Pulp and Paper Mill Energy Guidebook

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DR1

Energy Reduction Opportunities

We have never been in a mill where there were not significant energy reduction opportunities.

- **Typically 25 to 50% of energy reduction opportunities identified can be implemented without capital expenditures.**
- **Guidelines showing energy reduction opportunities that do not require capital are shown in later slides.**
- **Mills that do not implement energy reduction projects with less than one year payback will likely not survive long term.**
- **Wisconsin Focus on Energy and other state and utility programs offer incentives to encourage energy reduction.**
- Database of State Incentives for Renewables & Efficiency® - DSIRE (dsireusa.org)
- **Focus on Energy is developing a pulp and paper mill energy reduction guidebook. Some examples of energy best practices are shown in later slides.**

Slide 2

DR1 Dick Reese, 11/19/2020

Paper Mill Best Practice Categories

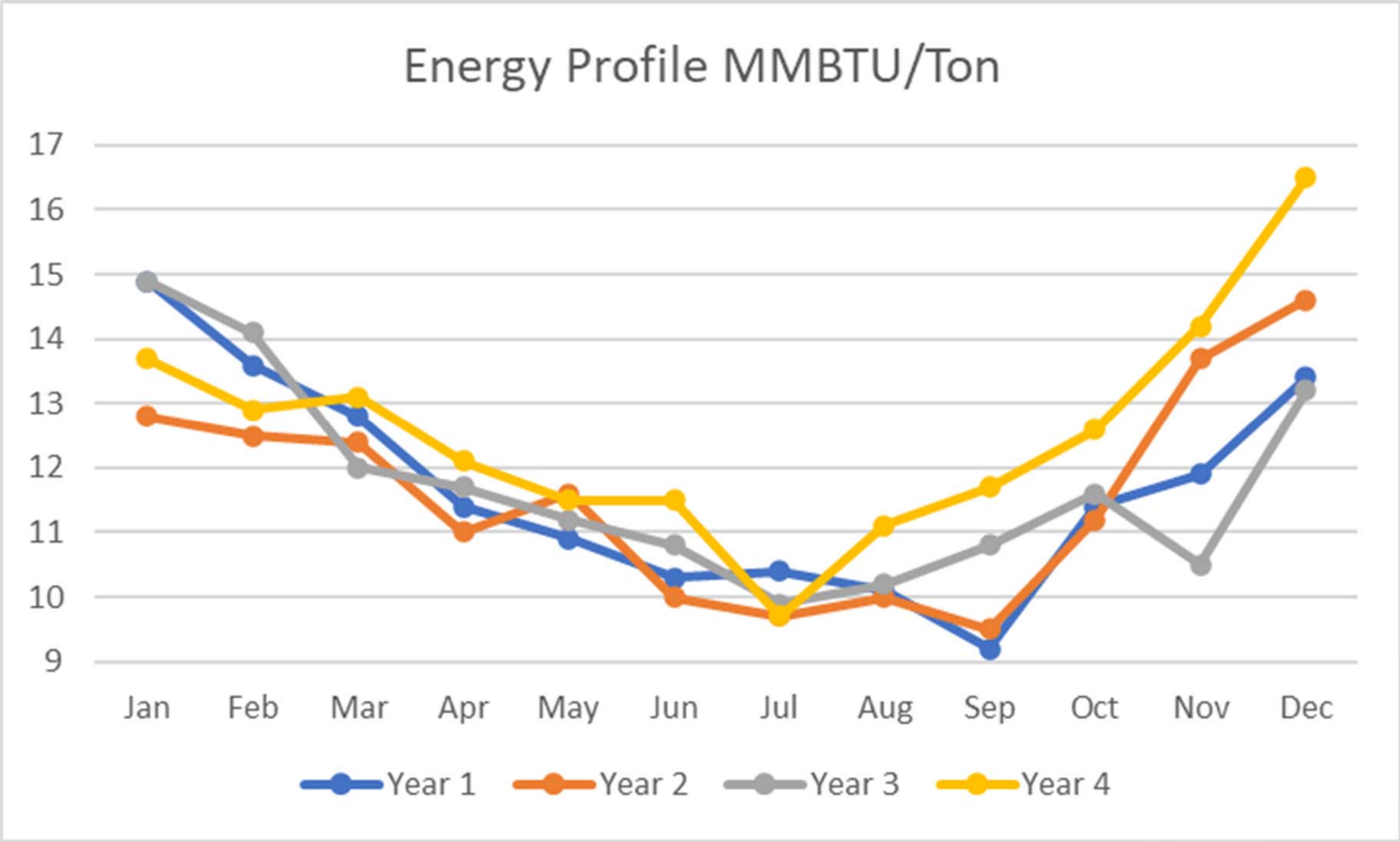
- Centerlining
- Compressed Air
- Doctoring
- Dryer Steam and Condensate
- Energy Monitoring and Display
- Low-No Cost
- Maintenance
- Operations
- Pulping and Broke Processing
- Pumping
- Refining
- Showering
- Steam Systems
- Vacuum Systems
- Ventilation
- Water Conservation

