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ENERGY BEST PRACTICE

GUIDEBOOK

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Pulp and Paper
Energy Best Practice Guidebook

Provided By:

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Funding for this guidebook was provided by Focus on Energy. Focus on Energy is a public-private partnership offering energy information and services to energy utility customers throughout Wisconsin. The goals of this program are to encourage energy efficiency, use of renewable energy, enhance the environment and ensure the future supply of energy for Wisconsin.

With:

Aue Energy Consulting
Benjamin A. Thorp, Inc.
Center for Technology Transfer, Inc.
D&S Design and Engineering
Science Applications International Corporation

May, 2005

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FORWARD

Are You A World Class Energy Consumer?

World class energy users have:

1. Benchmarked energy consumption in their mill
2. Defined a quantifiable, affordable energy reduction goal
3. Established a multi-year plan to meet their energy reduction goals
4. Assigned a cross-functional team to implement the plan
5. Firm commitments from mill manager for mill-wide improvements in energy efficiency and demand reduction

If your mill lacks any of these essential ingredients, this best practice guidebook will help you get there.

What Others are Saying about the Guidebook:

Lars Bengtsson, President, Stora Enso North America

> "***Rising energy prices continue to be a concern for our company. This guidebook provides several ideas that will help reduce our energy costs."***

Bill Ward, Energy Manager, Proctor and Gamble Paper Products Company

> ***"The Best Practices Guidebook is a great tool to help energy practitioners make an immediate impact on conservation and efficiency. That is critical to our industry's competitiveness in an era of rapidly increasing energy prices***."

Mark Kowlzan, Senior Vice President, Packaging Corporation of America

> "***With today's rapidly rising energy costs, this is great information every mill manager will want to put to use to improve the bottom line."***

Executive Summary

The objective of this Pulp and Paper Energy Best Practice Guidebook is to provide resources and methods to drive down energy use and energy related costs in pulp and paper mills. Using this guidebook, a mill manager will be able to benchmark his or her facility against a comparable low energy using facility and significantly reduce energy needs for their mill.

Contents include:

- Benchmarks for typical Wisconsin pulp and paper mill configurations
- Guidelines for conducting an Energy Best Practices Study
- Documentation of over 50 best practices for process energy use and other best practices for common system energy use
- Best practice funding and financing opportunities
- References for further opportunities in pulp and paper energy efficiency and energy demand reduction

The intent of the **Guidebook** binder format is to provide a "living" document that can be updated continually with new Best Practices and Case Studies provided by the Focus on Energy program (and others) with direct input from Pulp and Paper industrial leaders. In addition to this guidebook, the Focus on Energy program can provide technical assistance and possible financial incentives to support the implementation of energy efficiency measures you may want to pursue. We encourage you or your staff to give us a call at 800-762-7077 to find out how we may be able to help you reach your energy cost reduction goals.

INTRODUCTION

The past two decades have brought significant change to the paper industry in Wisconsin. Mergers and acquisitions have significantly altered the playing field. Competition has evolved from simply selling products to the more complex challenge of promoting the mill from both an internal and an external context. Earnings are no longer segregated for use by the facility that generated them, and mills are under constant scrutiny and review.

The first and most obvious change is staff downsizing to reduce costs. Mills are now operating with minimal technical and support staff. One negative aspect of this change is a focus on today's issues with little time for the future. A mill cannot adopt a technology if it is unaware of its existence. This phenomenon is furthered by the lack of capital and staff to exploit or implement identified technology. One response to this challenge is to learn how to cost effectively use outside resources.

A second, but more subtle and equally significant factor influencing mills is lack of understanding in regard to energy costs. Although energy is one of the top three costs of doing business, improving labor productivity or saving money on raw material is viewed as more immediate and measurable. Energy costs on the other hand are not easily influenced and many mills still view them as a semi-fixed expense. One response to this challenge is to have a long term energy reduction plan that is supported at the corporate level.

A third challenge is access to energy conservation information. Today's decision makers typically include corporate executives as well as the resident facility managers. The array of assets controlled under a single corporate umbrella is much larger today than in the past. Good technical ideas are often tempered on factors well beyond the confines of a single mill. The fit must first satisfy the overall corporate objective before implementation within the organization. Innovation is not bound by geography so an idea proposed for one facility may well be implemented elsewhere, and yet ignored at the originating location. The most effective response is to have mill manager ownership of the energy reduction plan so that it can be advocated at every opportunity.

Development of the Guidebook

Funding for this best practice guidebook was provided by Focus on Energy. The following Focus on Energy Pulp and Paper team members contributed to the development of this guidebook:

- **Benjamin Thorp** has held several leadership positions with major pulp and paper manufacturers, including Georgia-Pacific, Chesapeake, James River and others, with special emphasis on energy efficiency and Vision 2020.
- **Dave Borowski,** former Executive Vice President from Green Bay Packaging, has held leadership positions with the Wisconsin Paper Council and TAPPI committees.
- **Jerry Aue** served for 11 years as Energy Manager at Stora Enso North America (Consolidated Papers); led pulp and paper energy initiatives at the Energy Center of Wisconsin.

- **Masood Akhtar,** Executive Director of the Center for Technology Transfer, CEO of Biopulping International and formerly with USDA Forest Products Laboratory.
- **John Nicol,** Industrial Program Manager for the Focus on Energy's Business Program – more than 20 years of experience in industrial energy efficiency.
- **Brent English,** Director of Commercialization, Center for Technology Transfer and formerly with USDA Forest Products Laboratory.
- **Craig Schepp,** Focus on Energy Advisor.
- **William Lumsden,** Focus on Energy Advisor.

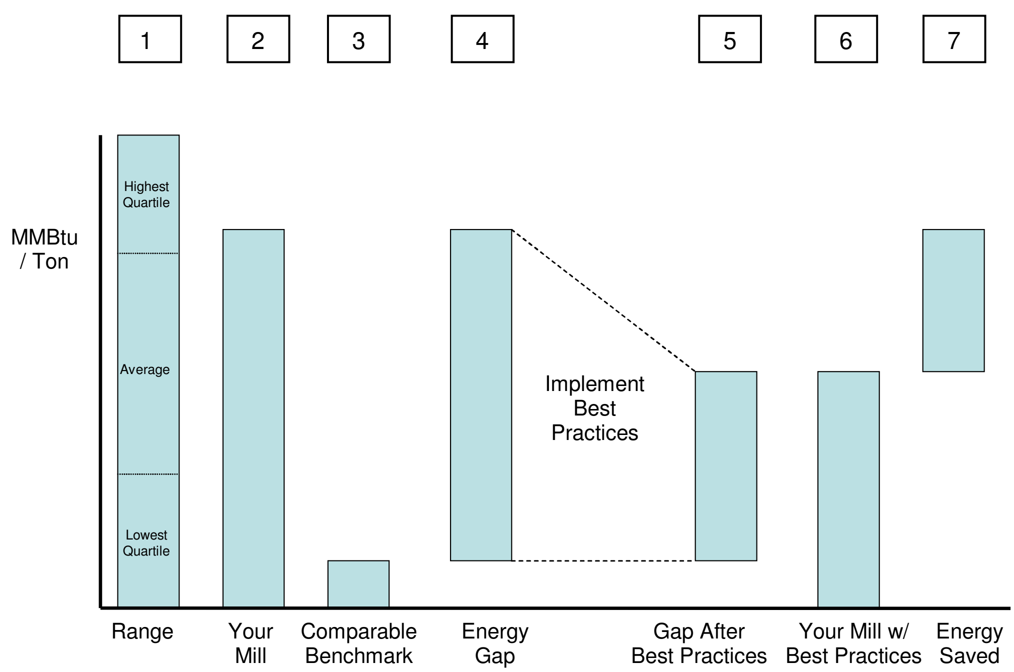
BENCHMARKING

Benchmarking is the process of determining who is the very best, who sets the standard and what that standard is. In business, many things are benchmarked, for instance, who is best in sales or customer service or what is the least amount of scrap that others make in the production of their product. In our case, it is how much energy does your mill use per salable ton of paper produced, and how does that compare to the best performance of others making a similar product.

Going through a benchmarking exercise for your mill is critical to minimizing energy use. If you do not know what the standard is you cannot compare yourself against it. Benchmarking allows you to compare your mill to those with top energy performance, determine the gap between their mill and yours, and helps you set targets and model results for best practice implementation.

Figure 1 illustrates a basic benchmarking process and gap analysis which is critical to minimizing energy use. Please note that this process focuses on gross energy use, does not consider energy generation and does not credit any operation for energy generation.

Figure 1: General Example of Potential Energy Savings through Benchmarking and Gap Analysis



- **Bar 1 - Range**: shows the range of energy users for mills of your configuration and grades. Outside expertise is often used in determining the energy value for Bar 1. (For assistance in finding information on this range call the Focus on Energy – Industrial Program at 800-762-7077) Note that Bar 1 will not start at zero because all mills use energy. Bar 1 serves as a reference for the rest of the figure.

- **Bar 2 – Your Mill**: You will need to determine the gross energy use for your mill.

- **Bar 3 – Comparable Bench Mark**: Find a comparable benchmark for a low energy use mill with your configuration and comparable grades. This will typically be a first decile (top 10% in low energy consumption per ton of salable pulp or paper) mill from the data used to assemble the first bar. Table 1 below lists energy consumption for top energy performing mills--those that would be in the top decile (top 10%). Mill configurations, except for market pulp, are typical for Wisconsin. Numbers in this Table 1 are meant as a starting point for benchmarking, but further investigation should be completed to ensure that this value is valid. Again, Focus on Energy is available to assist with determining this benchmark value for your mill.

Table 1: Energy Benchmarks - Gross Thermal/Power Consumption per Ton of Salable Paper[1]

	Market Pulp Mill		**Recycled Linerboard**		**Fine Paper** (purchased Kraft)		**Coated 1-3** (purchased Kraft)		**Coated 4-5** (purchased Kraft and self-produced Ground wood)		**Recycled Tissue**	
Units	**MMBtu**	**kWh**	**MMBtu**	**kWh**	**MMBtu**	**kWh**	**MMBtu**	**kWh**	**MMBtu**	**kWh**	**MMBtu**	**kWh**
Wood/Chip Conveying	0	18	-	-	-	-	-	-	0	15	-	-
Pulping, repulping or recycling	1.5	63	0.8	110	0.6	90	0.6	100	0.2	30	1.8	300
Mechanical Pulping	-	-	-	-	-	-	-	-	1.3	575	-	-
Oxygen Delignification	0.4	68	-	-	-	-	-	-	-	-	-	-
Bleaching	2.0	91	-	-	-	-	-	-	0.1	10	0.5	50
Pulp Making	2.0	128	-	-	-	-	-	-	-	-	-	-
Paper Making	-	-	4.0	310	3.9	410	4.5	590	4.7	600	6.0	581
Black Liquor Evaporation	2.7	27	-	-	-	-	-	-	-	-	-	-
Utilities (includes wastewater)	2.0	138	0.3	30	0.3	30	0.3	30	0.4	30	0.6	30
Kiln & Recausticizing	1.0	46	-	-	-	-	-	-	-	-	-	-
Total	**11.6**	**579**	**5.1**	**450**	**4.8**	**530**	**5.4**	**720**	**6.7**	**1,260**	**8.9**	**961**

[1] Table cells without data are not applicable. The data for the pulp mill came from The Canadian Industry Program for Energy Conservation and the data for the remainder came from Jaakko Poyry and reconciled with the Institute of Paper Science and Technology techno/economic model.

When using Table 1, please also note that energy benchmarks are quite dependent on technology design. For example, in the tissue industry, many newer machines are Through Air Drying (TAD) design. These are more energy intensive but have other product benefits.

- **Bar 4 – Energy Gap:** Subtract the benchmark (Bar 3) from the energy use for your mill (Bar 2). This is the energy gap between your mill and the benchmark. Although using a “floating bar” is not customary graphics, in our case it better represents the difference between your mill and the benchmark mill because the horizontal axis is not at zero.

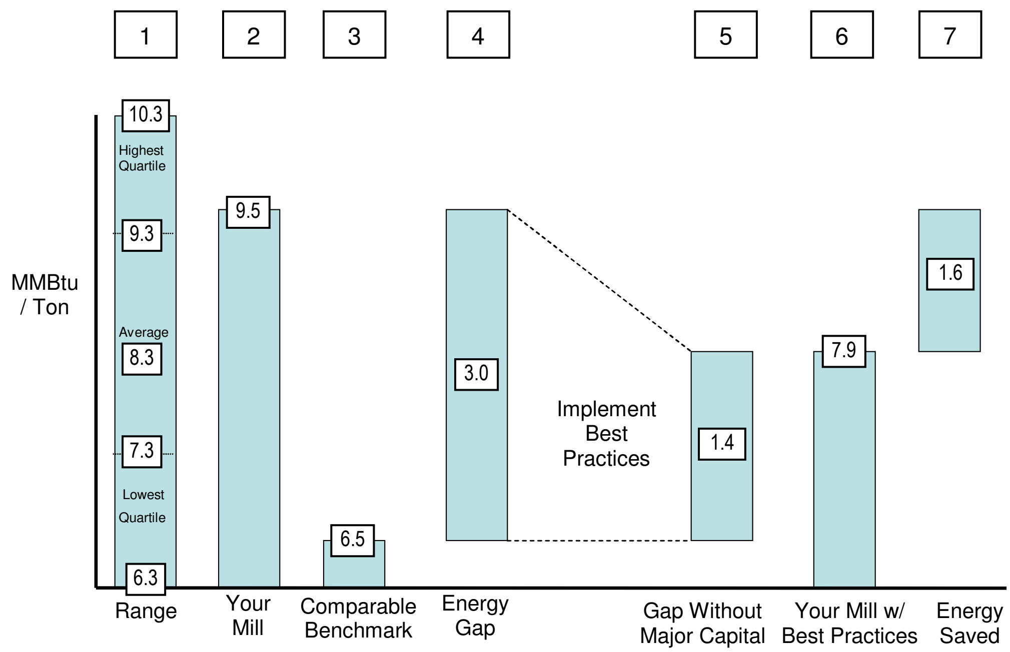
- **Bar 5 – Energy Gap Possible without Investing Major Capital**: Analyze the gap and determine which best practices are expected to have a satisfactory rate of return. Experience has shown that 50% to 70% reduction of the gap can be achieved with no capital or modest capital which has a satisfactory return on investment (ROI). Closing the full gap is typically not economically attractive. This can be due to the age of equipment and the original configuration of the mill. Typically, the energy reduction goal is selected and best practices are implemented to achieve that reduction. The Best Practice Energy Study described later will illustrate an example in which the reduction can be achieved. Bar 5 shows the gap after selected best practices have been implemented.

- **Bar 6 – Your Mill with Best Practices Implemented**: Add the benchmark (Bar 3) back to the gap after the best practices have been implemented (Bar 5) to get the new energy use of your mill.

- **Bar 7 – Energy Saved**: Graphically shows the energy saved by subtracting (Bar 6) from (Bar 2).

Figure 2 on the next page illustrates an example of this process when it is applied to the thermal side of a particular mill. In this example, the mill makes coated #4 paper and buys Kraft pulp from an adjacent facility (slush pulp by pipe). The mill also makes ground wood pulp.

Figure 2: Example of Potential Energy Savings for a Mill Making #4 Coated Paper



- **Bar 1 – Range**: A study was commissioned to determine the range of energy use of similar mills. It showed the range of gross energy use to be 6.3 to 10.3 MMBtu per ton. The first bar baseline is 6.3, the first quartile point is 7.3, the average is 8.3, the third quarter break is 9.3 and the max is 10.3 MMBtu per ton.

- **Bar 2 – Your Mill:** The gross energy use for the mill was measured to be 9.5 MMBtu per ton, a high energy use.

