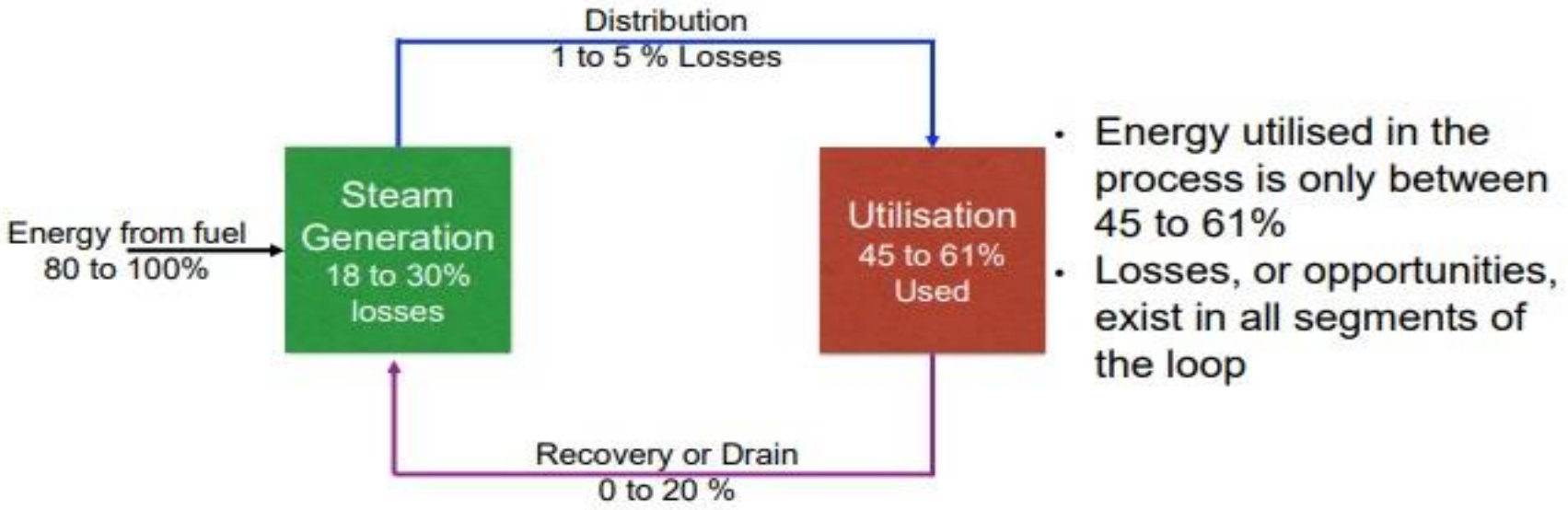
Future Projection of CO_2 Emission Upto 2029-30

S. No.	Type of raw material	Total Production in ton/year (2018-19)	Total Production in ton/year (2029-30)	Average Mkcal/ ton of paper	Total Energy consumption in Mkcal (year 2029-30)	Equivalent Coal consumption in ton (year 2029-30)	Total CO_2 emission by the sector in year 2029-30
1	Wood based	3385147	4126475	10.77	44442139	16015185	22901715
2	Agro based	1630020	1800557	9.698	17461799	6292540	8998332
3	Waste paper based (W/P)	2230362	2997420	4.153	12448285	4485869	6414792
4	Waste paper based (Packaging)	14227787	21060600	2.263	47660139	17174825	24559999
	Total	**21473316**	**29985052**		**122012362**	**43968419**	**62874839**