Pulp Mill Best Practice Categories

- Bleach Plant
- Blow Heat Recovery
- Brown Stock
- Caustic
- Evaporator
- Heat Exchangers
- Hot Water
- Low-No Cost
- Pulping

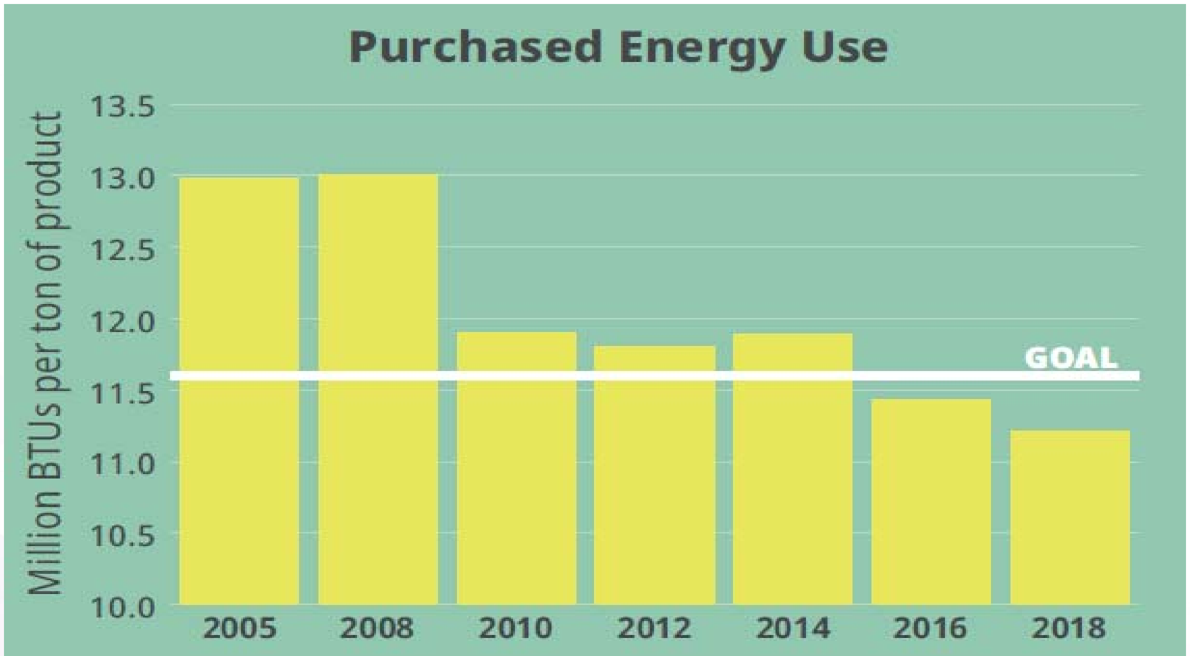
Pulp and Paper Mill Energy

- Pulp and paper manufacturing is energy intensive and the second most energy-intensive industry group in the manufacturing sector.
- The industry has made large strides in reducing total energy. Several mills and companies have achieved significant improvement.
- Energy cost represents 10 to 40 percent of total manufacturing cost (average~18%) and is an important factor in profitable operation.
- If operation and management personnel become familiar with how their facility uses energy and is billed for it, they can find ways to manage and reduce energy costs.
- The average mill can reduce energy consumption by 20 percent.
- Interactions between departments must be considered-pulp mill, paper mill, water systems, steam generation, etc.