- **Bar 3 – Comparable Bench Mark**: Table 1 (below) shows that a good energy performer has an energy use of 6.7 MMBtu per ton. However, the reference mill in Table 1 re-pulps baled pulp which consumes 0.2 MMBtu per ton. In order to obtain a proper comparison, 0.2 MMBtu per ton must be subtracted. This makes the height of (Bar 3) at 6.5 MMBtu per ton.

- **Bar 4 – Energy Gap:** The full gap is 3.0 MMBtu per ton, which is your energy consumption of 9.5 minus the benchmark of 6.5. The floating bar will run from 6.5 to 9.5 MMBtu per ton.

- **Bar 5 – Energy Gap Possible without Investing Major Capital**: Experience has shown an achievable goal without investing major capital is 50% to 70% of the 3.0 MMBtu per ton for a result of 1.5 to 2.1 MMBtu per ton savings. Let's calculate the impact of implementing Best Practice MW 9 (See **Best Practices** section of this **Guidebook**). A 12% savings (1.1 MMBtu) is typical for Best Practice MW 9. Another 5% reduction is typically achieved by improved operating practices. The energy use of your mill should be reduced from 9.5 MMBtu per ton to 7.9 MMBtu per ton.

- **Bar 6 – Your Mill with Best Practices Implemented**: (Bar 6) shows your improved mill as a 7.9 MMBtu per ton user. By comparing your mill to the first bar you can see that it has moved to a just-below-average energy consumer (remember, in our case, being below average is a good thing).

- **Bar 7 – Energy Saved**: (Bar 7) represents the 17% or 1.6 MMBtu per ton saved. If your mill pays $5.00 per MMBtu and the machine makes 800 tons per day (tpd), the annual savings is $2,304,000.

BEST PRACTICE ENERGY STUDIES

Objective

The purpose of this section is to provide mill management with the essential ingredients of a best practice energy study that would be conducted by an outside energy consulting firm. A best practice energy study of this type is for reducing energy consumption per unit of production, not on the efficient generation of energy. This summary comes from involvement in 50+ energy studies and review of at least another 50. The quality of the studies reviewed has varied widely. In the best cases, the cost of the study was recovered in a matter of weeks based on energy savings alone.

The difference in the quality of the studies reviewed was primarily due to the study scope definition. A Best Practice study will define both the breadth and the depth of the scope. The breadth definition will define whether it is the entire facility or selected systems like steam, pumps, air compressors, etc. The depth definition will define what work will be done and how the results will be characterized. Questions like energy balances need to be addressed up front. More importantly there is the issue of how the recommendations will be developed and presented. Ideally, the mill will need the cost and benefit of each recommendation estimated and prioritized by sequence and/or ROI.

Additionally, management needs to qualify potential energy study providers by obtaining references and selecting ONLY those with satisfied clients. The goal is to get a **long term energy reduction** plan that will be cost effective. The price of the study is a secondary issue compared to the potential savings.

The 80/20 Rule

Use the 80/20 rule of thumb for the proposal and all of the succeeding work. During this or any other study, it will become apparent that ~20% of the equipment, processes or systems will consume ~80% of the energy. It is this equipment or these systems or processes that need to be more closely examined for energy savings opportunities. The smaller opportunities can be recorded and become part of an ongoing “continuous improvement” effort to reduce energy.

It is a best practice to quantify energy use and numerically determine the high energy users. It is not a best practice to only study the equipment, processes or systems that someone **believes** use the most energy. Quantification also shows when the 80/20 rule may not be strictly applicable.

Pre-Study Work

Any best practice study will require pre-study work by the facility. The pre-study will be used by the outside team to become familiar with the facility and to make preliminary comparisons to benchmarks. Ideally, pre-study work should be defined in the contract and a sample form attached by the outside firm.

It is critical that a competent facility team be assembled to obtain **representative** and **accurate** data for the pre-study and be available to assist the outside team. Typical sources of pre-study data gathering include energy use reports, energy costs, equipment lists, Process and Instrument Diagrams (P&ID's), production reports, grade details, production centerlines and other cost data from accounting. The outside team of energy study providers will have limited time in the mill and a good cost effective practice is to make sure they use the limited time on important issues.

Another good practice is to understand the benchmarks that will be used and to understand their definitions. Mills maintain data differently and have definitions for terms that can be different from those used by the outside team. It is a good practice to reconcile these differences before the study begins. Important benchmarks include:

- Specific energy consumption for each unit operation in MMBtu per salable ton, kWh per salable ton and lb. steam per lb. water evaporated
- Weak black liquor temperature and solids
- Sheet solids after the press section on dominant grades
- Sewer losses and sewer temperatures
- Uptime, cull and trim
- Thousands of gallons of fresh water per salable ton
- Exhaust stack temperatures and humidity readings

Monitoring and Continuous Improvement

Energy monitoring is a critical part of any study. The facility cannot optimize energy use that is not routinely measured. It is common accounting practice to allocate energy costs to unit processes and this practice can lead to misallocation of these costs. Key areas that need to be monitored for each unit process include:

- Steam flows from each header
- Energy consumption – electricity, natural gas and/or biomass
- Fresh water use
- Sewer flows and temperatures
- Condensate return

Not only can allocation accounting be inaccurate, it can also be counterproductive to a continuous improvement energy reduction culture. For example, if paper machine clothing costs are kept as an actual line item and energy is allocated, the measurement system will pressure operations to use long life clothing verses more expensive clothing that is more energy efficient. One critical component of a best practice energy study is to determine the "health" of mill energy monitoring systems.

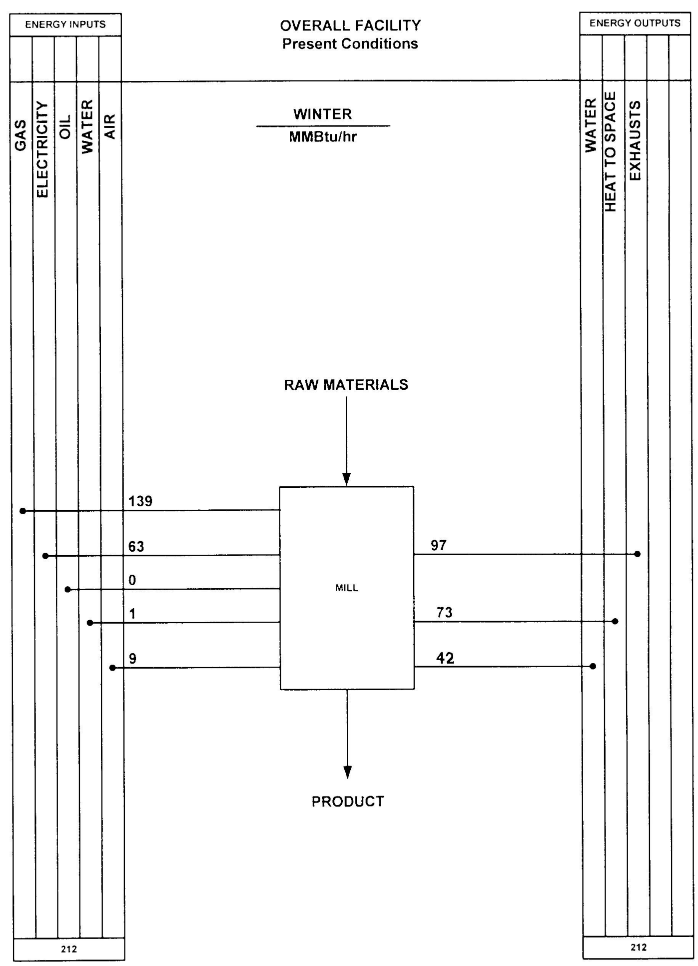
It is also critical to understand the process and the interactions between energy, quality, productivity, maintenance and safety. The most energy efficient way of operating may not be the best way in all cases.

Energy Inputs, Outputs and Energy/Mass Balances

Balances for energy and mass are the best way to look at the overall mill efficiency. An energy balance diagrammatically documents energy inputs and outputs, the energy flow and the transformation of energy within an area. Mass balance determines yield, loss of product or chemical and "deadload" all of which can affect energy reduction. The intent of this guidebook is to improve the energy efficiency of mill processes, and that is where our discussion will focus. Energy balance models are expensive and usually reserved for use after an energy reduction plan is formulated. Energy balance models can be developed for the entire facility, for unit operations and for major pieces of equipment. The scope of a study will determine necessity. Summer and winter conditions also must be considered.

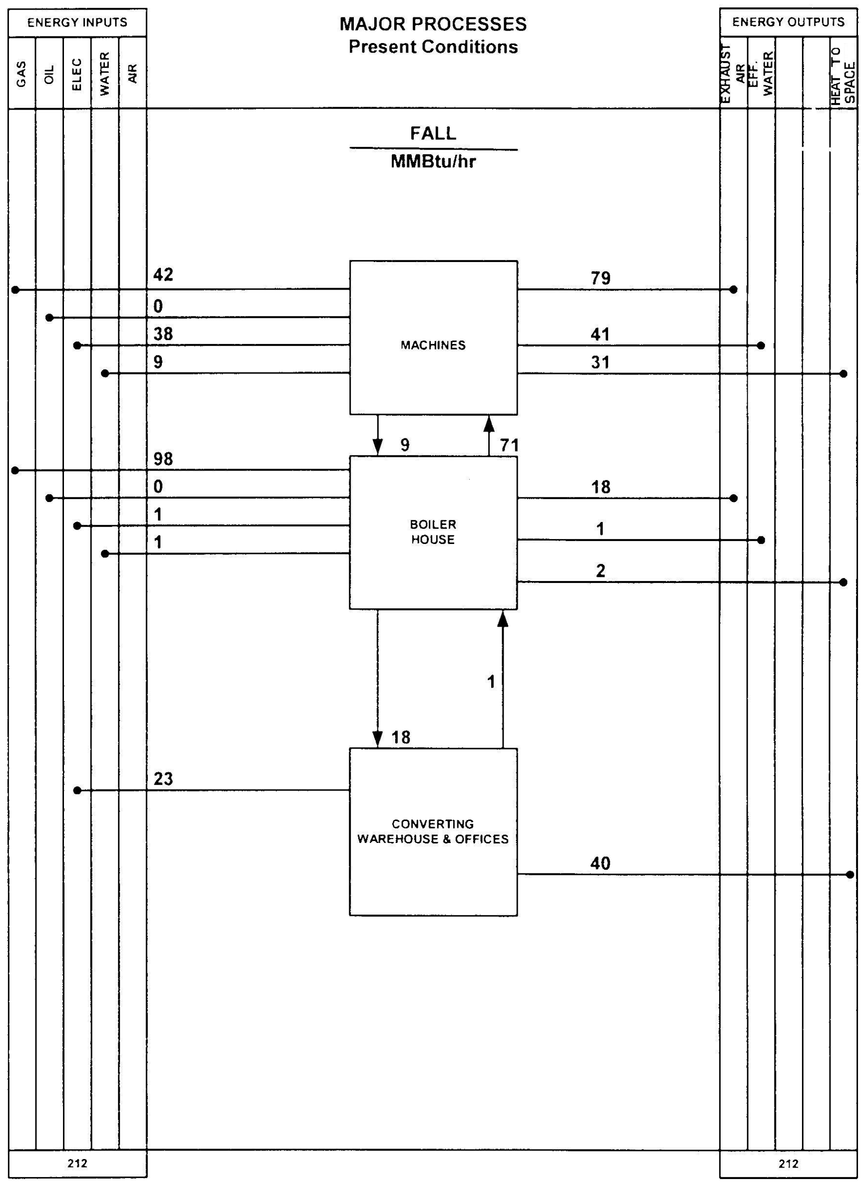
Figure 3 exemplifies an overall mill balance which will be expanded to illustrate a comprehensive energy balance. The left side shows inputs, which are well-understood by many operators and engineers. The right side shows outputs, **which are typically not well documented or understood**. All figures must me expressed in the same units - typically MMBtu's per hour. Input values for air and water are based on a given ambient temperature. Typically "heat to space" is obtained by subtraction, as it is difficult to measure.

Figure 3: Example of an Overall Mill Balance – Energy Input Equals Energy Output



The next level of detail is to produce balances for each unit of operation. To keep the balances relatively simple, a non integrated facility with three unit operations has been selected. These results are shown in **Figure 4**.

Figure 4: Sample Energy Balance with Three Units of Operation



The next level of detail is to insert major equipment and major systems (**Figure 5**). To keep the diagram relatively simple only the machines and two systems (steam and power) have been selected. Note that the overall energy use of 212 MMBtu per **hour** remains constant, but there is considerable interaction between systems and processes. Also, note that only machine 2 has a heat recovery system (lower right side of the machine block).