Lifecycle Phase
Dominant Emissions Sources
Decarbonization Strategies
UPSTREAM
Raw material extraction, collection, and preparation
Fossil fuels and electricity used in extraction or collection equipment.
Raw material transportation
Fossil fuels used to transport raw materials to preparation sites.
PRODUCTION PHASE
Pulping
Fossil fuels used for process heat.
Fossil fuels and electricity used for drying at non-integrated pulp mills.[1]
Chemical recovery
Combustion of black liquor and hog fuel in recovery boilers.
Fossil fuels used in lime kilns, and carbon dioxide emissions from the chemical reaction in the lime kiln.
Papermaking
Fossil fuels and electricity used to run paper machines, in particular the drying stage of the papermaking process.[2]
DOWNSTREAM
Waste-product disposal/reuse
Landfill emissions from decomposition of organic material in pulp and paper mill sludge.
Delivery and end-use
Fossil fuels used to transport paper products to customers.
Papermaking
Landfill emissions from decomposition of organic material in paper products.
Emissions resulting from new raw material procurement and manufacturing that could be avoided with greater recycling.
Energy Use Efficiency[3] would reduce emissions that come from boiler fuel, which is largely used to produce process steam and accounts for over 80% of the energy consumed by the pulp and paper industry.[4]
Low-Carbon Pulping Technology: A new class of solvents, known as deep eutectic solvents, may be able to dissolve wood into pulp—extracting lignin, hemicellulose, and cellulose—with significantly less energy required compared to traditional chemical pulping processes. There is currently research underway in Europe, with a plan for commercial implementation by 2030.[5]
Fuel Use Efficiency: Black liquor[6] gasification involves creating a clean syngas from black liquor, a byproduct of the pulping process. The syngas can then be used to produce electricity and process steam at higher efficiency than direct black liquor combustion in traditional recovery boilers. Syngas from black liquor gasification could also be used in biorefineries to produce biofuels and hydrogen, replacing the use of fossil fuels in other industries.
Carbon Capture could be used to address CO_2 emissions that are not easily avoided, such as those from boilers that burn biomass residue leftover after pulping, and from lime kilns used in the Kraft chemical recovery process.
The cost of carbon capture at pulp and paper mills has not been widely studied and remains uncertain. Developing the required transportation and storage infrastructure may be more challenging near pulp and paper mills, which tend to be in remote locations.[7]
Material Efficiency: Circular economy strategies, such as increased paper product recycling and using biomass waste streams throughout the pulp and paper value chain (e.g., forest residues and pulp and paper mill sludge), could reduce energy use.

Energy Savings Measures in Paper Industry

The Steam Loop



- Energy utilised in the process is only between 45 to 61%
- Losses, or opportunities, exist in all segments of the loop

Comparing the two examples

Parameter	Average Mill	Good Mill
Steam Consumption on the Machine	168 TPD	138 TPD
Steam Consumption in the Starch Cooker	12 TPD	10 TPD
Condensate Recovery	133 TPD @ 70 to 80 deg C	133 TPD @ 100 deg C
Flash Recovery	0 TPD	5 TPD
Feed Water Temperature	73 deg C	100 deg C
Steam to be Generated from the boiler	192 TPD	153 TPD
Make up water requirement	60 TPD, 31%	15 TPD, 10%
Blowdown in Boiler	2 TPD	1 TPD
Distribution Losses	11 TPD	4 TPD
Fuel Consumption	**36 TPD**	**25 TPD**

Opportunities for Optimisation

- Generation
  - Boiler Efficiency
  - Blow down optimisation
  - Feed water tank - Level, deaeration
- Distribution
  - Main line trapping
  - Location and operation of the main pressure reducing station
  - Steam metering
  - Valve Leakages on the distribution header
- Utilisation
  - Steam leakages from dryer isolation valves
  - Steam leakages from rotary joints
  - Reducing differential between steam and dryer surface temperature
  - Effective trapping or blow through system
  - Pressure control for groups
  - Temperature control for starch cookers
- Recovery
  - Recovering condensate at high temperature
  - Final flash steam recovery
- Others
  - Stock Flow Metering

Checklist for Energy Savings potential in Steam System

- **Fix steam leaks and condensate leaks**.
  - ✓ A 3 mm diameter hole on a pipe line carrying 7 kg/cm2 steam would waste 33 kilo litres of fuel oil per year.

