

FOREST PRODUCTS

Best Practices Assessment Case Study

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OFFICE OF INDUSTRIAL TECHNOLOGIES
ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

BENEFITS

- Saves a potential 729,000 MMBtu per year
- Saves a potential \$2.9 million per year in operating and energy costs
- Reduces water use

APPLICATION

Using pinch technology, plant energy managers can analyze site-wide heating and cooling requirements to identify thermal energy targets. Pinch technology primarily addresses two issues: minimum thermal energy required to operate a site, and target energy consumption. Using this technology, assessment staff can analyze site-wide heating and cooling requirements to identify a thermal energy target. Comparison between the target and measured energy consumption shows how much energy savings are actually possible. Ways of achieving this target can then be identified. These methods can be replicated in many paper plants across the United States.

Georgia-Pacific Palatka Plant Uses Thermal Pinch Analysis and Evaluates Water Reduction in Plant-Wide Energy Assessment

Summary

Georgia-Pacific Corporation employed water-reduction analysis and thermal pinch studies to identify water and energy conservation projects in its Palatka, Florida, paper mill. Assessment results included the following.

- The mill can support a planned water usage reduction of 2,100 gallons per minute (gpm) and at the same time improve operational flexibility.
- Eight additional energy projects could save 718,972 million Btu per year (MMBtu/yr) of steam and 10,483 MMBtu/yr of natural gas.
- There are cogeneration opportunities associated with heating recovery boiler air and the boiler feedwater steam-driven turbines. The assessment team evaluated additional power generation opportunities that involve improving the steam pathway. These projects could save about 3.2 megawatts (MW).
- Saturn gas turbines could provide cogeneration opportunities. The integration of a gas turbine with the tissue paper machines (TPMs) could generate 2.4 MW of additional power.
- An overall simulation model, process flow diagrams (PFDs), and a water catalog were developed for the study. If kept current, the PFDs would provide resources for future energy conservation project evaluation.

DOE-Industry Partnership

As part of the plant-wide energy assessment at the Palatka plant, Georgia-Pacific hired American Process Inc. (API) to carry out a water reduction study and an energy targeting study using its Successive Design Methodology (SDM™). The U.S. Department of Energy's (DOE) Office of Industrial Technologies (OIT) co-sponsored the assessment. OIT promotes plant-wide energy efficiency assessments that will lead to improvements in industrial efficiency, waste reduction, productivity, and global competitiveness. In this case, OIT shared assessment costs by contributing \$75,000 of the total \$225,000.



Company Background

The Palatka mill began operating in 1947 as part of Hudson Pulp & Paper Corporation. In 1979, the mill became part of Georgia-Pacific Corporation, which had acquired Hudson. Palatka Operations is composed of two primary business units, Kraft and tissue paper manufacturing. The mill produces natural and bleached Kraft paper, tissue paper, and a comprehensive line of consumer and commercial tissue products.

Annual Kraft output totals about 300,000 tons from two Kraft paper machines (KPMs). The mill's three TPMs annually produce a total of about 200,000 tons of tissue.

Assessment Approach

API's SDM methodology uses the principles of water and thermal pinch to identify water and energy conservation projects. Using PFDs and dynamic simulation models, assessment personnel can examine direct matches between "hot" and "cold" water flows. Direct matches (such as reuse of combined condensate for brownstock washing) can be identified immediately. Using SDM, assessment staff can also examine those matches that can occur only after treatment, (e.g., straining of white water and reuse in the bleach plant).

Pinch technology primarily addresses two issues.

- 1. What is the minimum thermal energy required to operate this site?*
- 2. What is the target energy consumption?*

Using this technology, assessment staff can analyze site-wide heating and cooling requirements to identify a thermal energy target. Comparison between the target and measured energy consumption shows how much energy savings are actually possible. Ways of achieving this target can then be identified.