Figure 5: Energy Balance Before Best Practices

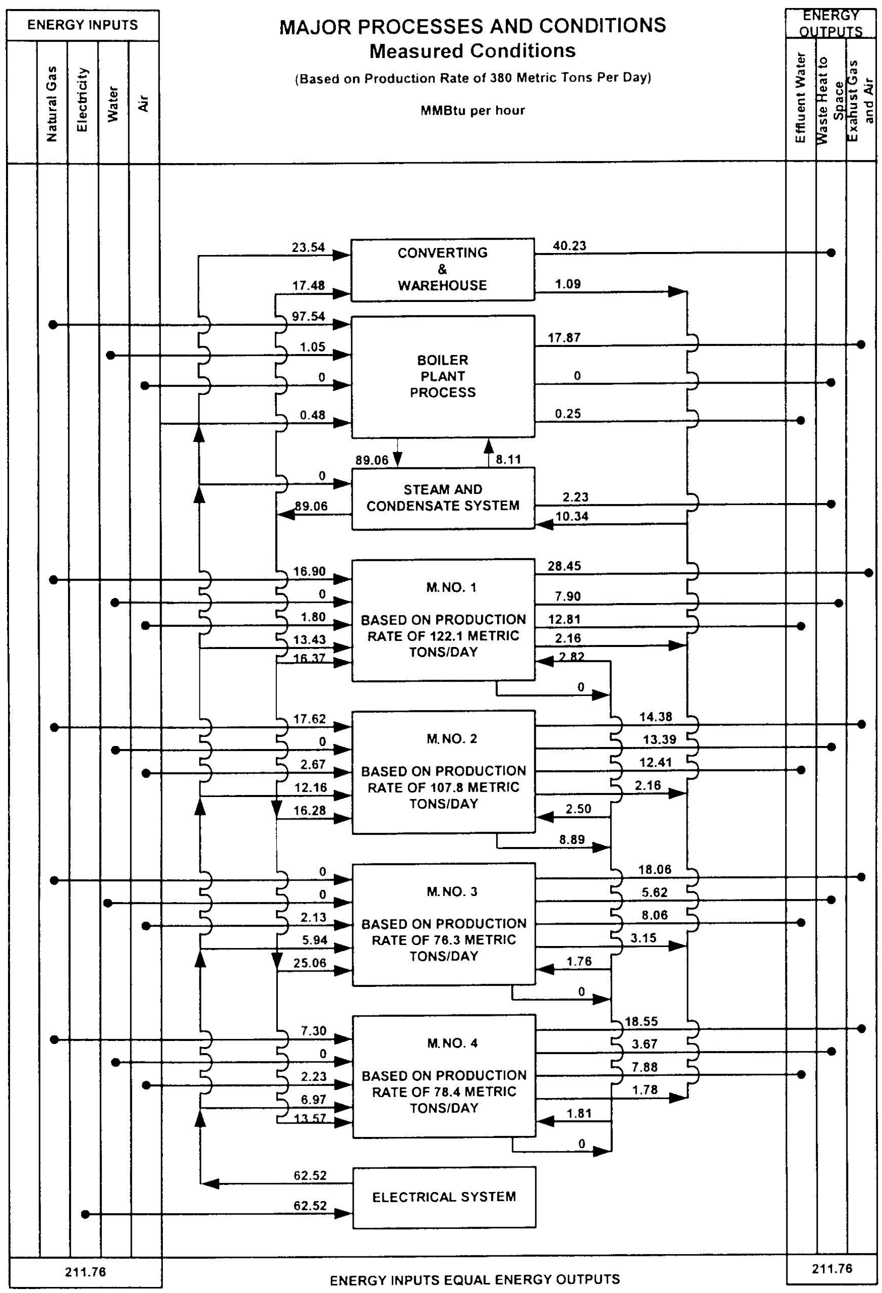
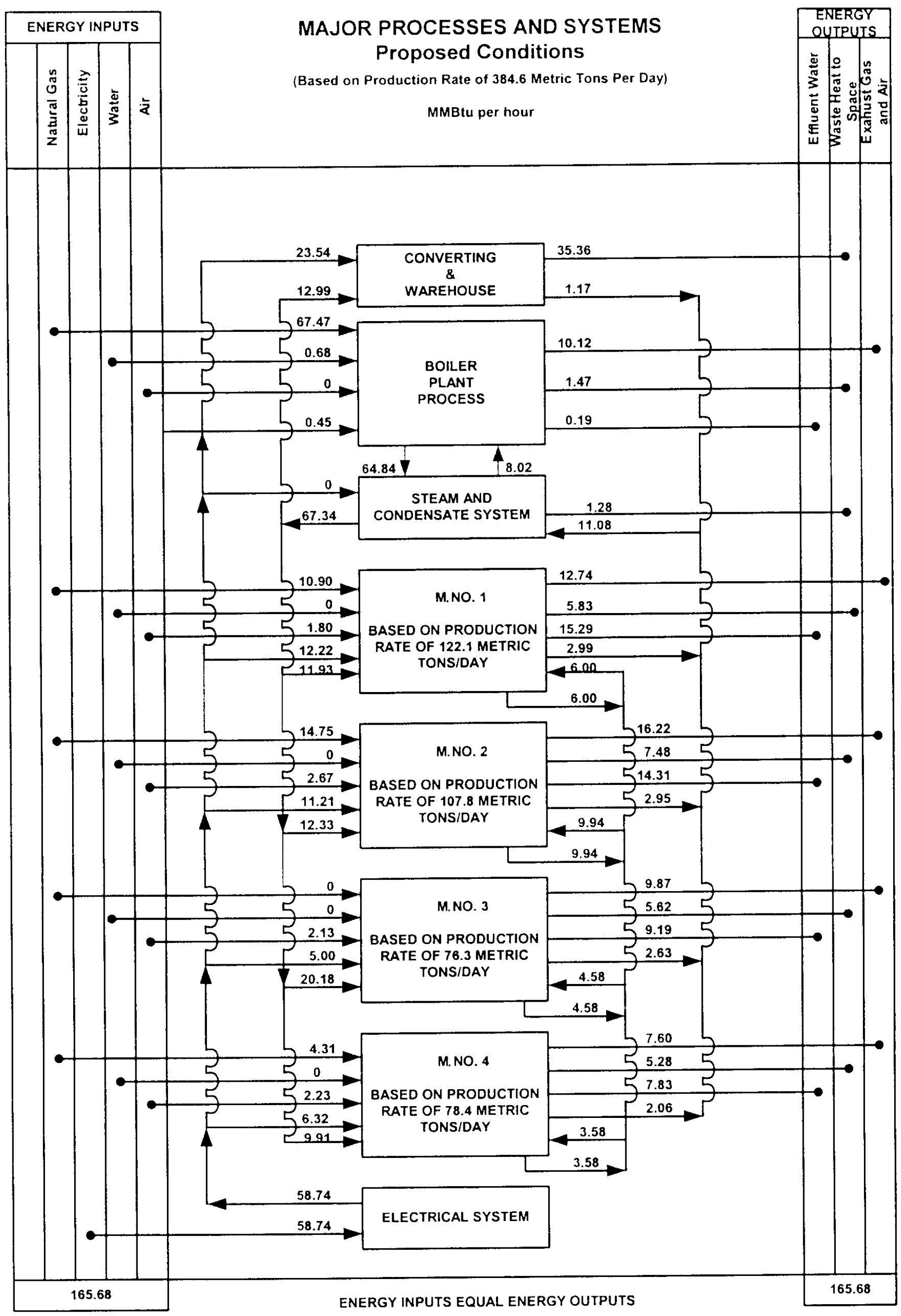


Figure 6 shows how the energy balance changes after implementation of best practices. Note that the recommended balance has a total use of 166 MMBtu per hour, or a reduction of 46 MMBtu per hour (~22%). One of the proposed changes was to increase heat recovery from 8.89 MMBtu per hour to 24.1 MMBtu per hour. This is a net reduction of ~16 MMBtu per hour and is 34% of the proposed 46 MMBtu per hour reduction.

Figure 6: Energy Balance After Best Practices – Net Energy Reduction of 22%



Analysis and Identification of Opportunities

There are only a limited number of ways to reduce energy consumption. Any energy study and master plan must focus on these approaches. They include:

- Eliminate the source (e.g., eliminate or shut off pumps, fans, steam flows)
- Increase system efficiency (e.g., increase black liquor solids and post press solids). System efficiency includes using the mass balance to eliminate losses and to minimize “deadloads” such as carbonate in the recovery cycle
- Reclaim heat (e.g., return condensate, displace primary heat with secondary heat)

Elimination: The first step is the simplest and can be the most surprising. For each process and function, ask the question, ”Is this process/equipment really necessary to meet the demands of the facility?” When the answer is “NO” the easiest savings are discovered. Elimination will probably involve operator retraining as certain procedures will change as equipment is eliminated or sidelined. Elimination can also reduce maintenance and inventory, thereby reducing operating overhead. Examples of opportunities to eliminate energy consumption include:

- As energy is reduced, partly utilized or standby boilers can be sidelined
- Gravity systems may supplant pumps and conveyors
- Felt dryer cans may be eliminated
- Low pressure receivers may eliminate condensate pumps
- As systems are eliminated, spare pumps and agitators can be removed
- In the summer months, steam heating coil valves may be turned off
- Live steam for water heating may be eliminated
- Eliminate stuff box recirculation (see Best Practice PM 7 for details)

System Efficiency: When equipment, processes and systems cannot be eliminated, evaluate increasing efficiency. This step requires process/system expertise and knowledge of new, available energy saving techniques. Since it is not effective to look at everything, it apply the 80/20 rule. Look at the ~20% of the equipment, processes and systems that use ~80% of the energy. Energy balances can be used to establish priority. In an integrated mill, the two largest users of thermal energy are paper machine dryers and black liquor evaporators. The largest power user is typically the “pumping system” (sometimes as high as 31%) so these are examples of places to start. The best practice strategy is to:

- Minimize water amount to be evaporated by the dryer cans and black liquor evaporators
- Optimize the performance of high energy users like pumping systems
- Use the form of steam, water, air and vacuum that is appropriate for the process
- Minimize all energy losses
- Minimize all recirculation
- Minimize all pressure drops
- Minimize fresh water consumption

On the later point, a common "mill myth" is that, if water is saved, the temperature of the effluent will increase proportionally. Numerous case histories have shown that the increase is disproportional and energy is saved. If there is a difference of 60℉ between inlet and effluent temperatures, then for every million gallons of effluent saved, ~18,000 pounds of 60 pound per square inch (psi) steam may be saved.

Heat Recovery: After unnecessary equipment and processes are eliminated, and the remaining equipment and processes are made as energy efficient as economically possible, heat recovery must be considered. Recovered heat can be used is to increase the temperature of process water and to heat make up air. Each of these has a major capital and maintenance cost that must have a payback meeting mill/corporate hurdle rates. Typical opportunities for heat recovery include:

- Return a high percentage of dryer can steam condensate
- Recover and reuse process water
- Recover heat from exhaust stacks and vents. There are three major types of air heat recovery systems:
    - air to air
    - air to water
    - air to glycol
- Note that it is not generally possible to recover heat from moderate temperature water which is why water conservation can have a "double impact."

Tools such as WinGEMS (simulation software that is commonly used in the pulp and paper industry) and pinch studies are useful in identifying the most cost effective heat recovery opportunities and the best use of the recovered heat. Interactions with other systems and the remainder of the mill are important considerations.

Essential Elements: Energy reduction is typically a cross functional, multi-year event. A master plan cuts across departments and functions. **A mill-wide perspective is critical and best achieved by mill management.** A master plan can be the purpose of an energy study or it can be developed by integrating energy saving ideas from a comprehensive energy study with mill business objectives. A master plan is always more effective than several disconnected projects. Essential elements of a best practice study include:

- A robust scope definition
- Quality pre-work
- Data based use of the 80/20 rule
- Evaluate the facility energy monitoring system
- Obtain critical energy balances
- Eliminate energy users
- Improve system efficiency
- Recover heat
- Management driven implementation

BEST PRACTICES

The pulp and paper industry best practices included in this document were compiled by the development team from literature reviews, personal experience and interviews with mill and vendor personnel. In most cases resources for additional information are provided. The best practices are separated into categories as reflected below in **Table 2**. The numbers associated with an individual best practice has no significance other than to identify it.

Table 3 is a list of all the best practices included in this guidebook. A **checklist** for these best practices that could be used to ensure proper consideration is in **Appendix A**. The Best practices in this section primarily relate to process energy use typically unique to the Pulp and Paper industry. Additional best practices for common support systems that are found in most industrial facilities, such as lighting and compressed air systems, are located in **Appendix B**. These should also be reviewed for energy cost reduction opportunities for these common systems.

Table 2: Best Practice Prefix Description

Prefix	Description
CPM	Chemical Pulp Mill
MW	Mill Wide
PM	Paper Machine
SFP	Secondary Fiber Plant
TMP	Thermal-mechanical (ground wood) Pulp Mill
UTL	Utility Plant
WY	Wood Yard

Table 3: Pulp and Paper Energy Best Practices

Area	#	Title
CPM	1	Lime Kiln Oxygen Enrichment
CPM	2	Carbon Dioxide Washing Aid
CPM	3	Digester Blow Heat Recovery System
CPM	4	Use of Pulping Aids to Improve Yields
CPM	5	Tertiary and Quaternary Combustion Air
CPM	6	Replace Wet Scrubbers with Electrostatic Precipitators
CPM	7	High Pressure Shower for Lime-Mud Pre-coat Filter
CPM	8	Solid Fueled Lime Kiln
CPM	9	Reline Lime Kiln Using High Performance Refractory
CPM	10	Efficient Bleaching Chemical Mixing in the Pulp Mill
MW	1	Stop Compressed Air, Water and Steam System Leaks
MW	2	Collect and Reuse Mill Hot Water
MW	3	Use Variable Frequency Drives on Motors with Variable Loads
MW	4	Use High Efficiency Motors
MW	5	Idle Equipment
MW	6	Minimize Pressure Drops

MW	7	Install and Use Real Time Energy Monitoring Systems
MW	8	Reduce Fresh Water Consumption
MW	9	Install Secondary and Tertiary Heat Recovery Systems
MW	10	Optimizing Pump Efficiency
MW	11	Capture Whitewater Waste Heat to Pre-Heat Mill Water
PM	1	Use Dryer Bars and Stationary Siphons in “Rimming” Dryers
PM	2	Keep Dryer Section Exhaust Humidity at Optimal Levels
PM	3	Use a Dryer Management System
PM	4	Operate Pocket Ventilation Between 180-195°F
PM	5	Use a Shoe Press in the Press Section
PM	6	Wet-Dry End Broke Surge Tanks
PM	7	Variable Speed Thick Stock Basis Weight Control
PM	8	Heat Felt Water
PM	9	Dryer Section Performance Monitoring
PM	10	Use Clarified Water as Vacuum Pump Seal Water
PM	11	High Performance Coater Air Dryer Nozzles
PM	12	Paper Machine Hood Heat Recovery
PM	13	Use Low Pressure Steam in Paper Machine Dryer Section
PM	14	Use Air Impingement Dryers for Coater In Place of Infra-Red Dryers
SFP	1	Secondary Fiber High Efficiency Pulper Rotors
SFP	2	Re-Pulping in a Continuous
SFP	3	Install Mid-Consistency Drum Pulper
TMP	1	Recover Heat from Latency Chest Vent
TMP	2	Use Load Management in Refining
TMP	3	Increase Rotational Speed of TMP Refiners
TMP	4	Minimize Steam Blow Through in TMP Refiners
TMP	5	Use Heat Recovery to Generate Hot Water
TMP	6	Use Heat Recovery to Generate Steam
UTL	1	High Solids Firing of Black Liquor in Recovery Boilers
UTL	2	High Temperature Video Monitors
UTL	3	Incinerate VOCs in Existing Sources
UTL	4	Modified Sootblower Operation
UTL	5	Improving Industrial Powerhouse Energy Operations w/Energy Mgmt.
UTL	6	Air Heater Tube Replacement
UTL	7	Upgrade the Boiler Burner
UTL	8	Reduct Forced Draft Fan Inlets
UTL	9	Distributed Boiler Control System
UTL	10	Optimize Bark Boiler Steam Generation
UTL	11	Automate Boiler Blow Down Controls
UTL	12	Recover Heat from Boiler Blow Down
WY	1	Automated Chip Handling and Thickness Screening

Best Practices Unit Definitions and Baseline

English (US) units will be used unless otherwise stated. The major energy units used are millions of Btu's (MMBtu) and kilowatt hours (kWh). Costs were arbitrarily selected as:

- $5.00 per MMBtu
- $0.045 per kWh ($275 per hp-year)
- $50 per ton of bone-dry wood (BD)

Standard sizes are required in a few cases. Those selected were:

- Mill=1,000 tons per day (tpd)
- Machine=800 tons per day
- Pulper=18 foot diameter with 60 inch rotor

CPM 1 - Lime Kiln Oxygen Enrichment

Best Practice Description	Oxygen is injected into the air stream feeding the lime kiln burners. The resultant kiln temperatures are hotter and give rise to fuel efficiency.
Primary Area/Process	This technique is applied to the lime kiln used to calcine lime in the pulping process.
Typical Energy Savings	Energy savings of 7% to12% have been documented and manufacturers make claims of up to 50% energy savings. In dollar denomination the documented savings would result in $35,000 to $60,000 annual savings.
Return on Investment	This is a low capital project that should cost less than $100,000. The offset is the cost of oxygen versus fuel cost. ROI is between 35% and 60%.
Stage of Acceptance	This is well known technology that is not widely adopted.
Practical Notes	Using oxygen enhances the through-put of the lime kiln and does a better job of calcining. The system can be turned on or off at will, depending on the cost of fuel and oxygen.
Specific Applications & Limitations	This technology is only applicable to sulfate based virgin pulp mills.
Resources	For information on this technology see: "Use of Oxygen Enrichment for Calciner Operation" By: Jake Swaney, Crestbrook Forest Industries, <u>Energy Conservation Opportunities 1981-1994</u> pp KP-6, Pulp and Paper Technical Association of Canada Montreal, QC Canada. There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	In addition to energy efficiency, this technology results in fewer emissions. Some mills install oxygen enrichment to satisfy air emission requirements.
Typical Productivity Impact	Using oxygen enhancement allows higher kiln temperatures that increase kiln capacity. If a mill is short of calcining capacity this technology can address that shortfall.

CPM 2 - Carbon Dioxide Washing Aid

Best Practice Description	Adding carbon dioxide to brown stock washers improves washer efficiency. The improved efficiency can manifest itself as increased production, lower wash water volume and/or decreased liquor carry-over.
Primary Area/Process	The technology is applicable to brown stock washers in the pulp mill.
Typical Energy Savings	The addition of carbon dioxide to the brown stock washing cycle allows a 10% reduction in wash water.
Return on Investment	This is not a capital intensive technology, but it is only available through a royalty agreement with the suppliers of carbon dioxide. ROI does not apply. The typical measure of success is the offset between cost and savings.
Stage of Acceptance	This is a new technology that has not been widely adopted.
Practical Notes	The technology has the potential to reduce bleach load and/or improve the quality of pulp going to the paper machines.
Specific Applications & Limitations	This technology is limited to paper mills that produce virgin pulp on-site.
Resources	“Brownstock Washing with Carbon Dioxide” PAPRICAN, Pointe-Claire, CANADA There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Using carbon dioxide as a washing aid decreases black-liquor carryover, which in turn reduces the consumption of bleach chemicals and/or drainage and formation aids.
Typical Productivity Impact	This technology can either improve existing washing or enhance washer throughput. Better pulp usually translates into better operations and productivity.