Energy Profile MMBTU/Ton
17
16
15
14
13
12
11
10
9
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Year 1
Year 2
Year 3
Year 4

AF&PA Purchased Energy Use (-13.3%)



2005 Baseline:

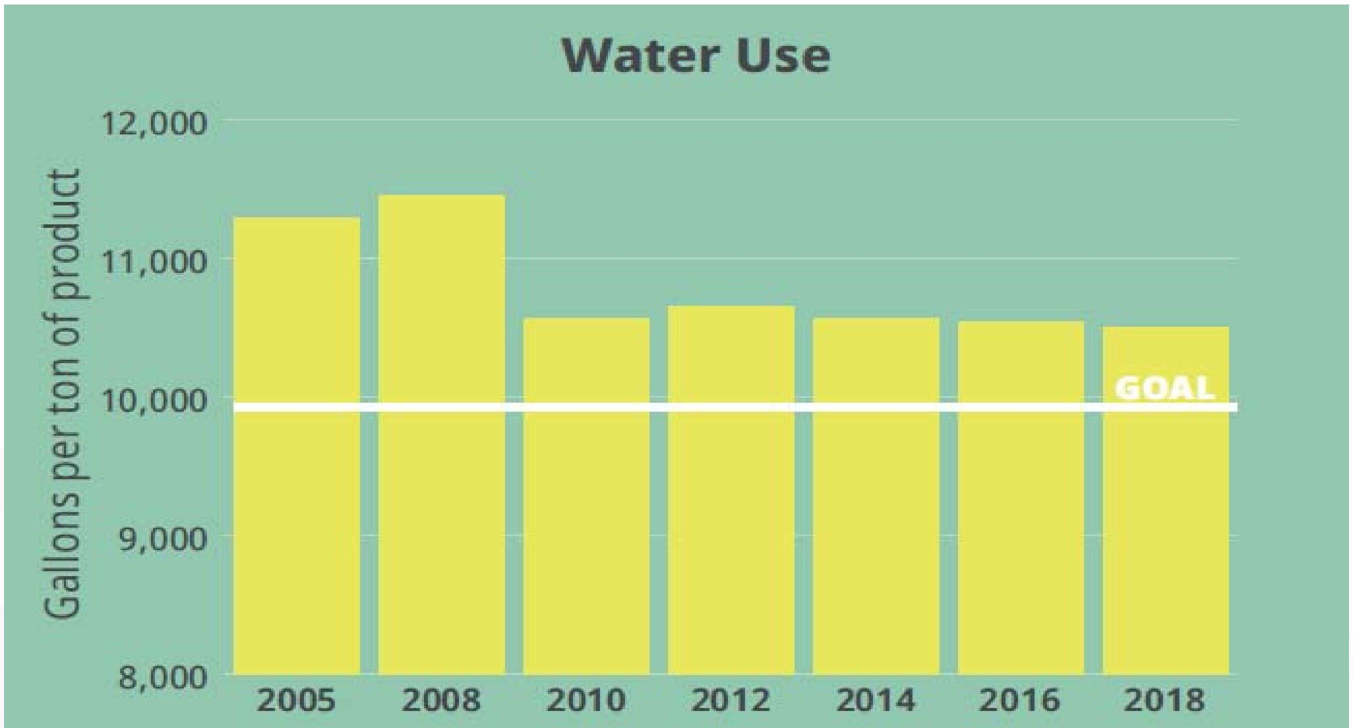
12.94 *million BTUs per ton of product*

2018 Performance:

11.21 *million BTUs per ton of product*

AF&PA Percent Recycling

AF&PA Water Use Goal-12% Reduction 2005 to 2020 (Actual 6.9%)