Pinch studies are most useful when there is a need to minimize both thermal energy and capital costs, such as:

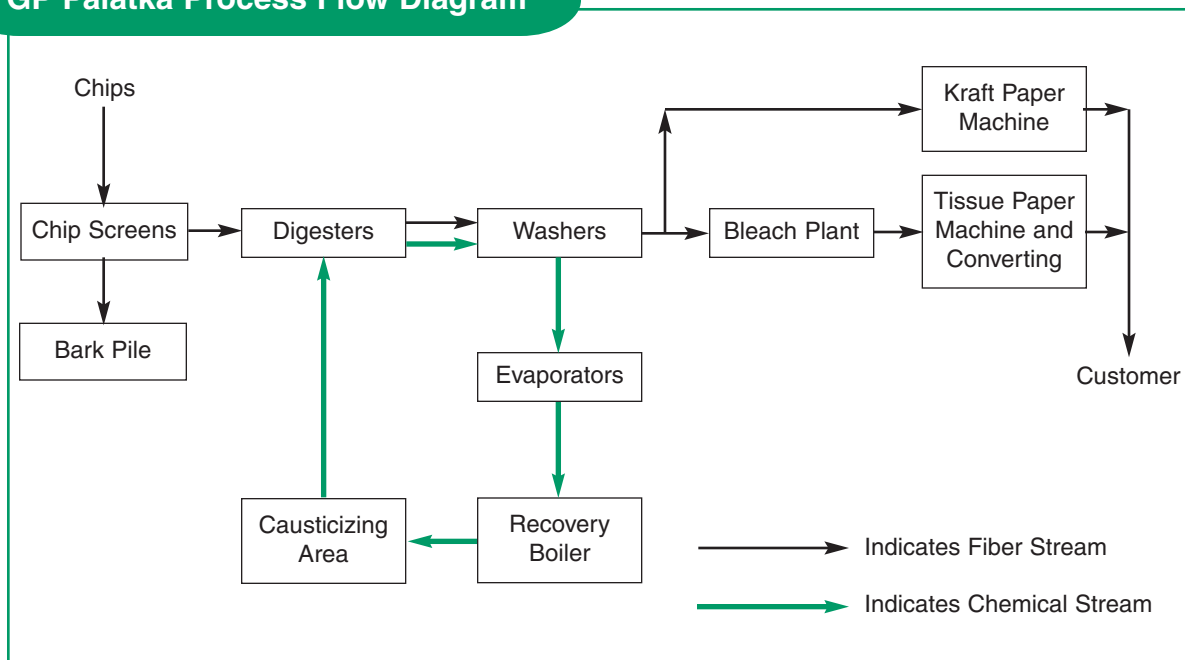
- In an existing mill undergoing an expansion
- On a greenfield site
- When implementing projects for environmental compliance
- When considering process changes
- When steam is in short supply
- For benchmarking (defining targets for site energy consumption)
- When fuel costs are high
- When investing in new process equipment (e.g., stripper or evaporator)
- When changing process equipment type (e.g., switching from batch cooking to modified or continuous batch processing, or adding de-inking to thermomechanical processing).

The site-wide energy assessment consisted of the following steps:

- Creating PFDs
- Performing an economic scenario analysis
- Developing a simulation model for current operations
- Performing a thermal pinch analysis (data extraction, targets, scope composites, and grand composite cogeneration analysis)
- Conducting a water study
- Performing a cost benefit analysis.

The Palatka mill is divided into several areas—power house, chemical recovery, digesters, washers, bleach plant, TPMs, and KPMs. Assessment personnel collected material and energy balance data (including temperature, pressure, flow, percent water, percent fiber, percent chemicals, and percent contaminants) for each area. After PFD development, data from all mill areas were collected for a pre-selected 3-day period, representing the mill near steady-state operating conditions. The fiber balance was simplified to reflect an average species distribution between different product grades.¹

GP Palatka Process Flow Diagram



The assessment team built an overall mill simulation model based on the PFDs and reconciled it using mill data and input from mill personnel. A catalog of water users (sinks) and effluent producers (sources) was constructed based on the reconciled model. Assessment staff then conducted the pinch analysis and the SDM. Finally, using results from the SDM analysis, preliminary projects were developed.