CPM 3 - Digester Blow Heat Recovery System

Best Practice Description	A digester blow heat system captures thermal energy from digester blow gasses. The thermal energy is typically used to heat shower water for use in the pulp mill.
Primary Area/Process	This technology is employed in the pulp mill area.
Typical Energy Savings	In a 1000 tons per day pulp mill up to 200 MMBtu per day can be recaptured. If all of this heat can be used the potential economic payback is $350,000 per year.
Return on Investment	This is a capital intensive project. Payback is a function of the mill's need for low-grade heat and fuel costs. Capital costs for this type of installation range between $2 to 3 million, resulting in an ROI of 12% to 15%.
Stage of Acceptance	This is a well known, but not widely adopted technology.
Practical Notes	Mills are required to condense digester blow gasses as part of their environmental permit. This is an add-on which reclaims the heat from condensation.
Specific Applications & Limitations	This technology is limited to paper mills using on-site virgin pulping.
Resources	"Georgia Pacific: Crossett Mill Identifies Heat Recovery and Operational Improvements that May Save $9.6 Million Annually", US Department of Energy Industrial Technologies Program, Phone: 800-862-2086, clearinghouse@ee.doe.gov "Pulp and Paper Case Study, Heat Recovery Opportunities at the Smurfit-Stone Mill in La Tuque" Canmet Energy, Technology Centre-Varennes Varennes, Quebec, Canada There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	The heat used in pulp making is already being generated through fuel combustion, reclaiming and reusing residual heat means less fuel has to be burned.
Typical Productivity Impact	Blow heat recovery has no impact on productivity.

CPM 4 - Use of Pulping Aids to Improve Yields

Best Practice Description	Although the exact mechanisms are not fully understood the addition of anthraquinone and/or polysulfides to pulp digesters enhances liquor penetration and improves cellulose yields.
Primary Area/Process	This technology is used in pulp mill digesters.
Typical Energy Savings	The use of pulping aids improves yield. Mills can either improve productivity or maintain productivity at a lower cooking time and temperature. In some studies overall savings per ton of bleached pulp are pegged at $19.50 per ton after accounting for the additional chemicals. In a typical pulp mill this could amount to $7 million per year.
Return on Investment	Since this is not a capital-intensive expenditure the ROI is not relevant. In practice the financial viability is measured by fiber savings versus cost of chemical. In most mills, the cost of the additive is less than the fiber savings.
Stage of Acceptance	This is well-known technology which is currently employed in mills whose wood and/or energy costs justify application.
Practical Notes	In addition to improved yields and lower steam consumption pulp quality and uniformity are improved.
Specific Applications & Limitations	Limited to paper mills that self-generate virgin pulp.
Resources	For information regarding this technology see: “A Dynamic Model of Kraft-anthraquinone Pulping” Thesis dissertation by: Mark Burazin IPST Anthraquinone Pulping: A TAPPI PRESS Anthology of Published Papers, TAPPI Press, Atlanta, GA There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	More pulp can be made from the same amount of incoming wood, or conversely less wood can be used to make the same amount of finished pulp.
Typical Productivity Impact	The use of pulping aids can either decrease energy and wood consumption or allow the mill to produce more pulp from the same amount of wood and energy.

CPM 5 - Tertiary and Quaternary Combustion Air

Best Practice Description	Most recovery boilers in the United States have three stages of air injection and only use the tertiary stage reluctantly. By enhanced use of the tertiary stage and installing and using a quaternary air injection port, mills can minimize carry over and tube fouling.
Primary Area/Process	This technology is used in pulp mill/recovery boiler
Typical Energy Savings	The frequency of water washing the recovery boiler can be reduced which means the boiler does not have to be brought up to temperature using natural gas or oil. A typical recovery reheat consumes 10 MMBtu which cost about $50,000.
Return on Investment	A quaternary air system can be installed for $300,000 to $500,000 depending on site specifics. The ROI on this project, including additional productivity contribution, ranges from 50% to 80%.
Stage of Acceptance	This is innovative technology and not widely adapted. All new recovery boilers feature this technology, but few existing boilers have been retrofitted.
Practical Notes	Improved air injection may enhance combustion efficiency. Retrofits are not for the timid. In new boilers, it is easier to model outcomes.
Specific Applications & Limitations	None.
Resources	1) "Recovery Boiler Technology in Japan" , Author: Honghi Tran, Pulp and Paper Center, University of Toronto. 2) United States Patent 6742463 "Combustion Air System for Recovery Boilers, Burning Spent Liquors from Pulping Process" There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Installing additional air injection also helps improve reduction efficiency leading to lower sulfur emissions and allow better control of NO_X.
Typical Productivity Impact	A "cold iron" recovery boiler outage typically requires a minimum of 48 hours. As specific profit margin on the incremental tons is significantly higher than the margin on average tons, eliminating one outage per year can gain 5.5% output with only variable cost inputs.

CPM 6 - Replace Wet Scrubbers with Electrostatic Precipitators

Best Practice Description	Traditionally lime kiln stacks have used wet scrubbers to control particulate emissions. The resultant effluent stream is recycled through the lime mud filter to recapture the solids. By using an electrostatic precipitator the particulate is captured in a dry form and can be injected directly into the lime kiln with no residual moisture.
Primary Area/Process	This technology is in the pulp mill area/lime kiln.
Typical Energy Savings	For every 1% reduction in moisture in the lime mud feeding the kiln energy consumption is reduced 46.4 MMBtu. Typical installations decrease water load to the kiln by 0.2% to 0.7%. Typical operating savings range from $10,000 to $30,000 annually.
Return on Investment	This is a capital-intensive project, and typically implemented for environmental reasons as many mills are being mandated to upgrade their kiln emissions to meet new emission limitation Maximum Achievable Control Technology (MACT) criteria. The difference in cost between a new scrubber and an electrostatic precipitator system is less than $300,000. The ROI on this project is between 3% and 10%.
Stage of Acceptance	This is an older technology, not yet widely adopted.
Practical Notes	Scrubbers require energy to circulate capture water while precipitators don't. The potential energy savings do not include recirculation energy savings.
Specific Applications & Limitations	This technology is limited to virgin Kraft pulp mills using lime kilns.
Resources	For information on this technology see: "Emission Control Technology" www.epa.gov/ttn/caaa/t3/reports/kraft_tsd/ch3-ptl.pdf There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	The electrostatic precipitator approach decreases fuel and power consumption.
Typical Productivity Impact	This device should not impact productivity. The simplistic nature of the product should decrease maintenance in the causticizing area.

CPM 7 - High Pressure Shower for Lime-Mud Pre-coat Filter

Best Practice Description	Lime mud filters use the solids in the solution being filtered to form a filter mat which de-waters the suspension. As the thickness of the mat increases, the dewatering efficiency decreases. By controlling the mat thickness and occasionally disrupting it with high pressure showers the overall efficiency is enhanced.
Primary Area/Process	This technology is in the pulp mill causticizing area.
Typical Energy Savings	For every 1% increase in solids energy consumption is reduced by 46.4 MMBtu per ton of throughput. Typical increases in solids range from 0.1% to 0.5% which results in energy savings of $5,000 to $25,000 per year.
Return on Investment	High pressure shower/doctor combinations can be retrofitted for $50,000 or less. The ROI on this project ranges from 10% to 50% per annum.
Stage of Acceptance	This technology is widely known, but not widely adopted in older mills. All new lime mud filters come with devices; about 50% of old filters have been retrofitted.
Practical Notes	Using a continuous shower on the pre-coat filters eliminates the moisture swings induced by traditional mechanical doctors. The more uniform feed moisture allows better optimization of kiln burners.
Specific Applications & Limitations	This technology is limited to pulp mills using lime kilns (i.e. Kraft mills).
Resources	For general information contact: Dr. Howard (Jeff) Empie, IPST Phone: 404-894-9708 e-mail: jeff.empie@ipst.gatech.edu There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Fewer emissions due to decreased fuel burning.
Typical Productivity Impact	This installation should not adversely impact operations or productivity. If the facility is lime kiln limited, this technology may allow increased through-put.

CPM 8 – Solid Fueled Lime Kiln

Best Practice Description	Lime kilns typically use gaseous or liquid fuels to process lime mud. By using solid fuel directly or installing a solid fuel gasifier mills can use residual renewable or other solid fuels.
Primary Area/Process	This technology is in the pulp mill/lime kiln
Typical Energy Savings	This process change does not improve energy efficiency, but it does improve the utilization of lower grade fuels.
Return on Investment	This is a capital-intensive project. The cost of an installed gasifier ranges from $2 million to $5 million. Dependant on the mill's existing fuel source cost the project may or may not have a financial return. In general, residual/solid fuels cost are about half as expensive as fossil fuels. On a typical lime kiln, annual savings would be about $2.4 million for an ROI range of 40% to 120%.
Stage of Acceptance	This is innovative technology not widely implemented. During the early 1980's several projects were implemented, but as the price of fossil fuels declined further conversions were not economically viable.
Practical Notes	For this type of project to succeed the mill must have access to a low-cost residual or solid fuel. Wood derived gas needs to be dried and perhaps supplemented with higher specific Btu fuels.
Specific Applications & Limitations	None
Resources	See: "Petcoke Firing in Lime Recovery Kilns Becomes an Option as Energy Costs Rise" By: Richard Manning, et.al., Pulp and Paper, December 2003 Power & Energy Also see: "Experiences of Foster Wheeler Fluidized Bed Gasification" www.gastechnology.org There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	In addition to increased utilization of solid fuels this technology allows the use of high sulfur fuels. The sulfur is captured by the calcium oxide and is beneficial in the pulping process. Also renewable biomass can be used.
Typical Productivity Impact	None

CPM 9 - Reline Lime Kiln Using High Performance Refractory

Best Practice Description	Relining a lime kiln is a routine maintenance event. With increasing fossil fuel costs mills should re-examine their choice of lining materials to assure they are using the best available insulating refractory.
Primary Area/Process	This technology is in the pulp mill area/lime kiln.
Typical Energy Savings	This is new technology with only empirical information. The manufacturer claims energy savings of 5%. In a typical mill this would result in an annual savings of $250,000.
Return on Investment	The difference in cost between standard and high performance is less than $20,000 for a typical kiln. The ROI is well in excess of 100%.
Stage of Acceptance	This is new technology which has not yet been widely adopted.
Practical Notes	In addition to offering energy savings, the new insulation offers the potential of a “gunned” application as opposed to the typical “brick lay-up” technique.
Specific Applications & Limitations	This technology only applies to mills with lime kilns (i.e. Kraft mills).
Resources	For information on this technology see:” Monolithic Refractory Material” US DOE Office of Industrial Technology. There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Save fossil fuel.
Typical Productivity Impact	Since the refractory is gun-applied, installation takes less time than the traditional bricking method. This could increase lime kiln “up” time.

CPM 10 - Efficient Bleaching Chemical Mixing in the Pulp Mill

Best Practice Description	Improving mixing efficiency lowers chemical consumption and energy requirements to run the bleaching process.
Primary Area/Process	This mixer improvement technology is on the front end of the process in medium consistency pulp.
Typical Energy Savings	New mixers may operate at as much as 70% less horsepower than older style mixers, reducing energy costs by as much as $100,000.
Return on Investment	This information is not currently available.
Stage of Acceptance	Innovative, but not widely known or adopted.
Practical Notes	Increased mixing efficiency can lower chemical use and more quickly get chlorine dioxide in contact with fibers before off-gassing. Reducing chemical use also reduces the burden on the wastewater treatment facility.
Specific Applications & Limitations	This best practice focuses on the front end of the bleaching process.
Resources	TAPPI, Online Exclusives, May 2003: New Mixer Reduces Energy Costs, Chemical Consumption at Pulp Facility. By David Lazare
Typical Environmental Benefits	Reduced chemical use and wastewater treatment, resulting in higher quality effluent.
Typical Productivity Impact	Could result in less manpower needed to load and monitor chemical addition systems.

MW 1 - Stop Compressed Air, Water and Steam System Leaks

Best Practice Description	The use of ultrasonic detection equipment allows the mill to locate compressed air and steam leaks during normal operations.
Primary Area/Process	This technology can be used throughout the mill.
Typical Energy Savings	In studies of typical mills it has been found that air leaks and inappropriate uses waste as much as 20% to 30 % of mill compressed air. In a typical mill with multiple air compressors the connected load can easily exceed 1,000 hp. If the mill can eliminate half the leaks and save 100 hp, the financial impact is $27,500 per year. Steam leaks can waste several hundred lbs per hour of condensate and energy. If leaks totaling 500 lbs per hour can be found and repaired the financial impact is $25,000.
Return on Investment	Ultrasonic detection equipment is inexpensive ($5000 to $10,000) and involves minimal training. A new system can easily generate in excess of 100% ROI.
Stage of Acceptance	This is a well known and widely adopted technology.
Practical Notes	Steam or compressed air leaks cause lower operating pressures for the system especially in isolated areas. This lower pressure can cause equipment malfunctions.
Specific Applications & Limitations	The primary limitation isn't the technology, but rather implementation. Historical emphasis on minimal staffing and the unwillingness to have extra people present on a shutdown can hinder some programs that would otherwise be effective.
Resources	Many trade journal articles support this best practice. A good source for additional information is the Department of Energy Web site. http://www.energy.gov
Typical Environmental Benefits	In addition to the positive impact of conserving electricity this technology can conserve water and fossil fuel.
Typical Productivity Impact	This best practice can have a positive impact on productivity by identifying problems before they slow down production.

MW 2 - Collect and Reuse Mill Hot Water

Best Practice Description	This best practice focuses on the classification/ collection and reuse of mill hot water streams. Most mills employ some degree of water reuse in their processes, but in some cases the water being recycled does not represent the best available option.
Primary Area/Process	This technology can be applied throughout the paper mill.
Typical Energy Savings	The energy savings available are a function of specific mill design, accordingly typical energy savings numbers are not applicable.
Return on Investment	A well designed water reuse plan that considers water quality including enthalpy will typically have an ROI of 30% to 50%.
Stage of Acceptance	This technology is well known and widely adopted.
Practical Notes	Conserving water is not a new idea, but not every recycling effort classifies and ranks waste streams based on their energy content. Mills need to consider seasonal conditions and formulate specific plans for specific conditions.
Specific Applications & Limitations	The only limitation to this technology is the process need. Some mills have more low-grade heat than they can profitably use.
Resources	For more technical information regarding this best practice see: US Department of Energy Office of Industrial Technologies Web site: www.**oit**.**doe**.gov There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Selectively recycling process effluent streams can eliminate the need to treat incoming water and reduce the amount of effluent the mill generates.
Typical Productivity Impact	Implementing this best practice should not impact mill productivity.

MW 3 - Use Variable Frequency Drives on Motors with Variable Loads

Best Practice Description	Variable frequency drives (VFD) alter motor output speeds to match the application requirement. They can be used to replace recirculation or throttling valves on water or condensate lines and to replace inlet or outlet vane dampers on fans.
Primary Area/Process	This technology can be used on rotating equipment throughout the mill. Agitators, pumps, fans and blowers are good candidates for variable speed drive implementation.
Typical Energy Savings	There are many applications where energy is wasted by employing a fixed-speed drive to accomplish a variable output. In mill studies, over 20% of all rotating equipment could employ variable-speed technology.
Return on Investment	Variable-speed technology has become affordable; in the optimal cases, ROI can range from 25% to 70%.
Stage of Acceptance	This is a widely known and widely accepted technology. Modern mills are equipped with VFD and they are gaining acceptance in older mills in retrofit applications.
Practical Notes	The implementation of variable speed drives can also allow the mill to "fine tune" processes. The process of matching loads and drives also means less stress on equipment leading to lower maintenance costs.
Specific Applications & Limitations	The primary limitation is not the technology, but rather the time required to identify, engineer and install the drives.
Resources	Most drive manufacturers offer some version of the variable-speed drive. For more energy related information see the US Department of Energy's Web site: www.**oit**.**doe**.gov There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	The primary environmental benefit stems from the decreased consumption of electricity.
Typical Productivity Impact	This technology offers the opportunity to more closely integrate variable processes throughout the mill. The enhanced integration can lead to improvements in uptime and productivity.