2005 Baseline:
11,281 *gallons per ton of product*

2018 Performance:
10,503 *gallons per ton of product*

Paper Machine Water Best Practices

Title	Water Best Practices
Overview Comments	•Use warm water from pulp mill
	•Increase use of clarified whitewater
	•Reduce use of seal water on pumps, agitators, refiners, etc.
	•Shut off seal water when equipment is down
	•Reuse vacuum pump seal water or install blowers
	•Minimize mill water make-up to stock and whitewater systems
	•Maximize entering stock temperatures
	•Use single nozzle traversing showers and smaller diameter nozzles
	•Keep cool water out of warm and hot water systems
	•Recover heat from paper mill effluent or hood exhaust
	•Modern saveall in good operating condition
	•Use filtered white water for all showers where possible
	•Eliminate once-through vacuum pump seal water with cascade or recirculation system
	-Use warm water for pump, agitator and refiner seals if available from a waste heat source
See Also	TAPPI TIP 0404-63-paper machine energy conservation
Primary Area/Process	Paper machine wet end
Economic Benefit	Reduced steam use. Lower water treatment cost.
Energy Savings	Steam savings can be significant but varies by application.
Other Benefits	Focus on Energy offers incentives where water reduction reduces steam use for heating water.
Stages of Acceptance	Medium

Water Conservation: Measuring and Modeling Wet End Water Balance

Best Practice	Establish a wet end water balance. Measure flows and temperatures using a non-contact flow meter.
Process	Measure flow and temperature input to the hot/warm reclaim tank. Identify the water sources. Measure flow and temperatures of all consumers of the hot/warm reclaim water Identify locations, flow and temperature of any fresh water tank overflow or discharge to sewer. Identify sources and flow quantity of fresh water heating Identify sources and quantify of process water heating. Identify any flow of fresh water make up. Address excess venting into heat recovery systems Balance heating requirement of tempered water consumers
Productivity Impact	N/A.
Economic Benefit	Payback is very good when the thermal heating value of reclaimed water is considered. The water/heating balance will assist to connect the best steps.
Energy Savings	Thermal savings for water reuse or displacement in the wet end is about $1000 year per gpm.
Water Savings	The wet end water balance helps identify the best places for water system changes.

Water Heating

Energy-efficient goal is no continuous usage of steam for heating whitewater.

Typical cost for heating whitewater 60 F degrees is $1,000 per gpm per year assuming a steam cost of $5 per 1,000 lb.

Establish a baseline water use per ton and compare water usage to TAPPI benchmarks. Machines with high water usage have the greatest opportunities with minimal capital.

Determine optimum silo temperature for each grade.

- Minimize total specific steam consumption.
- Temperature set point
- Be sure temperature sensor is properly calibrated

•Warm water from the pulp mill/evaporators at least 5 °F above silo temperature.

•Stock temperature to the high-density tank at least 5 °F hotter than silo temperature.

No mill water make-up into warm water and whitewater systems during normal operation.

Ensure no leakage of mill water through valves or emergency back-up systems.

Reduce fresh water entry into the wet end process, Operate cleaning and lube showers at design pressure and flow

Monitor/minimize fresh water seal water flows to rotating equipment (pumps, agitators, etc.)

Do not return tepid cooling water return into warm water tanks. Return to mill water supply or other beneficial reuse, mill water header or makeup vacuum seal water

Paper Machine Energy Performance Indices

Grade Index	Uncoated Woodfree	Bleached board	Liner	Corrugating medium	Market pulp	Fluff pulp	Recycled paper-board	News-print	LWC	Kraft paper	Specialty fine paper
Uptime, %	95	93	95	95	95	95	93	93	93	94	93
First quality, %	93	90	97	97	99	97	93	98	85	97	92
Overall machine											
Efficiency, %	89	84	92	92	94	92	86.5	92	79	91	85
Total steam											
consumption											
lb/reel ton	4,000	4,000	2,800	2,750	2,000	2,500	2,800	2,800	3,000	5,000	5,000
Electrical consumption											
kWh/reel ton	350	350	300	300	150	150	300	300	400	400	400
Total energy cons.											
MMBtu/reel ton	6.0	7.0	5.0	5.0	4.0	4.5	6.0	5.0	5.5	6.0	7.0
Vacuum energy consumption											
kWh/reel ton	40	40	40	40	20	20	50	60	75	70	100
Water consumption											
gal/reel ton	2,000	2,000	1,500	1,500	1,000	1,000	<1,000	2000	2000	1500	2,500