¹ Different grades of paper require different species of pulp. The balance does not cover every extreme; it uses an average distribution.

Results

The water reduction study examined how water is used and whether existing streams could displace fresh water usage. This study identified two major practical projects “A” and “B” that could be implemented to support a planned KPM water use reduction target, and concurrently improve operational flexibility.

The Palatka mill already had a highly efficient heat/energy recovery system in place. The maximum potential process steam savings identified by pinch analysis are 173 million Btu per hour (MMBtu/hr); the minimum process thermal steam target is 621 MMBtu/hr. To arrive at these numbers, assessment staff calculated the true marginal cost of injected and non-injected steam for each steam pressure level. A cost-benefit analysis was performed using the marginal cost of steam, the steam savings, and the capital cost estimates.

In addition to the projects identified in the water reduction study, the assessment team identified eight projects that could yield annual steam savings of 718,972 MMBtu and annual natural gas savings of 10,483 MMBtu. The total capital cost of these projects is estimated at \$7.7 million. Potential annual savings are \$2.9 million.

A target cogeneration analysis revealed practical opportunities for additional power generation of approximately 3.2 MW. Assessment personnel also investigated the cogeneration opportunity of using gas turbine flue gases for combustion air in the TPMs.

Projects Identified

Water Projects

The primary users of fresh water are the evaporators, the KPMs, and the boiler feedwater system, which together consume more than 50 percent of the total water used at the mill. The mill uses an estimated 18,000 gpm of fresh water.

Palatka’s No. 2 Kraft Paper Machine



Because the turbine condensers are integrated with warm-water production, it is impossible to save water without sacrificing power generation in the current mill water distribution configuration. Furthermore, the No. 3 evaporator condenser water system is very tightly coupled with the bleach plant and chlorine dioxide (ClO₂) plant water demands. This means that any imbalance would cause either makeup or water overflow. The proposed projects would allow independent control of warm water based on mill demands and improve the mill operational flexibility. The proposed water conservation projects are listed below.

Project A

The No. 1 and No. 2 water plants supply cooling water to the No. 2 and No. 4 turbine generator (TG) condensers respectively. The warm water generated from the No. 2 TG condenser is used in the No. 1 KPM. The No. 4 TG condenser supplies the No. 2 KPM and the TPMs. In order to maintain a vacuum, the condensers' water demand is more than 8,600 gpm and is currently balanced with the process needs. After the KPM water reduction project is implemented, the process needs will decrease by 2,100 gpm and create a warm-water imbalance.

Assessment personnel recommend routing condenser water from the No. 2 and the No. 4 TGs to a new cooling tower. They also propose using warm water from the pre-evaporator's surface condenser to supply the mill's warm-water demands. This project has an estimated capital cost of \$3.2 million.

Project B

Currently, the No. 3 evaporator condenser uses treated water, and the warm water produced supplies the bleach plant and ClO₂ plant users. This condenser's water requirements and those of the eventual users are very closely coupled. Sometimes there is an imbalance, which can create either warm-water overflow or warm-water makeup.

Assessment staff recommends directing water from the No. 3 evaporator condenser to the pre-evaporator cooling tower and directing water from the pre-evaporator surface condenser to the bleach plant and ClO₂ plants. With an estimated capital cost of \$316,000, this project would only produce water savings during periods of imbalance between demand and supply. It would, however, significantly improve operational flexibility.

Heat Recovery Projects

In addition to the water projects A and B, eight heat recovery projects were identified (Table 1). For the energy savings to correspond to realistic cost savings, the energy saved must displace fuel oil in the No. 5 boiler. The eight projects together can save nearly 719,000 MMBtu/yr in steam. (Project 5 is an alternative to project 2 and uses a different source of heat to achieve the same amount of steam savings.) The heat recovery projects involve the following plant components.