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MW 4 - Use High Efficiency Motors

Best Practice Description	Replace older, low efficiency motors with newer, high energy efficient motors.
Primary Area/Process	This technology can be applied mill wide to all electric motors.
Typical Energy Savings	Approximately 31% of paper mill electrical use is by pumps, 20% by fans, 5% by compressors and 44% by other equipment. Over half of the energy saving potential is available from changes to pumps and fans. The US Department of Energy estimates that average annual electric savings of $480,000 for each pulp mill, $680,000 for each paper mill and $500,000 for each board mill.
Return on Investment	The ROI to replace a new motor is low and typically not done. However, the incremental cost for a high efficiency motor is low, so the ROI for replacement is typically several hundred percent.
Stage of Acceptance	Well known and widely adopted.
Practical Notes	Typically this best practice is implemented when an existing motor is replaced or needs to go undergo significant repairs. The difficult parts are establishing a program and determining when it is economically justifiable to replace older operational motors.
Specific Applications & Limitations	No limitations
Resources	There are numerous examples of energy efficient motor use to be found on the US Department of Energy Web site: http://www.energy.gov
Typical Environmental Benefits	There will be reduced emissions from the power source directly related to the reduced consumption of electrical power.
Typical Productivity Impact	No productivity impacts are expected.

MW 5 - Idle Equipment

Best Practice Description	Idle non essential equipment when not in use.
Primary Area/Process	Areas where this action can be applied include: -spare refiners -second agitator in tanks and under-machine-pulpers -aerators in lagoons -recirculation loops -AC/heat in offices at night or weekends
Typical Energy Savings	Typical savings ~2,500 hp at $275 per hp-year, annual savings are approximately $688,000. Payback is huge even if the savings are small. Savings are greater if this lowers peak consumption due to utility pricing structure.
Return on Investment	Typically the investment is minimal, sometimes monitoring and control equipment with a typical cost in the tens of thousands. ROI ranges from 100% to 500%.
Stage of Acceptance	Well Known and widely used.
Practical Notes	Some operations require automation like the second agitator on the under-machine-pulpers being triggered by the break detector. There are typical increases in the life of equipment coupled with lower maintenance.
Specific Applications & Limitations	Not applicable to some "single line" operations which have no installed spares or where recirculation is required for mixing or control.
Resources	This best practice was documented from personal interviews and unpublished energy studies for major US paper companies.
Typical Environmental Benefits	This action lowers the environmental impact of the electrical generating facility in direct proportion to the energy saved.
Typical Productivity Impact	No productivity impacts are expected.

MW 6 - Minimize Pressure Drops

Best Practice Description	Design valves to control flows, not regulate them. Typical design is a single speed pump, a throttle valve and a trim valve. Best practice design is a variable speed pump and a trim valve for control.
Primary Area/Process	This technology applies to all pumping systems throughout the mill.
Typical Energy Savings	Savings of 10% to 20% of each installation are typical.
Return on Investment	This will be very specific to each application. Typically the ROI is 15% to 25% making this a replacement or rebuild opportunity.
Stage of Acceptance	Well known and widely used on new installations.
Practical Notes	These changes can also minimize process variations due to valve cavitations, etc. There will be many occasions where changes can only be justified when equipment is at the end of its useful life.
Specific Applications & Limitations	Greater results are achieved in areas of high-fluid flow.
Resources	This best practice was documented from personal interviews and tours of European mills which already use this best practice. Also see how a mill achieved 50% to 100% ROI just by trimming impellers in “Pump Study Shows BOISE Mill how to Cut Excess Use , Cost of Electricity”, by Gault and Rucker, in “Pulp and Paper”, May, 1986.
Typical Environmental Benefits	This will reduce emissions of the power generating facility in direct proportion to the electricity saved.

MW 7 - Install and Use Real Time Energy Monitoring Systems

Best Practice Description	Install an accurate, real time energy monitoring system. This will monitor energy on an hourly basis and report use for every unit operation in the mill. Establish use reduction goals and review them frequently with managers, supervisors and operators.
Primary Area/Process	This technology can be applied to all unit operations. Ideally it is applied to high energy unit operations first. Typical high energy users are evaporators and paper machines.
Typical Energy Savings	There is typically a 5% to 15% reduction in energy use by focusing on energy as a daily measured goal. Typical thermal usage for a US integrated mill is 25 MMBtu per ton (American Process Inc. data). 10% savings is 2.5 MMBtu per ton. For a 1,000 ton per day mill paying $5.00 per MMBtu this is $4.5 million. 10% savings in electric costs at $0.045 per kWh is $2 million for a 1,000 tpd mill. Annual savings are ~$6.5 million.
Return on Investment	The cost of monitoring systems varies, but typically are less than $6.5 million, giving an ROI greater than 100%.
Stage of Acceptance	Well known, but not widely practiced.
Practical Notes	One typical issue is getting buy-in from upper management or someone to sign the request for funds and commit to the energy savings. When the information is real-time the operators learn what measures work. Over time existing systems are operated at their minimum energy use.
Specific Applications & Limitations	The monitoring systems might not be installed in areas of low energy use (like the wood yard) due to real or perceived lack of a payback.
Resources	This best practice has been documented from personal interviews and experiences, and is also contained in numerous articles. See “Energy Monitoring Keeps Down Costs in Louisiana, by M. Broussard, V. Pylkkanen and T. Retsina in the 2003 TAPPI Engineering, Pulping and PCE&I Conference.
Typical Environmental Benefits	Mill emissions from boilers will be reduced 5% to 15% as well as emissions from power generating sources.
Typical Productivity Impact	No productivity impact is expected.

MW 8 - Reduce Fresh Water Consumption

Best Practice Description	Reducing your fresh water consumption significantly reduces the thermal energy leaving the typical mill discharging 20 million gallons per day. The low temperature (often <100°F) makes it uneconomical to attempt to recover heat, so reducing the fresh water consumption is the best practice.
Primary Area/Process	Typical measures include: -replace water seals with mechanical seals -use white water in “wash up” hoses -use white water to dilute converting broke -use white water for secondary fiber hydropulpers
Typical Energy Savings	Savings of 480 MMBtu per year are typical. For example, savings of 10% of the 175 million pounds of water per day are achievable. If the discharged water is 40°F hotter than the intake, annual savings are ~$1,260,000 based on a cost of $5.00 per MMBtu.
Economic Assessment	The ROI of water saving projects are typically greater than 100%.
Stage of Acceptance	Well known and widely adopted.
Practical Notes	There are equal or greater savings in reduced pumping and aeration costs. Water reduction eventually requires some degree of reuse. Some applications will require cleaning, conditioning or filtering.
Specific Applications & Limitations	Not applicable to mills in the bottom quartile of fresh water consumption.
Resources	There are numerous technical articles and mill energy studies documenting this best practice. See “Energy Reduction at a Kraft Mill” by Michael Towers on page 15 of the March, 2005 TAPPI Journal.
Typical Environmental Benefits	Reduced annual water use by 720 million gallons. Power generating equipment emissions will be reduced in proportion from either the mills generation equipment or the utility’s.
Typical Productivity Impact	None

MW 9 - Install Secondary and Tertiary Heat Recovery Systems

Best Practice Description	Install a heat exchanger to recover energy from hot sources and exhausts. Use this energy to heat make up air, make up water and process water.
Primary Area/Process	Typical examples include: -heat from machine hoods -heat from thermo-mechanical pulping (TMP) refiners -heat from boiler exhaust -heat from turbine exhaust
Typical Energy Savings	Typical thermal use for a US integrated mill is 25 MMBtu per ton. A 12% savings is 3 MMBtu per ton. At $5.00 per MMBtu that is $15 per foot. For a 1,000 ton per day (tpd) mill this is $15,000 per day or a savings of $5.4 million per year. Published pinch studies show 12% thermal energy savings.
Return on Investment	Selected heat recovery projects typically have a 25% to 200% ROI.
Stage of Acceptance	Well known and widely adopted. Widely used in the design of European mills for the last 25+ years.
Practical Notes	Pinch studies have also identified about 5% of thermal energy that can be saved through operational changes.
Specific Applications & Limitations	Recovery is most applicable in areas of the mill that have hot exhausts or high heat sources.
Resources	For one example See: "Energy Reduction at a Kraft Pulp Mill…" by Michael Towers on page 15 of the March 2003 TAPPI Journal. Also see two case histories in the article "Energy Conservation in Kraft Pulp Mills" by Borg and Chandra in the January 1987 issue of PIMA Magazine. Another reference is: "Conserving Energy in the Pulp Mill: A Review of Practical Experiences" by Borg in Pulp and Paper magazine, March, 1986.
Typical Environmental Benefits	There is the potential to reduce emissions from steam generating sources by 12%.
Typical Productivity Impact	None, unless the mill is steam or steam-permit limited.

MW 10 - Optimize Pump Efficiency

Best Practice Description	Correctly size pumps for the task at hand. Retrofit older pumps with variable frequency drives (VFDs). This technology reduces energy costs and is often cheaper than retrofitting with a smaller, more efficient pump.
Primary Area/Process	This technology can be used mill wide.
Typical Energy Savings	Some studies have indicated that many pulp and paper pumps are operating at less than 50% capacity, with about 10% operating below 10% capacity. Case studies have shown 50% or more energy savings.
Return on Investment	Varies on the baseline condition before implementation, but payback may be as little as one year for a ROI of over 100%.
Stage of Acceptance	Similar to the use of energy efficient motors and the use of VFDs for many applications, this technology is widely known and beginning to be implemented more widely.
Practical Notes	Optimizing pumping can result in minimized unscheduled downtime and reduces seal-replacement frequency and costs.
Specific Applications & Limitations	Implementing VFDs and taking advantage of their ability to tailor output to variable flow needs will require additional controls.
Resources	"Strategies for Optimizing Pump Efficiency and LCC Performance," by Mike Pemberton, TAPPI 2003 Fall Technical Conference.
Typical Environmental Benefits	Environmental benefits are linked to the reduced electrical consumption of the pumps.
Typical Productivity Impact	No productivity impact is expected.

MW 11 - Capture Whitewater Waste Heat to Pre-Heat Mill Water

Best Practice Description	Preheating fresh mill water with waste heat from whitewater reduces the steam needed to heat the mill water.
Primary Area/Process	This technology is applied to the fresh water coming into the mill.
Typical Energy Savings	Mississippi River Corporation reports reducing the energy to heat the mill water by one-third.
Return on Investment	There is insufficient data to calculate or estimate a payback or ROI at this time.
Stage of Acceptance	Widely known, but not widely adopted.
Practical Notes	Because white water fouls typical shell-and-tube heat exchangers, plant operators selected spiral heat exchangers for their ability to handle fluids with suspended fibers and particulate matter. It is reported that reducing the heat in the white water is also beneficial to the pulping process and allows for easier removal of contaminates during de-inking.
Specific Applications & Limitations	This best practice is targeted toward the fresh water coming into the mill.
Resources	TAPPI Online Exclusives: "Recycle Pulp Mill Cuts Energy Cost by One-third," Solutions!, September 2002.
Typical Environmental Benefits	Environmental benefits are in direct proportion to the reduced energy used to make steam, as well as the cooler water that is discharged.
Typical Productivity Impact	No productivity impact is expected.

PM 1 - Use Dryer Bars and Stationary Siphons in "Rimming" Dryers

Best Practice Description	By employing stationary siphons and dryer spoiler bars the amount of "blow-through" steam needed to remove the condensate from a paper dryer is minimized.
Primary Area/Process	This technology is applicable to the dryer section of the paper machine.
Typical Energy Savings	The steam saving associated with this technology range from 1,000 to 9,000+ lbs per hour. At a steam generation cost of $5/1,000 lbs this translates into potential savings of $35,000 to $300,000+ per year.
Return on Investment	The ROI is a function of the cost of modifying the existing steam supply and evacuation systems. Typically mills installing this technology see ROIs in the 25% to 80% range.
Stage of Acceptance	This is a well known and widely accepted technology with full adoption on new/rebuilt machines, but limited adoption on older machines.
Practical Notes	In addition to saving energy, this technology offers many other advantages ranging from more uniform cross machine direction temperature profiles to less steam consumption.
Specific Applications & Limitations	This technology is better applied to paper machines running with dryers in "rimming" condition.
Resources	There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	This technology minimizes the steam consumed in drying paper and can also reduce electrical consumption.
Typical Productivity Impact	Mills that have installed this technology report improved machine throughput, enhanced quality and faster recovery from upset conditions.

PM 2 - Keep Dryer Section Exhaust Humidity at Optimal Levels

Best Practice Description	The humidity of the air in the paper machine dryer hood is optimized for the best combination of productivity and energy efficiency.
Primary Area/Process	This technology is applicable to the paper machine dryer sections.
Typical Energy Savings	By employing good hood design and optimization energy savings of 3% to 5% can be realized. In a typical mill that can translate into financial savings in excess of $100,000 per annum.
Return on Investment	The ROI is a function of existing conditions and technology. If the hood is of modern design the ROI can be in the 30% to 50% range.
Stage of Acceptance	This is a widely known and widely accepted technology for new/rebuilt paper machines. Many older mills have not yet adopted the technology.
Practical Notes	This technology involves balancing the air system to achieve the optimal condition. Hood systems operating outside the optimal envelope will suffer from either productivity issues (hood sweating) or inefficient use of energy (too much air infiltration). Operating a hood at optimal humidity also increases heat recovery potential and ROI opportunities.
Specific Applications & Limitations	This technology can be applied to all paper machines running “can” dryers with exhaust hoods.
Resources	There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Operating at optimal conditions decreases the volume of dry air required to transport water vapor out of the hood. Since this air has to be handled and conditioned, optimizing its volume saves both electricity and thermal energy. Dryer emissions are reduced.
Typical Productivity Impact	In many cases optimizing the hood exhaust system has improved paper quality and enhanced machine speed.

PM 3 - Use a Dryer Management System

Best Practice Description	DMS™ control software is an advanced control system for the dryer section of a paper machine. Supervisory control of all system set points is used to optimize system operation and provide ease of use for the operators.
Primary Area/Process	This technology is applicable to the dryer section of the paper machine.
Typical Energy Savings	Conservative estimates in a world class machine have pegged the steam savings at 2,000 to 3,000 lbs per hour. Using a steam generation cost of $5 per 1,000 lbs this equates to financial savings of $70,000 to $100,000 per year.
Return on Investment	Depending on machine size and speed and the package that is purchased, the ROI can range from 40% to 100%.
Stage of Acceptance	This is innovative supervisory technology that has not yet been widely accepted. The first DMS was installed in Wisconsin in 2003 with support from the Focus on Energy program. Three additional DMS control packages were installed on paper machines in Wisconsin by the end of 2004.
Practical Notes	In addition to saving steam this system minimizes blow through, eliminates water-filled dryers and improves recovery from cold start-up or sheet breaks.
Specific Applications & Limitations	This technology is limited to machines with "can" type dryers and can be expanded to include/integrate dryer section air and heat recovery systems.
Resources	For more technical information contact Wisconsin Focus on Energy for a copy of their case study: http://www. focusonenergy.com Phone: 800-762-7077 There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	This technology minimizes steam consumed to dry paper thereby decreasing the consumption of fuels.
Typical Productivity Impact	Implementing this technology can result in better quality paper and improved productivity.