TAPPI Tip 0404-63, paper machine energy conservation 2021

Steam Distribution/Condensate Return
Best Practice

Title	Steam Distribution/Condensate Return
Overview Comments	•Inspect and repair steam traps (see DOE steam Tip Sheet #1)
	•Insulate steam distribution and condensate return lines (see DOE steam Tip Sheet #2)
	•Use vapor recompression to recover low pressure waste steam (see DOE steam Tip Sheet #11)
	•Flash high pressure condensate to generate low pressure steam (see DOE steam Tip Sheet #12)
	•Use vent condenser to recover flash steam energy (see DOE steam Tip Sheet #13)
	•Use low-grade waste steam to power absorption chillers (see DOE steam Tip Sheet #14)
	•Install removable insulation on valves and fittings (see DOE steam Tip Sheet #17)
	•Use steam ejector to reduce venting of low pressure steam (see DOE steam Tip Sheet #29)
See Also	Department of Energy (DOE) Steam Tip Sheets
	Inveno Engineering Steam Engineering Best Practices
Primary Area/Process	Boiler Room
Economic Benefit	Reducing waste of steam will lower the amount of fuel purchase
Energy Savings	Reduced loss of heat to buildings and atmosphere
Applications & Limitations	Most facilities can benefit from improvement in these areas
Other Benefits	Improving steam line insulation reduces ambient temperature in buildings
Stages of Acceptance	Medium

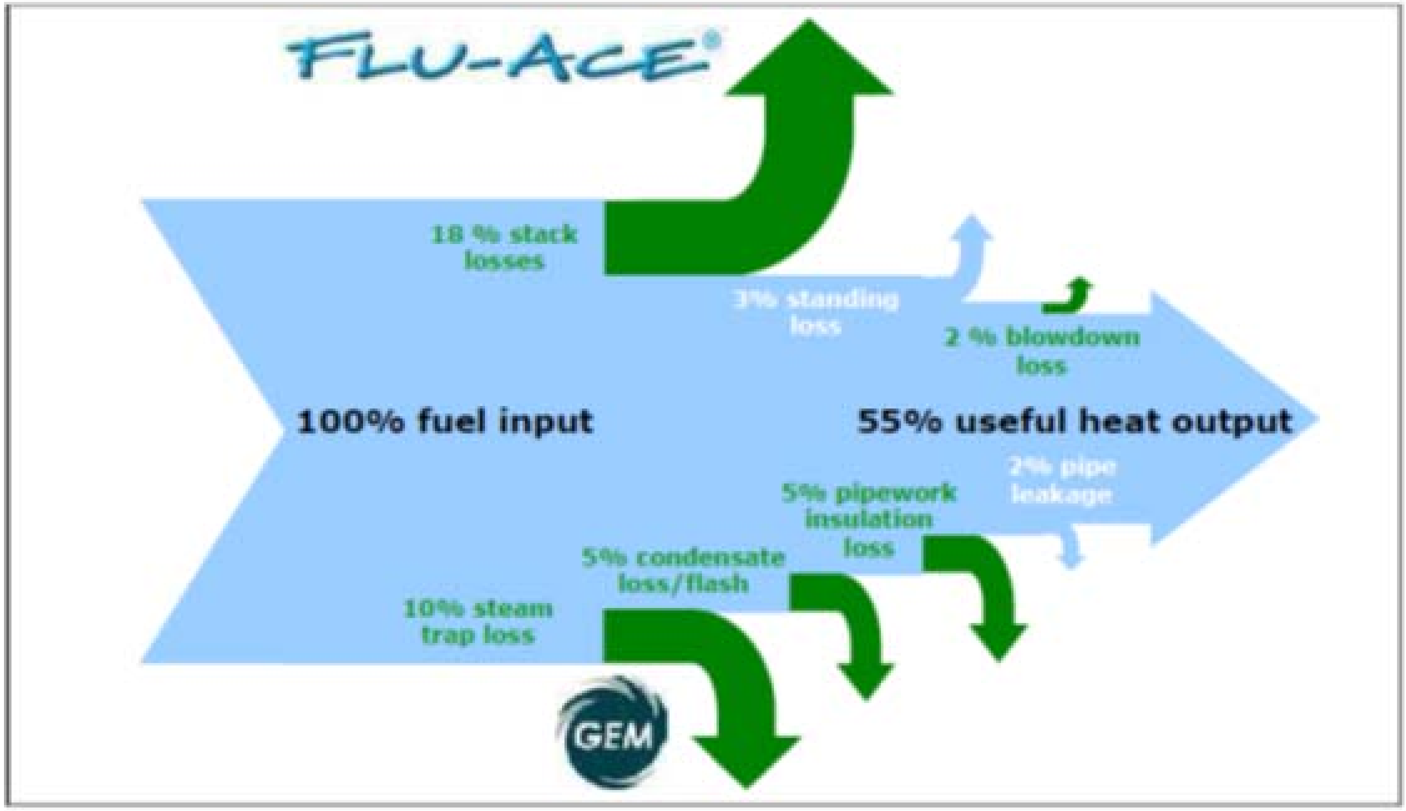
Paper Machine Dryer Condensers and Condensate Return