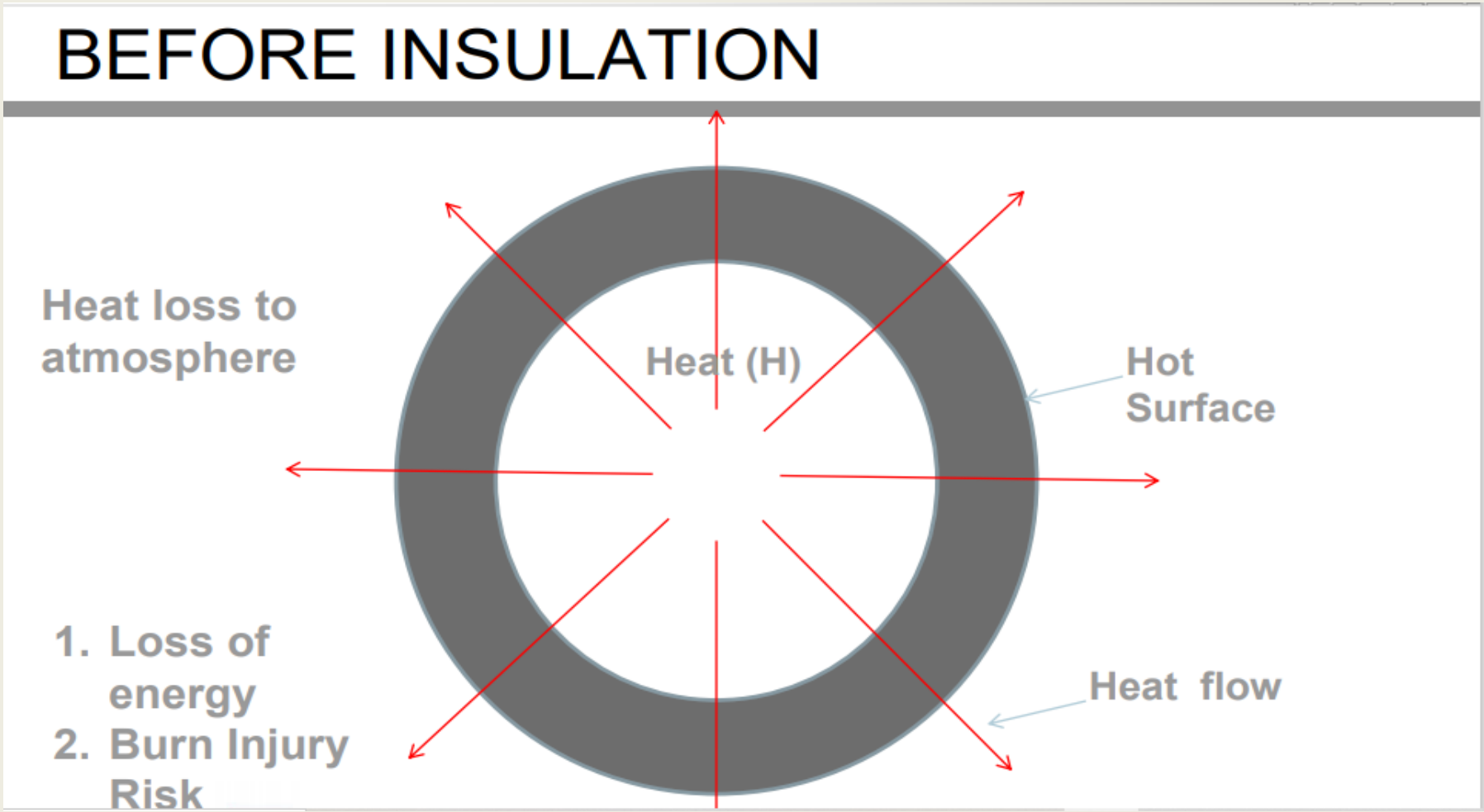
- **Ensure condensate is returned or reused in the process.**

- **Remove air from indirect steam**.
  - ✓ 0.25 mm thick air film offers the same resistance to heat transfer as a 330 mm thick copper wall.