PM 4 - Operate Pocket Ventilation Between 180-195°F

Best Practice Description	Pocket ventilator air supply temperatures should be maintained at the lowest level possible consistent with runability.
Primary Area/Process	The pocket ventilating system is a sub-system of the paper machine drying section. Pocket ventilators feed air between the dryer cans and the web on the paper machine.
Typical Energy Savings	By maintaining proper supply temperatures mills can realize steam savings of 1,000-2,000 lbs/hours. This manifests itself in financial savings in excess of $20,000 per year.
Return on Investment	This can be a "no cost" opportunity for the mill with a resultant infinite ROI.
Stage of Acceptance	This is a widely known practice that is well accepted. The issue is one of maintaining focus.
Practical Notes	A properly operating pocket ventilation system enhances machine runability and product quality. The paper machine operators are often so focused on productivity that issues like pocket ventilation temperatures are often ignored.
Specific Applications & Limitations	This application has no technical limitation; the biggest challenge is in implementation.
Resources	There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	A more conscientious effort in optimizing pocket ventilation temperatures can reduce the overall energy needed for paper drying and reduce emissions.
Typical Productivity Impact	Implementing proper pocket ventilator air supply temperatures should not adversely impact productivity.

PM 5 - Use a Shoe Press in the Press Section

Best Practice Description	The shoe press is a device that improves the mechanical dewatering of paper or board by extending the dwell time during the pressing operation in the paper machine.
Primary Area/Process	This technology is applicable to the paper machine.
Typical Energy Savings	Typical sheet moisture is reduced 2% to 5 % at the exit of the press section, which reduces the steam requirement of the dryer section. Annual financial savings are a function of the type and amount of paper/board being manufactured. Typical annual savings range from $250,000 to more than $1,000,000.
Return on Investment	The cost of incorporating a shoe press installation during a machine rebuild can be $1,000,000 or higher depending on machine width. Mills that install shoe presses are typically more interested in enhanced sheet properties and productivity than in their potential to save energy. A typical ROI including these factors is in the 20% to 40% range.
Stage of Acceptance	This is a well known, but not widely accepted technology.
Practical Notes	Shoe presses have a range of benefits that are difficult to precisely quantify. They offer the potential of better strength properties due to enhanced sheet consolidation which may enable practices such as lightweighting or fiber substitution. Sheet surface properties may also change affecting coating and sizing considerations.
Specific Applications & Limitations	The application of shoe presses is limited to new machine installations or major rebuilds of the press section.
Resources	For additional information see: "Johnsonburg Mill Installs Single Nip Shoe Press," Glen Ostle, Paper Age February 2001. There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	The reduced amount of steam required translates into less combustion of fuel.

PM 6 - Wet / Dry End Broke Surge Tanks

Best Practice Description	Broke that is generated on the paper machine is segregated into undried or dried classification. Each class of broke is treated based on its point of origination.
Primary Area/Process	This technique is applied to the paper machine operation.
Typical Energy Savings	By only treating the dried fraction of the broke, mills can save the deflaking energy that would have been expended treating mixed broke. In a typical mill with 3% couch pit broke, this amounts to savings of $8,500 per year.
Return on Investment	The cost of providing the extra tankage is a function of the mill layout, but typically an ROI of 20% can be achieved.
Stage of Acceptance	This may be a widely known technique, but it isn't widely incorporated by the industry. Most mills use a common broke system.
Practical Notes	A mill can either construct separate systems or relocate the deflaking function to only handle dried broke.
Specific Applications & Limitations	The application of this technology is a function of pulping difficulty of the finished product. If the finished product broke is easily repulped the technology has no specific benefit.
Resources	For additional information see: "Broke Systems for Mechanical Printing Papers," Harju Lattunen, Sunds Defribrator "Broke Systems for LWC, MWC, and HWC," H. Selder, W. Mannes, W. Matzke PTS-Streicheri Syposium, 1995
Typical Environmental Benefits	The primary environmental benefit results from the decreased consumption of electrical energy.
Typical Productivity Impact	This application should have no adverse impact on productivity.

PM 7 - Variable Speed Thick Stock Basis Weight Control

Best Practice Description	Replace pulp or paper machine stuff boxes (which have ~20% recirculation) with variable speed pumps and trim valves (which have no recirculation).
Primary Area/Process	This best practice is aimed at market pulp mills and paper machines.
Typical Energy Savings	For a typical 1,000 tpd machine, savings are ~40 hp (for recirculation). At a cost of $275 per hp per year, typical savings are $11,000/year.
Return on Investment	Retrofit costs are machine specific and cost several hundred thousand dollars. Sometimes gains in quality and production (quicker grade changes) make this cost effective. Otherwise this technology is best applied during rebuilds.
Stage of Acceptance	Well known and widely used on new installations
Practical Notes	This best practice improves basis weight control and quicker paper grade change time. There are also piping and control savings on a new machine or a major wet end rebuild.
Specific Applications & Limitations	This best practice is limited to pulp and paper machines.
Resources	There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Minimal
Typical Impact on Productivity	There will be productivity increases on each grade change which will be machine specific. On some machines there could be a reduction in sewer losses during grade changes. On machines with machine direction basis weight issues (that will be reduced by this technology) there will be a reduction of cull tonnage. Either of these changes will have a larger impact on costs than the energy reduction.

PM 8 - Heat Felt Water

Best Practice Description	This best practice recommends preheating the felt water because most of the water in the nip comes from the felt. Water removal benefits can be achieved by heating the water in felts, which is most economically done with "waste steam" in boxes or showers over cleaning Uhle boxes.
Primary Area/Process	Pulp or paper machine press sections
Typical Energy Savings	Typically an 18°F increase in sheet temperature increases press solids by 1 point of consistency and reduces drying energy by 4%. For a gain of 1 percentage point of post press solids and a drying energy of 6 MMBtu per ton the savings is 0.24 MMBtu per ton. For a 1,000 tpd machine and a gain of one percentage point of post press solids the annual savings is ~$432,000.
Economic Assessment	The installed cost of a low pressure steam box is typically less than the annual savings so the ROI is >100%.
Stage of Acceptance	Well known, but not widely practiced.
Practical Notes	Implementing this best practice may result in more uniform felt performance over useful life due to the felt running cleaner and more "open." Fewer sheet breaks may also be experienced.
Specific Applications & Limitations	This best practice is aimed only at return felt runs of pulp and paper machines.
Resources	1) TAPPI TIP 0404-52 Press Section Optimization. 2) "Use of Steam Showers to Condition Press Fabrics ," P. Wells, 2003 Spring TAPPI Technical Conference.
Typical Environmental Benefits	Environmental benefits may be seen in the waste water treatment plant in proportion to the reduced amount of water that may need treatment.
Typical Productivity Impact	A productivity increase of 4% may be available on dryer limited machines for each 1 percentage point increase in post press solids.

PM 9 - Dryer Section Performance Monitoring

Best Practice Description	Regular monitoring of conditions and timely implementation of preventive maintenance on the dryer section of the paper machine.
Primary Area/Process	This best practice is specifically for the dryer section of the paper machine.
Typical Energy Savings	Exact data are not available and energy savings will vary widely due to the condition and baseline operating parameters of the existing dryer section. Typically, ensuring that the dryer section is operating correctly will be the most energy efficient way to run.
Return on Investment	Exact data are not available and ROI will vary widely due to the condition and baseline operating parameters of the existing dryer section.
Stage of Acceptance	This is a TAPPI "TIP" and is well known and widely adopted.
Practical Notes	Dryer section performance has a major effect on sheet quality, production rates and energy efficiency. Regular performance monitoring can help ensure that dryer section operation is optimized and can direct maintenance and troubleshooting efforts before minor problems get worse.
Specific Applications & Limitations	This "TIP" is specifically for the dryer section of the paper machine.
Resources	TAPPI TIP 0404-33, Revised 2003 ©TAPPI.
Typical Environmental Benefits	Environmental benefits are proportional to reduced fuel and steam usage.
Typical Productivity Impact	A well operating dryer can have positive effects on overall paper machine productivity.

PM 10 - Use Clarified Water as Vacuum Pump Seal Water

Best Practice Description	Clarified water is of sufficient quality and temperature to be used as seal water for vacuum pumps. This will replace fresh water or capital equipment for cooling recirculated pump water.
Primary Area/Process	This technology is in the pulp or paper mill.
Typical Energy Savings	There will be energy savings for fresh water that would be heated and discharged. A Canadian mill saved 1,400 cubic meters (370,000 gallons or 3.2 million lbs) which would have a 30℃ (54℉) temperature rise (same as other process water). This equals 173 MMBtu per year. At a cost of $5.00 per MMBtu, annual savings are $865,000.
Return on Investment	A control loop, piping and filter should cost ~$200,000. ROI would be ~400%. The cost at a Canadian mill was ~$100,000 and the savings of ~$300,000 yielded a 300% ROI.
Stage of Acceptance	Well known, but not widely accepted. Re-circulating loops with cooling towers are more widely accepted, but requires more capital.
Practical Notes	A filter may need to be installed if there is sand or other contaminates present.
Specific Applications & Limitations	This is not likely applicable to mills that have recirculating loops for vacuum pump seal water.
Resources	This was adapted from PM 63, Energy Conservation Opportunities 1981-1994 by PAPTEC.
Typical Environmental Benefits	Fresh water and effluent savings in direct proportion to the amount of clarified water used.
Typical Productivity Impact	None expected

PM 11 – High Performance Coater Air Dryer Nozzles

Best Practice Description	Air dryers are commonly used for coater drying. Replacing old technology nozzles with high performance nozzles can significantly improve drying performance and reduce energy.
Primary Area/ Process	This technology is for coater air dryers.
Typical Energy Savings	10% to 15% increase in drying efficiency.
Return on Investment	Fairly low capital investment, with paybacks typically in the order of 12 months, or an ROI of greater than 100%.
Stage of Acceptance	Well known technology, with proven results.
Practical Notes	In addition to increased drying efficiency, improvements in runnability and maintenance are also often realized.
Specific Applications & Limitations	Applicable to all coated grades. No real limitations. Suitable for both gas and steam heated dryers.
Resources	There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Reduced gas or steam release due to increased drying effectiveness.
Typical Productivity Impact	Impact includes better drying, improved runnability, equal or better sheet quality, reduced maintenance.

PM 12 – Paper Machine Hood Heat Recovery

Best Practice Description	Paper machine hood exhaust typically contains significant energy. Using heat recovery, much of this energy can be reclaimed and returned to process.
Primary Area/ Process	This technology is applicable to the dryer section of the paper machine, but may also include other sources (e.g. vacuum pump exhaust)
Typical Energy Savings	Wide range of energy savings potential dependent on hood exhaust volumes, temperature and humidity, heat demands, etc. Savings in the order of 11 MMBtu per hour are possible.
Return on Investment	Depending on machine size and speed, and type of hood, the payback can range from 12 to 24 months, or an ROI of 50% to 100%.
Stage of Acceptance	This technology is widely accepted and is considered standard (essential) practice in most northern mills.
Practical Notes	In addition to saving energy, these systems may also reduce exterior ice accumulation and stack noise emissions.
Specific Applications & Limitations	Applicable to all paper, board and tissue grades. There are many variations in technology (air/air, air/water, air/glycol) and available equipment. Proper equipment/system application is critical to successful operation of the heat recovery system. A use for the recovered heat is needed to make heat recovery viable. Preferably, load (sink) should be constant (e.g. process related) and match PM hood operation. Multiple heat recovery systems (air, water, glycol) can be combined in a single system or applied separately.
Resources	There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Reduced energy demand and stack noise emissions. Potential reductions in steam and gas.
Typical Productivity Impact	Typically no impact on productivity.

PM 13 – Use Low Pressure Steam in Paper Machine Dryer Section

Best Practice Description	Historically dryer section steam cans were heated with medium to high pressure steam. Often the dryer section can be rebuilt to utilize excess, less costly, low pressure steam.
Primary Area/ Process	PM dryer section with steam heated dryer cans.
Typical Energy Savings	Utilization of low pressure steam offsets using higher-cost, medium-to-high pressure steam.
Return on Investment	Wide range of ROI dependent on relative costs of low versus high pressure steam, and the proximity of the dryer section to the low pressure steam source. Payback can vary typically from 12 to 24 months (ROI 50% to 100%) depending on extent of rebuild.
Stage of Acceptance	Widely accepted in all paper grades. This is the trend for all new machines and major rebuilds where there is low pressure steam available.
Practical Notes	Provides an excellent steady "base load" for effective utilization of low pressure steam; which is essential for the efficient operation of TMP plants.
Specific Applications & Limitations	Must have a source of reliable, low pressure steam, typically TMP, relatively close to the pulp mill.
Resources	There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Use of low pressure steam eliminates venting excess steam to atmosphere; and facilitates reducing main high pressure boiler operation.
Typical Productivity Impact	No negative impact on productivity.

PM 14 – Use Air Impingement Dryers for Coater In Place of Infra-Red Dryers

Best Practice Description	The latest advances in impingement drying technology shows impingement drying to be significantly more efficient than traditional gas or electric infrared (IR) drying for coating drying.
Primary Area/ Process	This technology is mostly applicable to coating drying, but is also gaining acceptance for general paper drying in place of traditional steam cylinders.
Typical Energy Savings	Impingement drying is 20% to 30% more energy efficient than typical infrared drying when considering lbs. of water evaporated per MMBtu of energy consumed.
Return on Investment	Depends heavily on machine size, speed, and condition of existing equipment, maintenance costs and number of dryers. ROI needs to be established on a case by case basis.
Stage of Acceptance	Widely accepted and supported by extensive research and a large operating reference base.
Practical Notes	Systems can be either gas (natural or LPG) or steam heated. Very low maintenance and (fire) risk compared to IR.
Specific Applications & Limitations	Applicable to all coated grades. Sufficient plant floor space is needed to accommodate associated equipment (fans, burners). Initial capital cost slightly higher than IR, but with much better lifecycle and operating cost performance.
Resources	There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	High energy utilization efficiency compared to other technologies, resulting in reduced energy consumption and cost. Capable of utilizing steam in place of gas.
Typical Productivity Impact	No negative impact on productivity. Improved machine efficiency, better runnability, no risk of fires, little to no maintenance.

SFP 1 - Secondary Fiber High Efficiency Pulper Rotors

Best Practice Description	The application of this technology, metallurgy and machining techniques have resulted in a more energy efficient rotor for pulper applications.
Primary Area/Process	This technology can be incorporated in both the secondary fiber processing area as well as on the paper machine.
Typical Energy Savings	Energy savings range from 10% to 30%. If the traditional pulper applies 1 hp/tpd the savings range from $6,000 to $18,000 per year.
Return on Investment	This is not a capital-intensive project. Given the fact that rotors are a long-term consumable in the paper mill, the new rotor design can be substituted for conventional design when change out is required. The additional cost is minimal. Estimated ROI >100%.
Stage of Acceptance	This is new technology which is not widely adapted.
Practical Notes	Mills do not have any sort of track record regarding this technology. They are comfortable with the old and are reluctant to incorporate any risk associated with changing.
Specific Applications & Limitations	None
Resources	For information regarding this technology see: "Redesigned Pulper Rotor Offers Energy Savings at Equal Recycled Stock Quality," John Egan, "Pulp and Paper," April, 2004. "CFD Builds a More Efficient Pulp Chopper," Machine Design, 2004. There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Environmental benefits result from less consumption of energy.
Typical Productivity Impact	Changing the pulper rotor should not impact productivity in either direction.