- Condensate can contain as much as 16% of the energy used to produce steam
- Value of condensate ranges from $3,000 to $4,000 per gpm per year depending on fuel costs and other factors.
- Condensate return should target 90% returned back to the boiler
- Return all condensate from indirect steam users to the power house at as high pressure and temperature as possible.
- High pressure condensate can be returned to the boiler DA tank.
- Ensure no condensate pump, piping, or drain line leaks
- Ensure proper level control of all flash tanks and condensate collection tanks. Use high quality reliable visual level indicators
- Higher pressure condensate should be pumped to lower pressure collection tanks and not to the vacuum condenser.
- If condensate must be flashed at low pressure, reuse flash steam where it will replace fresh steam
  -Wet end dryers
  -Preheat pocket ventilation air
  -Steam showers (with proper trapping and piping design)
  -Flash steam should generally not be used to heat water
- Measure and display dryer vent rates to the condenser.

Inveno Engineering Steam Best Practices

- Eliminate steam venting-NO steam venting
- Eliminate steam leaks-three leaks per year
- Insulate steam and condensate piping >140ºF
- Recover 90% of condensate (except direct injection)
- Measure and display overall boiler efficiency
- Implement boiler operation best practices
- Steam trap management

Energy Losses In A Steam System



PV Supply Air Heating

240°F (116°C)=$720,000 per year (+60%)
210°F (99°C)=$585,000 per year (+30%)
180°F (82°C)=$450,000 per year
150°F (66°C)=$315,000 per year (-30%)

Make up air 80°F (27°C)
Steam supply 50 psig (3.45 bar)
Steam cost $5.00/1,000 lb ($11.00/1,000 kg steam)
Supply air volume 120,000 cfm (3,400 m³/min)

TAPPI Tip 0404-63-Paper Machine Energy Conservation (2021)

Operator Rounds Best Practice

Operator rounds should be utilized to manage systems that are not visible in DCS or data historians. Examples of areas where operator feedback from rounds include:

- Roof or mezzanine rounds to check for leaking vent and safety relief valves.
- Roof supply and machine room ventilation temperatures.
- Condenser systems.
- Steam leaks in piping or through vent valves or safety relief valves.
- Any dumping of condensate
- Compressed air lines open or leaking.
- Water lines open or leaking to the drain.
- Tanks overflowing to the sewer.
- Steam pipe insulation
- Equipment which is vibrating or making excessive noise
- Building air infiltration
- Loss of ventilation

Doctor Blade Application Best Practices

- Use appropriate blades for roll cover type
- Set correct blade angle
- Keep blade holders clean
- Change pressure tubes before they crack and leak
- Keep correct air pressure in tubes
- Check air lines for leaks
- Change blades in critical positions before machine performance goes down
- Have rigid blade holders profiled by a specialist
- Use low drag blades on dryers to reduce drive load
- Keep dryer doctor load less than one pli
- Keep proper loading and unload when unnecessary.
- Change worn blades

Compressed Air Systems

Compressed air systems represent a large electrical energy consumer in the Pulp and Paper industry.