Bleach plant—Pulp is bleached with several chemicals. The chemicals are applied in different stages at a specific temperature, pressure, retention time, pulp concentration, and chemical concentration. Between stages, the pulp is washed with water to remove the chemicals. The wash water is heated in the direct steam mixers prior to the Eop (the addition of caustic, oxygen, and peroxide to remove color bodies) and ClO₂ stages and is heated in a trim heater for the Eop washer shower.

Tissue paper machine—Hot water is used to wash the felts that transport the pulp mat through the paper machine. Felt clogs with fiber and additives that must be washed out.

Recovery Boiler Deaerator—Steam is used for heating the makeup water and for deaeration. Deaeration removes oxygen from the feedwater to prevent boiler corrosion.

Table 1. Heat Recovery Projects

Project No.	Project Description	Annual Steam Savings (MMBtu)	Annual Natural Gas Savings (MMBtu)	Project Cost (\$)	Annual Savings (\$) ¹
1	Demineralized water heating	214,032		1,300,000	856,128
2 ²	ClO ₂ filtrate heating	71,635		800,000	286,541
3	ClO ₂ heating	25,334		300,000	101,338
4	TPM combustion air preheating		10,483	600,000	41,933
5 ²	Alternative to Project 2	71,635		600,000	286,541
6	White-water heating	196,560		2,000,000	786,240
7	Vapor take-off	41,059		800,000	164,237
8	Reflux condenser rework	170,352		1,900,000	681,408
Totals³		718,972	10,483	7,700,000	2,917,824

¹ Annual savings based on 24 hours per day; 365 days per year run time and standard utility costs of \$4 per MMBtu.

² These projects are alternatives to each other.

³ Excluding Project 5, which is an alternative to Project 2.

Power House Deaerator—Steam is used for heating the makeup water and for deaeration.

Kraft Paper Machine—Steam is used to control the white-water temperature in the wire pit. The wire pit contains water used to dilute the pulp entering the paper machine.

Project 1

Currently, the No. 2 water plant supplies the demineralizers with the necessary makeup water for the deaerators. The makeup water for the powerhouse deaerator is heated by the condensate from the utility boilers' continuous blowdown tank, which adds about 1.3 MMBtu/h to the system. The recovery boiler deaerator makeup water is first heated in the vent condenser by flash steam from both the main condensate and the evaporators' condensate tanks. The demineralized water is then heated to 95° F by the recovery boiler blowdown in the waste heat exchanger. Finally, the warm water from the turpentine condensers exchanges heat with the recovery boiler demineralized makeup water, increasing the temperature of the latter to 119° F.

There are three separate proposed projects that compose Project 1. Project 1A would condense a part of the No. 4 evaporator 6th effect vapor using approximately 1,010 gpm of demineralized water. This way, the demineralized water could be heated to 120° F, reducing the heat rejected in the No. 4 evaporator cooling tower. Project 1C would enable Eop effluent to be used in a new water heater to further increase the demineralized water temperature to 135° F.

Project 1B would create a closed loop around the turpentine condensers and the turpentine boiler feedwater heater. Therefore, water from the turpentine condensers at 188° F would reach the boiler feedwater heater. There, it would heat demineralized water to 180° F while the transfer water would

return to the turpentine condensers at 108° F. A standpipe is incorporated with mill water makeup for emergency temperature control of the turpentine condensers. Water from the two heat recovery routes would be collected in a new demineralized water tank that would then supply the two deaerators at 151° F.

Project 2

Currently, pulp from the Eop press is diluted with ClO₂ filtrate (approximately 130° to 140° F) and heated with 60 pounds per square inch gauge (psig) steam in the ClO₂ steam mixer to keep the ClO₂ tower temperature at about 160° F. There is an opportunity to preheat the ClO₂ filtrate (used for dilution) to reduce the steam injection requirements.

In Project 2, 8 MMBtu/h would be extracted from the accumulator and used to increase the filtrate temperature to about 150° to 160° F. The total potential steam savings are equal to the heat in the accumulator vent and are estimated to be equivalent to 8,200 pounds per hour (lb/hr) of direct 60-psig steam (about 72,000 MMBtu/yr). A buffer tank has already been added to maintain the filtrate at a constant temperature as the accumulator vent varies with each digester blow.