SFP 2 – Repulping in a Continuous Mode

Best Practice Description	Traditionally the repulping of baled virgin pulp has been approached as a "batch" process. Recent advancements in pulper design and computer assisted controls allow this process to be continuous.
Primary Area/Process	This technology is employed in the stock preparation area.
Typical Energy Savings	Switching from batch to a continuous process can save up to 40% of the energy consumed in this operation. A nominal size 400hp motor with savings of 160hp, at $275 per hp-yr, yields cost savings of $44,000 per year.
Return on Investment	The ROI of this application is a function of the cost to convert from batch to continuous. If the pulper can be adapted, the capital costs are in the range of $100,000 and the ROI is 44%.
Stage of Acceptance	This is a widely known, but not widely accepted practice.
Practical Notes	In addition to saving energy, adopting this technology can enhance pulp uniformity.
Specific Applications & Limitations	The primary limitation is the exiting pulper. If the pulper can be converted to continuous operation the cost is reasonable; on the other hand if a new pulper is required the ROI becomes marginal.
Resources	For additional information see: "Continuous Slushing of Chemical Pulp," K. Liebsher, Voith-Sulzer publications.
Typical Environmental Benefits	The primary environmental benefit is related to lessening the consumption of electrical energy.
Typical Productivity Impact	If the mill needs additional repulping capacity this technology can improve throughput of existing equipment.

SFP 3 - Install Mid-Consistency Drum Pulpers

Best Practice Description	Drum pulpers use mechanical agitation instead of conventional viscous shear to repulp reclaimed fiber.
Primary Area/Process	This technology is used in secondary fiber processing.
Typical Energy Savings	Drum pulpers use 30% to 50% less electrical energy than traditional pulpers. Using 1hp/tpd a typical mill could save $45,000 to $75,000 per year.
Return on Investment	A drum pulper installation costs between $1.5 to $2.5 million. An expected ROI ranges from 1.8% to 5%.
Stage of Acceptance	This is a widely know technology which is being widely adopted.
Practical Notes	Conventional pulping is a rather aggressive way to reduce paper or board to fibers. In addition to fiber separation, the process also reduces the size of any contaminants making them harder to separate from the fibers. The more gentle action of the drum pulper allows contaminants to remain intact allowing for easier removal. In many cases, mills have been able to modify down-stream processing resulting in additional energy savings.
Specific Applications & Limitations	This process is limited to paper mills that reprocess post consumer recovered paper or board.
Resources	For information on this technology see: "Advances in Paper Recycling Technology," Paper Age, July, 2001. "Recovered Fiber Reaches New Heights," Pulp and Paper Europe, December, 2001. Union Paper Thermie Project: "First Small/Medium Sized Paper Plant with High Efficiency, Flexibility and Savings for a Strong Valorization of Recycled Paper," Aldo Fornai and Sergio Fornai.
Typical Environmental Benefits	Less water and less energy is required.
Typical Productivity Impact	The drum pulper requires less maintenance than the conventional rotor type pulper. In a typical mill a drum pulper will improve productivity by 1%, which generates an additional $50,000 in profitability.

TMP 1 - Recover Heat from Latency Chest Vent

Best Practice Description	Install showers in the latency chest vent to scrub and condense the vented steam. "Condensate" will cascade into the latency chest and increase its temperature.
Primary Area/Process	This technology is aimed at the TMP plant.
Typical Energy Savings	In one example, the recovered heat was calculated to be 70 MMBtu per day.
Return on investment	In the example cited, at a cost of $5.00 per MM BTU the savings would be $125,000 per year. The cost of adjustable flow showers is several thousand dollars so the ROI is approximately 50%.
Stage of Acceptance	Well known, but not widely accepted. This is one potential component of a TMP heat recovery system.
Practical Notes	This assumes that there will be an increase in stock and paper machine web temperatures. An increase of 3°C (~5°F) was observed at Kruger Trios Rivers for a different project that added heat to the latency chest.
Specific Applications & Limitations	Other trials have shown that there is a 1 percentage point increase in post press solids for each 10°C increase in web temperature. Each percentage point of higher solids reduces drying steam by ~4%.
Resources	Adapted from TMP 9 (and TMP 19) in Energy Conservation Opportunities 1981-1994, PAPTAC.
Typical Environmental Benefits	Reduced steam plant emissions in direct proportion to the reduced steam generated.
Typical productivity Impact	There is no direct impact unless this heat is carried forward to increase headbox temperature which increases post press solids on dryer limited machines.

TMP 2 – Use Load Management in Refining

Best Practice Description	Add refining capacity and storage in excess of daily need. Curtail refining during "peak hours" or at other times like machine startups to minimize mill peak. This may also require the purchase of software to monitor and forecast mill power and pulp use.
Primary Area/Process	This technology is for TMP Refiners.
Typical Energy Savings	Load shifts of 15 MW have been achieved.
Return on Investment	Depending on demand charges this can save $2 million to $3 million annually. Capital cost can be $5 million to $10 million giving an ROI of 25% to 50%. This is an ideal adder to any rebuild of the TMP plant as returns will be higher.
Stage of Acceptance	Well known, but not widely adopted (due to low power rates). It has been adopted at mills like Abitibi, Thorold, Canada and Bear Island, Ashland, VA.
Practical Notes	This may not result in the savings of specific energy consumption, but it will reduce the load on the utility which delays the installation of additional capacity.
Specific Applications & Limitations	Applicable to mills having high electric refining, a high mill peak and a significant demand charge.
Resources	Adapted from TMP 10 in Energy Conservation Opportunities 1981-1994, PAPTAC.
Typical Environmental Benefits	Delays additional utility capacity. More storage typically results in fewer spills and less fiber lost to the sewer.
Typical Productivity Impact	Load management will typically not impact productivity.

TMP 3 - Increase Rotational Speed of TMP Refiners

Best Practice Description	Increase the rotational speed of high intensity refiners to achieve the desired freeness with lower consumed power.
Primary Area/Process	This technology applies to the TMP plant
Typical Energy Savings	The savings can be 3 kWh per bone-dry (BD) ton.
Return on Investment	For a 1000 tpd facility with a cost of $0.045 per kWh savings can be $486,000 annually. ROI is estimated at ~50%.
Stage of Acceptance	Innovative, but not widely adopted. This was a development project between Kruger, Hydro Quebec, Sunds (now Metso) and Sprout Bauer. In the mid 90's it was implemented on primary refiners. Pilot plant results demonstrated the following: • DD Refiner-22% to 30% savings • SD Refiner-17% to 20% savings • DC Refiner-15% to 20% savings
Practical Notes	There can be higher maintenance costs for equipment with higher rotational speed. Pulp quality will also need monitoring.
Specific Applications & Limitations	Applicable to high intensity refiners.
Resources	Adapted from TMP 15 in Energy Conservation Opportunities 1981-1994, PAPTAC.
Typical Environmental Benefits	Reduction of emissions from power generating facilities.
Typical Productivity Impact	There is no impact on productivity expected unless the mill's refiner capacity is constrained.

TMP 4 - Minimize Steam Blow Through in TMP Refining

Best Practice Description	Develop TMP refiner operating practices to minimize differential pressures. Operation of TMP refiners at steady-state does not require additional energy. However, operators use steam for startup and tend to maintain the use of steam to minimize trips and plugs and to generate more production. Significant steam savings can result from development of procedures and implementing training.
Primary Area/Process	This technology is for TMP refiners.
Typical Energy Savings	Steam reductions of 20,000 lbs per hour (~20 MMBtu per hour) have been reported. For a 1,000 tpd facility with a cost of $5.00 per Btu the savings can be $864,000 per year.
Return on Investment	The ROI is excellent (>100%) because only minor capital will be required to remove bottlenecks for stable operation.
Stage of Acceptance	This is well known, but not widely adopted. When steam costs were low in many mills the value of steam savings was not worth the potential loss of production while implementing a system. Now mills need both low cost and budgeted production.
Practical Notes	Operator training has typical “side benefits” of increased safety and production.
Specific Applications & Limitations	There must be relatively high steam use in the TMP plant partly caused by “high blow through.”
Resources	Adapted from TMP13 in Energy Conservation Opportunities 1981-1994, PAPTAC
Typical Environmental Benefits	Reduction of emissions from steam-generating facility proportional to the decreased steam needed.
Typical Productivity Increases	Development of uniform operating practices and associated training can have a positive impact on productivity.

TMP 5 - Use Heat Recovery to Generate Hot Water

Best Practice Description	This best practice calls for the installation of direct contact heat exchangers to extract energy from the primary and secondary separators to heat water for the paper machines and for “make up” water for the steam plant.
Primary Area/Process	This technology is applicable to the TMP plant.
Typical Energy Savings	In the example cited below, heat recovery was ~490 MMBtu per day.
Return on Investment	For this example, using a cost of $5.00 per BTU, savings will be $882,000 per year. Installed costs are ~25% of savings so the ROI will be ~400%.
Stage of Acceptance	Well known and widely adopted, heat recovery systems are capable of generating 1.1 to 2.3 tons of clean steam (at dryer can pressures) per ton of pulp. Typical ranges are 1.1 to 1.9 tons.
Practical Notes	The assumption is that paper machine water and steam plant make up water is heated with primary steam and that this steam can be saved.
Specific Applications & Limitations	This best practice is applicable to ground wood refining.
Resources	Adapted from TMP1 in Energy Conservation Opportunities 1981-1994 by PAPTEC
Typical Environmental Benefits	• Reduced steam plant emissions • Reduced fresh water use • Reduced load on ponds
Typical Impact on Productivity	This best practice is not expected to impact productivity.

TMP 6 - Use Heat Recovery to Generate Steam

Best Practice Description	This best practice calls for capturing dirty steam and using the thermal energy to make clean steam and hot water with the use of heat exchangers.
Primary Area/Process	This technology is applicable to the TMP plant.
Typical Energy Savings	In one example the mill was able to recover ~57.5 MMBtu per hour of dirty steam and run it through heat exchangers to produce 30 MMBtu per hour of clean steam and 27.5 MMBtu of hot water. Steam pressure was elevated to 44 psig with a thermo-compressor. Heat recovery systems are capable of generating 1.1 to 2.3 tons of clean steam (at dryer can pressures) per ton of pulp. Typical ranges are 1.1 to 1.9.
Return on Investment	At a cost of $5.00 per MMBtu, the savings would be ~$2,500,000 per year. With a capital cost of ~$1,000,000, ROI would be ~250%.
Stage of Acceptance	Well known and widely adopted on new installations.
Practical Issues	There will be additional cleaning and maintenance of the heat exchangers.
Specific Applications & Limitations	This best practice is limited to pressurized refining.
Resources	Adapted from TMP12 in Energy Conservation Opportunities 1981-1994 by PAPTEC
Typical Environmental Benefits	• Reduced steam plant emissions • Reduced water consumption • Lower load to waste water treatment ponds
Typical Productivity Impact	There is no expected impact on productivity unless the mill is steam limited.

UTL 1 - High Solids Firing of Black Liquor in Recovery Boilers

Best Practice Description	By evaporating more water from black liquor the water load to the recovery furnace is reduced. The net result is better overall heat efficiency.
Primary Area/Process	This technology is applied in the recovery areas of the pulp mill.
Typical Energy Savings	The energy savings from installing high solids on a 1,000 tpd black-liquor recovery system are estimated at a net of 200 MMBtu per day. At $5 per MMBtu this translates into an annual savings of about $350,000.
Return on Investment	This is a capital intensive project with expected costs of $2.5 million to $5 million. The ROI on this type of installation is 7% to 14%.
Stage of Acceptance	This technology is well known, but not been adopted.
Practical Notes	Increasing black liquor solids allows a greater throughput which may allow for more virgin pulp production.
Specific Applications & Limitations	This technology is limited to paper mills that produce virgin pulp on site and use non-direct contact evaporation.
Resources	For information on this technology see: 'High Solids Black Liquor Firing in Pulp and Paper Industry Kraft Recovery Boilers," W.T. Southands, J.T. Blude and J.A. Dickinson, US DOE. Web site: www.osti.gov/bridge/product.biblio.jsp?osti_id=607516 Also see: "Black Liquor Recovery Boilers," Mika Jarvinen, Helsinki University of Technology, Phone: Country code: 09-4513657 There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	In addition to better thermal efficiency, this technology improves chemical reduction and lowers sulfur compound emissions.
Typical Productivity Impact	High solids firing improves the reliability of the recovery process and diminishes the risk of smelt-water explosive events. The enhanced reliability can improve productivity by 2% which equals an estimated $140,000 in increased profits per year. The high solids firing technology also increased the capacity of the recovery furnace which allows mills that are constrained to produce more virgin pulp.

UTL 2 - High Temperature Video Monitors

Best Practice Description	Recovery boilers are subject to chemical ash deposition in gas passages. To deal with this potential, soot blowers are periodically deployed to dislodge buildups. This is an inexact process. A high-temperature camera capable of differentiating ash from boiler surfaces allows operators to monitor the effectiveness of soot blowing and take remedial action.
Primary Area/Process	This technology applies to boilers.
Typical Energy Savings	If the new video technology eliminates one recovery shut-down per year the direct energy savings are estimated at $50,000.
Return on Investment	This is not a capital intensive project and installation typically does not require downtime. In mills that have experienced plugging requiring a shutdown and internal water-washing, this technology could pay for itself in a little as one year. ROI is 100%.
Stage of Acceptance	This is a new technology developed specifically for the paper industry. While not yet widely adopted, it has excellent payback potential.
Practical Notes	The high-temperature video camera has the potential to minimize or eliminate unscheduled recovery boiler outages. In addition to the energy savings associated with cold startup, the technology helps improve pulp mill productivity and "uptime."
Specific Applications & Limitations	This technology is limited to paper mills that produce virgin pulp on site.
Resources	For information on this technology see: "System for Detection and Control of Deposition in Kraft Recovery Boilers," Dr. Peter Ariessohn, US DOE. Web site: www.osti.gov/bridge/product.biblio.jsp?osti_id=816034 There are a number of commercial resources for this technology. Please contact one of the Wisconsin Focus on Energy representatives listed in Appendix C if you need additional information.
Typical Environmental Benefits	Energy savings and eliminating upset conditions.
Typical Productivity Impact	A "cold iron" recovery boiler outage typically requires a minimum of 48 hours. As specific profit margin on the incremental tons is significantly higher than the margin on average tons, eliminating one outage per year can improve productivity 5.5% or $400,000.

UTL 3 - Incinerate VOCs in Existing Sources

Best Practice Description	This best practice is about incinerating volatile organinc compounds (VOC) to be compliant with the air part of the EPA regulation known as the "Cluster Rule." This requires 98% destruction of VOCs from defined sources. Typically mills install separate incinerators with existing sources used as backup. The more energy efficient systems direct the VOCs to the lime kiln or recovery or waste-fuel boiler and use the other as backup.
Primary Area/Process	The primary application of this best practice is in brown stock washing.
Typical Energy Savings	This technology is pulp mill specific. Savings range from none to as much as 10 MMBtu per hour. Assuming 5 MMBtu per hour as the average and a cost of $5.00 per MMBtu, the potential annual savings are ~ $125,000. Typically this will be gas savings.
Return on Investment	The major capital requirement is for controls and lines. This will be very mill specific and is typically in excess of 1 million dollars. This makes the ROI under 10% and this technology becomes most attractive when there is an area rebuild or when the current system needs a major overhaul.
Stage of Acceptance	Well known and widely adopted.
Practical Notes	There are concerns of possible increases in contamination or fouling of lime kilns and recovery boilers. In some mills, the source of the VOC is some distance from the existing combustion sources.
Specific Applications & Limitations	This is limited to mills which have installed separate incinerators for VOCs.
Resources	This best practice was developed from tours of low energy use mills by Jerry Aue of Focus on Energy.
Typical Environmental Benefits	Lowers gas usage and therefore lower CO_2 emissions.
Typical Productivity Impact	None

UTL 4 - Modified Sootblower Operation

Best Practice Description	This method of sootblower operation delays the initiation of full cleaning flow in order to clean the boiler tubes only during the retract pass of the nozzles, as the lance is withdrawn from the boiler.
Primary Area/Process	This best practice is applied to the heat transfer surfaces of Kraft recovery boilers.
Typical Energy Savings	International Paper's Androscoggin Mill reports a savings of 134,980 lbs. of steam per day, or 47% of sootblower steam normally used.
Return on Investment	At a rate of $4.50 per 1,000 lbs. of steam, the savings was determined to be at least $533 per day, or annual savings of approximately $187,000. The cost to modify 22 sootblowers was about $55,000, therefore the project was paid back in less than four months for a ROI of 300%.
Stage of Acceptance	Innovative, not widely known or adopted.
Practical Notes	Because steam usage is reduced, there are additional saving by including makeup and treatment chemicals associated with replacing the boiler feed water.
Specific Applications & Limitations	This technology is limited to Kraft recovery boilers using the patented One Way™ sootblower lance.
Resources	"Experiences with Modified Sootblower Operation for Energy Efficiency Improvement," Copyright 2000 Diamond Power International, Inc. and International Paper Company.
Typical Environmental Benefits	Environmental benefits are in direct proportion to the reduced energy used to make steam, as well as a reduced need to treat chemicals in the wastewater treatment plant.
Typical Productivity Impact	No productivity impact is expected.