•Document your compressed air system. Include all compressors, air dryers, storage tanks, filters, branch supplies with shut offs. Identify major air consumers.

• Meter and record, compressor power, individual compressor flows, system pressures, branch flow.

• Manage leaks-The average facility has 30 to 35% leakage if it has not taken recent action to identify and repair leaks. Target leakage rate of less than 10%.

• Become familiar with and use ultrasonic leak detectors as part of normal maintenance reliability actions.

• Discourage use of poly tubing or piping practices which do not have robustness of life expectancy

• Install no loss air drains for condensate removal

• Identify the most critical process consumers, whose design establishes supply air minimum pressures or dew points

• Install engineered nozzles vs drilled pipes.

• Minimize use of venturi coolers for component cooling. Know the cost and value of the air being consumed.

Basic Steps in Building an Energy Management Program

Mill Energy Discovery: No-Low Cost 1

Energy waste takes many different faces. Once you recognize what it looks like, the concepts are repeated throughout the mill. Usually, "the way we always run it", has not considered energy efficiency.
Implementation of energy efficient practices is one of the most controllable costs in a facility

- Know energy costs. Real costs, both fixed and incremental. Sites that implement energy reduction should be able to see 3-5% reduction year on year with implemented improvements.
- Know and track energy used-kilowatts, natural gas process and buildings, water supply, and compressed air. Record effluent flow and temperature.
- Establish key metrics to keep score and provide evidence of success.
- Create an energy scoreboard so progress is known and communicated.
- Engage everyone in the mill. You need field people to provide observation feedback. You need key maintenance folks to make repairs. Your operators can provide input on their processes.
- Identify an energy champion. "Find the enthusiastic and technically sound." It is not an assignment it is a passion and drive to improve.
- Equip your observation team with a simplified setpoint-flow-temperature to economics chart, so any of them can readily assess economic value.
- Engage assured support from the mill manager and the mill financial controller. The site controller will provide an unbiased economic value to improvements that the site manager can present.
- Make flow sheets readily available in reproducible sizes (11 x 17). Your field team needs them. Flow sheets for process, water, steam, condensate, and compressed air. Make corrections as discovered.
- Basic tools required are: high intensity flashlight, non-contact and contact thermometers, bucket with hose, and stopwatch.

Mill Energy Discovery: No-Low Cost 2

- Identify and monitor fresh water/process water crosstie valve positions.
- Preferably install fresh water meters on wet end process entry branch supply lines and create a daily metric of freshwater entry.
- Eliminate use of fresh water for foam knockdown, trim knockdown, and sheet knockoff.
- Create an energy recovery equipment checklist and verify the systems are operating.
- Check roof heat economizers for proper operation
- Establish a winter exhaust operation and shut down building exhausts not needed.
- Create a simple “cost of waste” spreadsheet for fresh and heated water, steam leaks, condensate leaks, and air leaks. Simple enough that the janitor can estimate cost of the waste.
- Use bionic ears and thermography to check steam trap operation. Fix blowing traps.
- Listen for and repair air leaks. Do not use poly tubing for air lines-heat deteriorates and leaks abound.
- Perform a down day flashlight sewer walk. Identity the source and quantity of water going to the sewer during shut downs. Note: this is what enters the process when it is running also.
- Perform a roof walk weekly. Look for steam venting. Identify the cause.
- Replace any incandescent lamp with LED.
- Replace globe fixture lamps with direct wire LED.
- Monitor dryer drainage vent rates. When out of limits have operators check differential pressure setpoints and proper cascading of the system.
- Engage mill personnel. More eyes looking for waste supports energy reduction culture.