- **Inspect steam traps regularly and repair malfunctioning traps promptly.**

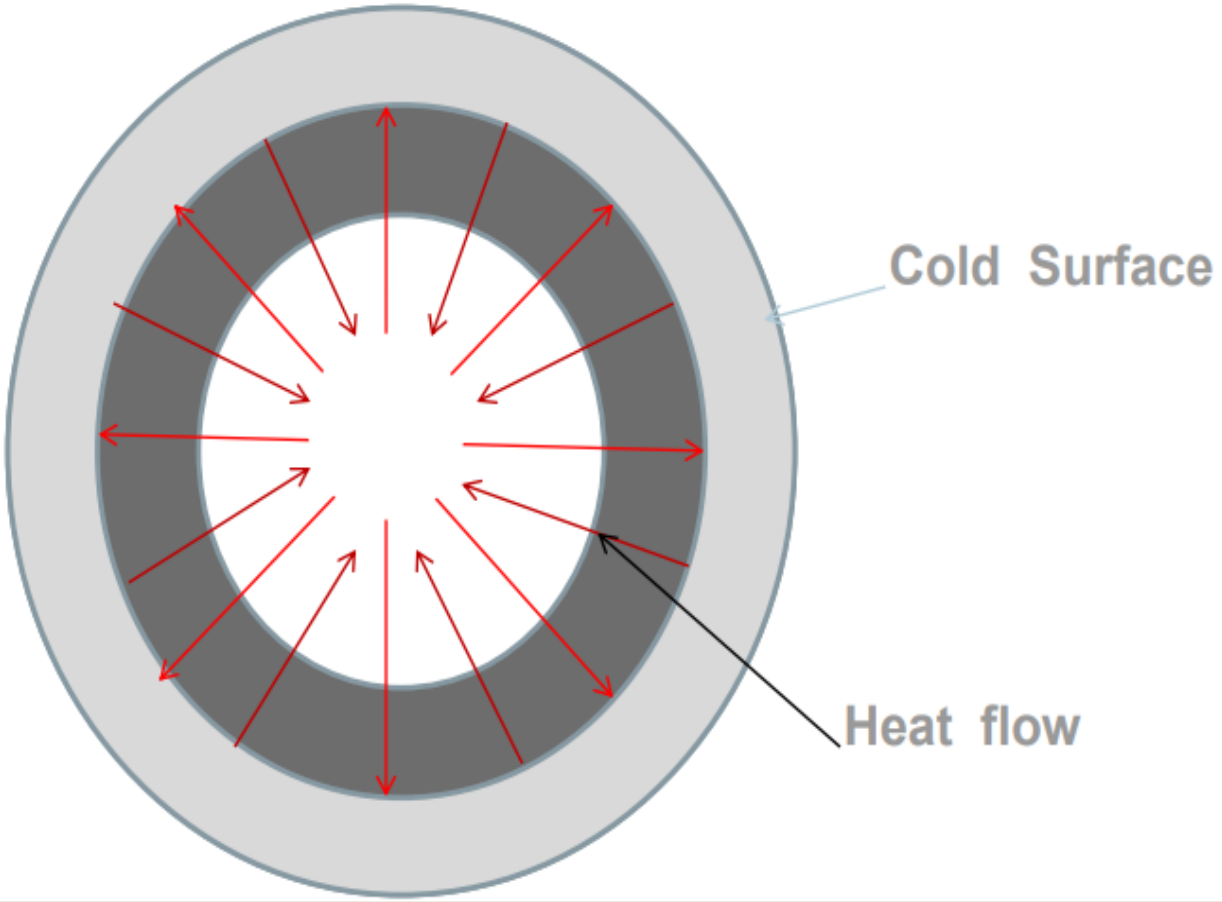
- **Maintain lowest acceptable process steam pressures.**