Project 3

At present, the ClO₂ solution is added to the bleach plant stages at a temperature of 95° F. In Project 3, the ClO₂ solution sent to the bleach plant towers would be heated with filtrate from the caustic extraction stage.

Project 4

Ambient combustion air is currently used in the tissue combustion chamber. In Project 4, heated makeup air would be used as combustion air instead, reducing the natural gas used in the combustion chamber by about 4 percent. For this project, assessment personnel assumed that the existing economizer has adequate area and no additional heating unit would be necessary to heat the combustion air.

Project 5

This project is an alternative way to preheat the ClO₂ filtrate sent to the screw dilution with the exhaust vapor from the No. 4 TPM (an alternative to Project 2).

Project 6

Currently, steam is injected into the No. 1 KPM silo to control the white-water temperature at about 125° F. Project 6 would enable the use of No. 3 and No. 5 TPM exhausts to maintain the white water temperature. Both TPM exhausts are necessary to supply the required heat to the white-water.

Project 7

The weak black liquor sent to No. 1 and No. 2 evaporators is heated by 60-psig steam in a heater. Project 7 would incorporate the use of vapor from the 4th effect of the No. 4 evaporator to preheat the weak black liquor entering the No. 1 and No. 2 evaporators. This would increase the steam flow to the No. 4 evaporator by about 3,000 lb/hr. The steam saved in the weak black liquor heater would be about 8,000 lb/hr, thus yielding net steam savings of about 5,000 lb/hr (approximately 41,000 MMBtu/yr).

Project 8

Currently, the stripper reflux vapor is condensed with the accumulator condensate, which is then flashed for pre-evaporation. The condensate from the condensing turbines returns to the deaerators without any further heating at around 127° F. Project 8 would allow the use of the recovery boiler feedwater from Project 1B to condense the vapor from the stripper. The existing reflux condenser could be used for this purpose.

Cogeneration Opportunities

Assessment staff identified a project for heating recovery boiler air involving the replacement of high-pressure steam with low-pressure steam (i.e., 160-psig steam would replace 400-psig steam, and 60-psig steam would replace 160-psig steam). This would enable the turbine-generator to generate more power because more energy would be extracted from the steam. The steam-driven turbines could be replaced with electrically-driven turbines that have higher net energy efficiency.

Cogeneration opportunities involving process load shifts and turbine efficiency were also investigated. The recovery boiler air is currently heated with 160-psig steam and 400-psig steam to about 358° F. Heating the air to nearly 290° F with 60-psig steam and then to 358° F with 160-psig steam could generate an additional 0.8 MW.

In addition, there are three boiler feedwater steam-driven turbines. Replacing the three turbines with electric motors could yield an additional 2.4 MW.

The assessment team also investigated the use of gas turbine flue gases for TPM combustion air. The flue gases of a gas turbine can replace fresh combustion air in TPMs, resulting in very competitive electricity production. All gas turbines are burning fuel with high excess oxygen (200 percent to 300 percent). Their flue gases are often used for further combustion in another burner. The energy produced by fuel burning in the gas turbine is either transformed into electrical power or exits the gas turbine in the flue gases, significantly increasing system efficiency. Therefore, if two solar Saturn gas turbines were used and their exhausts integrated into the three tissue machines, approximately 2.4 MW additional power would be generated.



BestPractices is part of the Office of Industrial Technologies Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and best energy-management practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

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Industry of the Future—Forest Products and Agenda 2020

In November 1994, DOE's Secretary of Energy and the Chairman of the American Forest and Paper Association signed a compact, establishing a research partnership involving the forest products industry and DOE. A key feature of this partnership was a strategic technology plan—**Agenda 2020: A Technology Vision and Research Agenda for America's Forest, Wood, and Paper Industry**. Agenda 2020 includes goals for the research partnership and a plan to address the industry's needs in six critical areas:

- Energy performance
- Environmental performance
- Capital effectiveness
- Recycling
- Sensors and controls
- Sustainable forestry

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