Paper Machine Energy Reduction-No-Low Cost 1

- Maintain accurate steam and condensate, process and fresh-water flow sheets
- Lower whitewater temperatures
- Reduce seal water flows to rotating equipment
- Lower PV supply air temperatures (<180ºF)
- Shut off steam to unfelted bottom unorun dryers
- Shut off steam to felt dryers
- Shutdown pulpers when stock is slushed or integrate controls to finish batch just in time
- Optimize dryer differential pressures
- Check dryer drainage vent valves for condition and proper operation
- Monitor condenser heat load-dryer drainage key metric
- Look for condensate leaks-repair as needed
- Shut off some uhle box vacuum pumps-one box per felt after the pickup
- Shut off agitators in pulpers when the machine is running
- Control press shower water temperatures-same as whitewater temperature

Paper Machine Energy Reduction-No-Low Cost 2

- Move wet end trim squirts on narrow deckle grades
- Minimize wet end shower flows
- Change shower nozzles regularly
- Control press shower water temperatures
- Monitor vacuum pump seal water flows
- Graduate flat box vacuums
- Optimize steam flow to steam showers
- Shut off steam to steam boxes when not beneficial
- Maintain steam box profile control valves
- Minimize compressed air system pressures
- Monitor condenser heat load
- Raise sheet moisture into size press
- Optimize refiner plates
- Optimize reel turn ups
- Monitor/optimize saveall operation
- Check white water system makeup valves for condition and proper operation

Utility Energy Reduction-No-Low Cost 1

- Maintain accurate steam and condensate flow sheets to assist system training, repairs, and improvement
- Measure and display energy key metrics in a manner most useful to the operator to initiate actions on deviation from excellence
- Regularly check temperature of sootblower poppet valves to ensure they are not leaking (do this at least 1 hour after sootblower has run). Leaking poppet valves represent steam loss and can also damage boiler tubes.
- Regularly check sootblower operating pressures to ensure proper cleaning without excessive steam usage. Excessive pressure can also result in boiler tube damage.
- Model the steam balance operating the steam driven equipment in lieu of electrical driven equipment where the overall balance allows.
- Keep turbine condenser vacuum systems in good condition to maintain design vacuum levels. Every 1.0” Hg increase in condenser pressure results in 2.5% efficiency loss.
- Create a department operation model to identify the most cost-effective operation strategy. This should consider fuel choices, generation choices, time of day generation, and equipment operation choices. Use it.
- Condensing steam in turbine condenser typically does not offer good economics (fuel cost greater than value of electricity produced)
- Establish an overall utility scoreboard to capture the impact of the actions.

Utility Energy Reduction-No-Low Cost-2

- Optimize boiler blowdown (boiler water conductivity as high as possible within established requirements)
- Regularly check pressure reducing valves for condition and proper operation
- Optimize boiler excess oxygen
- Maintain turbine condensers in clean condition to maximize vacuum
- Maintain and use dew point demand systems on desiccant air dryers
- Monitor condensate return percentage - find/correct causes for poor performance
- Do not keep boilers on "hot backup" or operate more boilers than needed "just in case"
- Audit compressed air system for leaks/repair leaks
- Monitor differential pressure on compressed air system filters/replace as needed
- Operate compressed air system at lowest pressure required (each 2 psi=1% energy). Do not operate extra compressors.
- Optimize operation of soot blowers in solid fuel boilers
- Pressure reduce as much steam as possible in the most efficient turbine if multiple options are available
- Calculate costs on a regular basis to determine if it is economical to condense steam in turbine(s)
- Identify the causes of steam venting and develop a plan to eliminate them
- Regularly survey steam traps and repair/replace those that have failed
- Measure "U" factor of energy recovery heat exchangers on a regular basis, clean as needed

Energy Guidebook Appendix

1. References
2. Pulp and Paper Mill Energy Reduction Technologies
3. "Practical Strategies to Reduce Pulp and Paper Mill Energy Use"
4. "Pulp Mill Energy Audit Pays Off"
5. TAPPI TIPS Related to Energy
6. Pulp and Paper Mill Energy Myths
7. Print and Paper Myths and Facts
8. Steam Tables
9. Inveno Engineering Steam Engineering Best Practices
10. DOE Tip Sheets by System

Effort is important, but knowing where to make an effort makes all the difference.

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