Energy Savings potential with Insulation



AFTER INSULATION

Heat loss prevention due to insulation



1. Cost Saving
2. Improved Safety

Common scene in industry

Checklist for Energy Savings potential in Insulation

- **Repair damaged insulation**
  - ✓ A bare steam pipe of 150 mm diameter and 100 m length, carrying saturated steam at 8 kg/cm2 would waste 25,000 liters Furnace Oil in a year.
- **Insulate any hot or cold metal or insulation**.
- **Replace wet insulation**.
- **Use an infrared temperature gun to check for cold wall areas during cold weather or hot wall areas during hot weather.**
- **Ensure that all insulated surfaces are cladded with aluminium**.
- **Insulate all flanges, valves and couplings**.
- **Insulate Open Tanks**.
  - ✓ 70% heat losses can be reduced by floating a layer of 45 mm diameter polypropylene (plastic) balls on the surface of 90 degree Celsius hot liquid condensate.

Energy Savings potential in Paper Machine Section

The drying process

Challenges and solutions in the drying process

Challenges:

- Rotating at 50-60 rpm
- Normally industries insulate with glass/mineral wool
- Water resistance very low
- Insulation peel off within 2-3 month
- Promote corrosion

Solution:

- Resin bounded mineral wool slabs
- Water vapor resistance factor: 1
- Chemically neutral, neither cause nor promote corrosion

Economic savings and payback time

Drying Drums, Nos 38, Ø1.5m,
No 1, Ø 4.5m

Total not insulated area: **128m²**
Temperature: **105°C**

What is the impact if this drums were insulated up to the latest standards:

Investment:	Rs. 420,000
Cost Savings:	Rs. 855,000/ Year
Payback time:	**6 Month**

Energy Savings potential in Paper Machine Hood

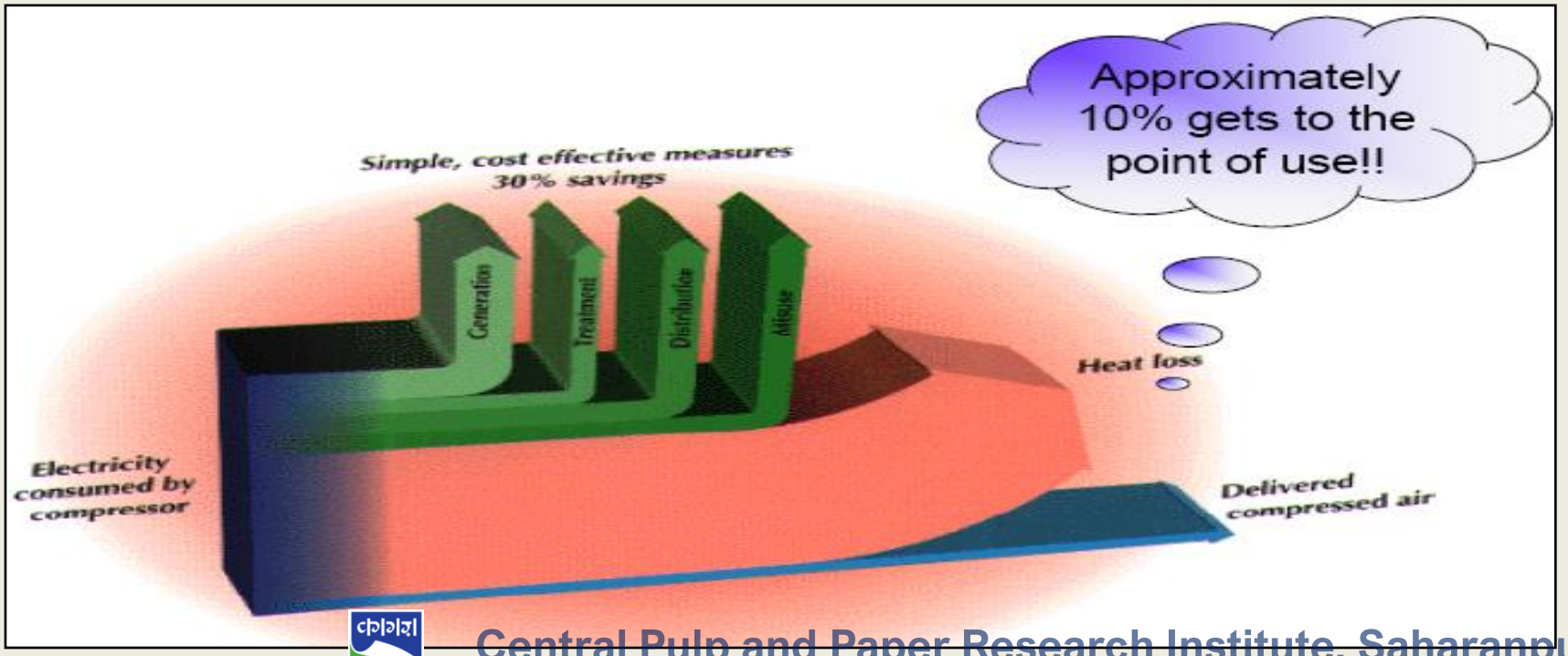
- The water evaporated during paper drying is captured and removed from the dryer by a hood air system.
- There are three types of paper machine hoods: open, semi-open, and closed. Open hoods are rarely in use
- A closed hood uses only one-third as much air as an open hood to remove the same amount of moisture.
- An estimated 15-20 percent reduction in steam can be achieved by replacing a semi-open hood with a closed hood.
- This, in turn, means a savings of about 40-50 percent of the electricity used by air-circulation fans. A closed hood reduces heat losses and allows recovery of more waste heat than is possible with a semi-open hood.

Energy Savings potential in Compressed Air System

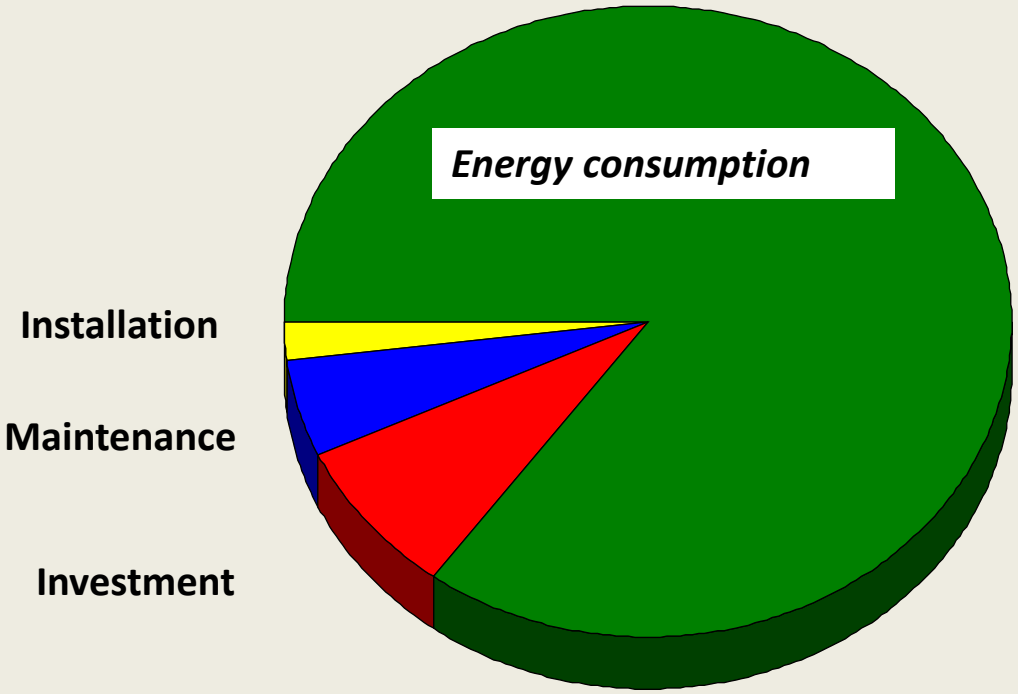
Compressed air is one of the most expensive utilities in industries. Cost of energy of the compressed air is at least 5 times that of electricity.

Significant Inefficiencies

- Compressors: 5 to > 50,000 hp
- 70 – 90% of compressed air is lost



Life Cycle Cost of an Air Compressor



- Energy cost can account for up to 90% over a ten year working life.
- Within 12 months, the capital cost is usually exceeded by the running costs.
- First cost represents the lowest of the three costs.
- Energy consumption by far is the most significant factor in operating cost of an air compressor.

Checklist for Energy Savings potential in Compressor & Compressed Air System

- **Location**

✓Significant influence on energy use

- **Elevation**

✓Higher altitude = lower volumetric efficiency

- **Air Intake**

✓Keep intake air free from contaminants, dust or moist

✓Keep intake air temperature low

✓Every 5 degree C rise in inlet air temperature = 1% higher energy consumption

- **Pressure Drops in Air Filter**

✓Install filter in cool location or draw air from cool location

✓Keep pressure drop across intake air filter to a minimum.

✓Every 250 mm WC pressure drop = 2% higher energy consumption

Checklist for Energy Savings potential in Compressor & Compressed Air System

- **Use Inter and After Coolers**

✓Inlet air temperature rises at each stage of multi-stage machine

✓Inter coolers: heat exchangers that remove heat between stages

✓After coolers: reduce air temperature after final stage.

- **Pressure Settings**

✓Reducing delivery pressure

✓Operating a compressor at 120 PSIG instead of 100 PSIG: 10% less energy and reduced leakage rate

- **Compressor controls**

✓Automatically turns off compressor when not needed

- Consider variable speed drive for variable load on positive displacement compressors.

Checklist for Energy Savings potential in Compressor & Compressed Air System

- Install a control system to coordinate multiple air compressors.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple air compressors.
- Reduce Air compressor discharge pressure to the lowest acceptable setting.
  - ✓ Reduction of 1 kg/cm^2 air pressure would result in 9% input power savings. This will also reduce compressed air leakage rates by 10%.
- Use the highest reasonable dryer dew point settings.
- Minimize purges, leaks, excessive pressure drops, and condensation accumulation. (Compressed air leak from 1 mm hole size at 7 kg/cm^2 pressure would mean power loss equivalent to 0.5 kW)

Checklist for Energy Savings potential in Compressor & Compressed Air System

- Reduce Compressed Air Usage.
  - ✓ Eliminate inappropriate air users
  - ✓ Use brushes, blowers, or vacuum systems instead of compressed air to clean parts or remove debris
  - ✓ Use blowers, electric actuators, or hydraulics instead of compressed air blasts to move parts
  - ✓ Use high efficiency nozzles instead of open orifices

Energy Savings Potential in Motors

Replacement of rewinded and old inefficient motors with Energy Efficient Motors

- In small and medium industries use of old in efficient motors and rewinding is a general practice.

✓ If rewinding is not done properly, the efficiency can be reduced by 5-8%

- High savings can be achieved by replacing old or rewinded motors with New energy efficient motors which runs on a efficiency of more than 90% with following added advantages:
  - Improvement in Power factor
  - Efficiency is high even at low loads.
  - Lower Noise Level
  - Low life cycle cost

Energy Savings potential in Lighting

Replacement of inefficient ligtings with LED Lights

- Lighting is often overlooked at industrial facilities, though it often uses 15-25 percent of the overall energy budget.
- Small and Medium industries are still using old inefficient lighting fixtures which can be replaced by Energy Efficient LED lights.
- 20-30% savings can be achieved by replacing old lights with new efficient lights.

Conclusion

As paper production is projected to increase, significant efforts must be made to reduce the emissions intensity of production. This can be accomplished primarily by moving away from fossil fuels as an energy source and encouraging innovation in technologies that reduce the amount of heat needed for pulp and paper drying.

The pulp and paper sector will need to be highly energy efficient and innovative in a future that is shaped by ambitious climate and energy policies. Decarbonisation cannot be achieved by a single measure alone but can be achieved through the combination of one or more measures that have the potential for emission reduction.

THANK YOU

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