UTL 5 - Improving Industrial Powerhouse Operations with an Energy Management System

Best Practice Description	Use distributed controls systems (DCS) to increase operational efficiency in the powerhouse. DCS regulates and increases the flow of information. Efficiency is improved with an adjunct energy management system.
Primary Area/Process	This technology applies to functions in the powerhouse: • Header pressure stabilization • Supervisory control of electrical line with real-time pricing • Economic model for calculating best operating cost recommendations • "What if?" capabilities • Load shedding
Typical Energy Savings	One example claimed that dump and vent steam losses were reduced by 50,000 lb. per hour in the summer.
Return on Investment	Cost can be high, typically several hundred thousand dollars. Each mill needs to evaluate ROI and payback.
Stage of Acceptance	Well known, but not widely adopted.
Practical Notes	Cost savings may result from: • Actions and decisions based on economic models that provide best operating cost decision support • Improved stability in header pressures while operating boilers and turbines at their most efficient points within the mill's operating protocols • Supervisory tie-line control • Improved planning for outages and emergency situations ▪ Load shedding advice
Applications & Limits	This technology is limited to the powerhouse.
Resources	• "Improving Industrial Powerhouse Operations with and Energy Management System," J.R. Thomas and A.R. Daamen, Vol. 81: No3 TAPPI JOURNAL. • "Reduce Pulp & Paper Mill Energy Costs Though Multi Unit Optimization," Srinivas Budaraju, 2002 TAPPI Fall Conference and Trade Faire. • "Energy Conservation Opportunities 1981-1994" ENERGY COMMITTEE – Pulp and Paper Technical Association of Canada. Examples SP65 and SP80.
Typical Environmental Benefits	Improved combustion and fewer emissions.
Productivity Impact.	No productivity impact is expected.

UTL 6 - Air Heater Tube Replacement

Best Practice Description	The prime objective of this best practice is to insure the combustion air pre-heater tubes are in good repair and not leaking.
Primary Area/Process	This technology can be applied to all types of boilers using combustion air preheaters in the flue gas stream.
Typical Energy Savings	Energy savings will depend on the condition of the tubes before removal, with the greatest savings stemming from replacing those tubes in the worst condition. One report indicated that inlet air temperature increased by about 50°F , resulting in over 2 MMBtu per hour additional heat supplied to the boiler by the inlet air. Another installation that replaced the entire preheater unit resulted in a 6 MMBtu per hour savings.
Return on Investment	The savings vary widely and depend on the successful implementation of the best practice. Those mills who have defrayed maintenance the longest, and therefore are running the most inefficiently will realize the greatest return. Because there is such variability in any given mill's pre-heater tube condition, there is insufficient data to calculate or estimate an ROI or payback period at this time.
Stage of Acceptance	Well known, but not widely adopted
Practical Notes	Leaking air heater tubes are "out-of-sight" and therefore often "out-of-mind" increasing the likelihood the condition will be ignored.
Specific Applications & Limitations	This best practice targets combustion air preheater tubes for boilers.
Resources	"Energy Conservation Opportunities 1981-1994," ENERGY COMMITTEE – Pulp and Paper Technical Association of Canada. Examples SP-5 and SP-30.
Typical Environmental Benefits	Improved combustion and fewer emissions in direct proportion to the fuel saved.
Typical Productivity Impact	No productivity impact is expected

UTL 7 - Upgrade the Boiler Burner

Best Practice Description	The prime objective of this best practice is to ensure the latest and most efficient boiler burner technology is installed.
Primary Area/Process	This technology can be applied to all types of boilers.
Typical Energy Savings	The savings vary widely and depend on the successful implementation of the technology and the condition and efficiency of the burners being replaced. One example of savings incurred: • Reduced Natural gas by 50 cubic meters per tonne pulp, or about 30% At February 2004 prices, 50 cubic meters represents a savings of $8.00 to $9.00 per metric ton.
Return on Investment	In one application using oil burners, replacing circular oil burners with parallel throat burners with racer type atomizers had a payback of approximately one year, or a 100% ROI.
Stage of Acceptance	Well known, but not widely adopted.
Practical Notes	One plant replacing their oil burners also reduced the load on their dust collectors and reduced dust collector plugging. They also noticed that by improving their air control they improved their bark burning efficiency.
Specific Applications & Limitations	This best practice targets installing new and efficient burners in boilers.
Resources	"Energy Conservation Opportunities 1981-1994," ENERGY COMMITTEE – Pulp and Paper Technical Association of Canada. Examples SP8 and SP24.
Typical Environmental Benefits	Improved combustion and fewer emissions in direct proportion to the fuel saved. Additional benefits are also incurred because of more complete combustion.
Typical Productivity Impact	No productivity impact is expected.

UTL 8 - Reduct Forced Draft Fan Inlet

Best Practice Description	The prime objective of this best practice is to capture escaped heat within the building to increase the inlet air temperature in forced draft combustion.
Primary Area/Process	This best practice can be applied to all types of boilers as well as other forced draft type of systems.
Typical Energy Savings	In one documented example, using ducted air from the top floor of boiler house increased air temperature entering the forced draft fans from an average of 60°F to 109°F, saving about 70,000 MMBtu per year. In another example wherein the inlets were placed very near the ceiling of the boiler room, average temperature was increased from 60°F to 109°F for a savings estimated at 21,000 MMBtu per year. A third example using two large boilers had savings of 40,000 and 52,000 MMBtu per year, respectively.
Return on Investment	The ROI can be quite rapid, often about 200% (six month payback), as sheet metal ducting is relatively inexpensive and easy to install. Documented installations in the reference listed below ran from about $16,000 to about $50,000 in 1980's money.
Stage of Acceptance	Well known, but not widely adopted.
Practical Notes	Evens out temperature in the boiler room, making it more comfortable, especially in summer. It is often an easy retrofit for conscientious operators. Duct work can be routed externally if room is tight in the boiler room.
Specific Applications & Limitations	This best practice can be applied to many forced-air applications.
Resources	"Energy Conservation Opportunities 1981-1994" Compiled by the ENERGY COMMITTEE – Pulp and Paper Technical Association of Canada. Examples SP11, SP20, SP44 and SP53.
Typical Environmental Benefits	Improved combustion and fewer emissions in direct proportion to the fuel saved.
Typical Productivity Impact	No productivity impact is expected.

UTL 9 - Distributed Boiler Control System

Best Practice Description	A distributed control system can optimize wood waste fuel firing and reduce fossil fuel firing. Steam and power imbalance can also be improved, leading to reduced dump and vent steam losses.
Primary Area/Process	This technology can be applied to all types of dual-fuel boilers.
Typical Energy Savings	One cited example claimed that dump and vent steam losses were reduced by an average of 50,000 lb. per hour during summer.
Return on Investment	Implementation costs can be high, typically several hundred thousand dollars. Because of the high cost of implementation, mills will need to fully evaluate the ROI and payback on a case-by-case basis.
Stage of Acceptance	Well known, but not widely implemented.
Practical Notes	Because boiler conditions are displayed real-time, the operator can take immediate advantage of opportunities to improve efficiencies and reduce costs, based on predetermined combustion strategies.
Specific Applications and Limitations	This best practice targets the installation of new distributed control systems in duel fuel boilers.
Resources	"Energy Conservation Opportunities 1981-1994," ENERGY COMMITTEE – Pulp and Paper Technical Association of Canada. Examples SP65 and SP80.
Typical Environmental Benefits	Improved combustion and fewer emissions in direct proportion to the fuel saved and amount of fossil fuels displaced by biomass. Additional benefits are also incurred because of more complete combustion.
Typical Productivity Impact	No productivity impact is expected.

UTL 10 - Optimize Bark Boiler Steam Generation

Best Practice Description	This best practice involves running a series of trials at different steam generation rates, keeping a constant bark feed and using different gas flows to optimize the cost/unit energy vs. the load curve. The result should be the most efficient steam generation rate.
Primary Area/Process	This technology can be applied to all types of dual-fuel boilers with the example cited being for the bark boiler.
Typical Energy Savings	In the example cited, fossil fuel savings were $230,000 per year.
Return on Investment	Since there is no capital investment, this best practice has a excellent return on investment.
Stage of Acceptance	Well known, but not widely adopted.
Practical Notes	This best practice facilitates the establishment of a plant wide boiler loading schedule. By optimizing each boiler to its cost/unit energy vs. the load curve, additional savings may be realized.
Specific Applications & Limitations	This best practice targets dual-fuel boilers.
Resources	"Energy Conservation Opportunities 1981-1994," ENERGY COMMITTEE – Pulp and Paper Technical Association of Canada. Example WHP-03.
Typical Environmental Benefits	Improved combustion and fewer emissions in direct proportion to the fuel saved and amount of fossil fuels displaced by biomass. Additional benefits are also incurred because of more complete combustion.
Typical Productivity Impact	No productivity impact is expected.

UTL 11 - Automate Boiler Blow Down Controls

Best Practice Description	This best practice involves replacing manual continuous blow down valves set for the worst possible conditions with computer controlled valves that respond to control level sensors in the system. The net result is a reduction in the continuous blow down rate on boilers.
Primary Area/Process	This technology can be applied to all types of boilers using continuous blow down.
Typical Energy Savings	In the example cited, energy savings were about $12,000 per year.
Return on Investment	In the example cited, automating boiler blow down had a payback of about six months for a ROI of 200%.
Stage of Acceptance	Well known, but not widely adopted.
Practical Notes	Automating blow down reduces the amount of water being wasted and therefore the amount of water treatment chemicals will also be reduced. This may also lower the demand on the wastewater treatment facility.
Specific Applications & Limitations	This best practice targets opportunities to automate boiler blow down controls.
Resources	"Energy Conservation Opportunities 1981-1994," ENERGY COMMITTEE – Pulp and Paper Technical Association of Canada. Example SP 97.
Typical Environmental Benefits	Reduced energy consumption and reduced chemicals in the plant wastewater.
Typical Productivity Impact	No productivity impact is expected.

UTL 12 - Recover Heat from Boiler Blow Down

Best Practice Description	This best practice involves recovering the heat from continuous blow down and using it to preheat the boiler make-up water.
Primary Area/Process	This technology can be applied to all types of boilers using continuous blow down.
Typical Energy Savings	In the examples cited, energy savings were about 25,000 to 30,000 MMBtu per year.
Return on Investment.	In the examples cited, paybacks of 12 to 18 months were noted for an ROI of 67% to 100%.
Stage of Acceptance	Well known and widely adopted.
Practical Notes	Preheating the make-up water reduces the feed water heating system steam demands.
Specific Applications & Limitations	This best practice targets opportunities to recover heat from boiler blow down operation.
Resources	"Energy Conservation Opportunities 1981-1994," ENERGY COMMITTEE – Pulp and Paper Technical Association of Canada. Examples SP19 and SP72.
Typical Environmental Benefits	Environmental benefits are incremental based on reduced overall fuel usage.
Typical Productivity Impact	No productivity impact is expected.

WY 1 - Automated Chip Handling and Thickness Screening

Best Practice Description	Automated chip handling uses a first-in/first-out inventory system to maintain more consistent wood chip aging. The chip screening system assures more uniform raw material feeding the digesters.
Primary Area/Process	This technology is used in the wood yard area of the pulp mill.
Typical Energy Savings	The more uniform chip and higher yields result in fewer cooks for the same amount of pulp. Estimated energy savings are $500,000 per year.
Return on Investment	This best practice can result in digester yield increases of 5% to10% which must be offset by the volume of material screened out as undersized (typically 2% to 3%). The technology allows mills to cook to higher kappa numbers while still maintaining pulp quality. For a typical mill the annual raw material savings are $1 million per year. The estimated ROI is 15% to 20%. If a mill elects to take the savings as improved productivity the ROI can easily double.
Stage of Acceptance	This is a well known, but not widely adopted technology.
Practical Notes	In addition to higher pulp yields the technology gives higher by-product yields and results in less chip damage due to handling.
Specific Applications & Limitations	This technology is limited to virgin mills.
Resources	For information regarding this technology see: "Material Handling Upgrade Helps Maintain Chip Quality," Lester A. Ward, Pulp and Paper, May, 2003.
Typical Environmental Benefits	Less wood is needed per ton of pulp this backs up into forestry practices, wood procurement, transportation, handling and processing. All of these have environmental impacts.
Typical Productivity Impact	The ability to improve digester yield can impact mill costs or the savings can be taken as production increases using the same amount of raw material.

APPENDIX A
Checklist for Pulp and Paper Energy Best Practices – Page 1

Best Practice Analyzed? (Date)	Further review Needed? Yes/No	Best Practice Possible? Yes/No	Area	#	Title	Typical ROI
			CPM	1	Lime Kiln Oxygen Enrichment	35 to 60%
			CPM	2	CO2 Washing Aid	TBD
			CPM	3	Digester Blow Heat Recovery	12 to 15%
			CPM	4	Pulping Aids to Improve Yields	TBD
			CPM	5	Install Quaternary Air	50 to 80%
			CPM	6	Lime Kiln Electrostatic Precipitators	3 to 10%
			CPM	7	Precoat Filter Shower	10 to 50%
			CPM	8	Solid Fuel Lime Kiln	40 to 120%
			CPM	9	Refractory Reline	>100%
			CPM	10	Efficient Chemical Mixing	TBD
			MW	1	Compressed Air, Water and Steam Leaks	>100%
			MW	2	Hot Water Collection	30 to 50%
			MW	3	Variable Frequency Drives	25 to 70%
			MW	4	High Efficiency Motors	>100%
			MW	5	Idle Equipment	100 to 500%
			MW	6	Minimize Pressure Drops	15 to 25%
			MW	7	Real Time Energy Monitoring	>100%
			MW	8	Reduce Fresh Water Consumption	>100%
			MW	9	Secondary and Tertiary Heat Recovery	25 to 200%
			MW	10	Optimizing Pump Efficiency	>100%
			MW	11	Capture Whitewater Waste Heat	TBD
			PM	1	Dryer Bars and Stationary Siphons	25 to 80%
			PM	2	Dryer Exhaust Humidity	30 to 50%
			PM	3	Dryer Management System	40 to 100%

Checklist for Pulp and Paper Energy Best Practices – Page 2

Best Practice Analyzed? (Date)	Further review Needed? Yes/No	Best Practice Possible? Yes/No	Area	#	Title	Typical ROI
			PM	4	Pocket Ventilation	Very large
			PM	5	Use of a Shoe Press	20 to 40%
			PM	6	Wet-Dry End Broke Surge Tanks	20%
			PM	7	Basis Weight Control	TBD
			PM	8	Heat up Felt Water	>100%
			PM	9	Dryer Section Performance Monitoring	TBD
			PM	10	Use Clarified for Vacuum Pump Seal	300 to 400%
			SFP	1	High Efficiency Pulping Rotors	>100%
			SFP	2	Re-Pulping Continuous	44%
			SFP	3	Drum Pulper	2 to 5%
			TMP	1	Recover Heat from Latency Chest Vent	50%
			TMP	2	Use Load Management in Refining	25 to 50%
			TMP	3	Increase the rotational speed of high intensity TMP refiners	50%
			TMP	4	Minimize steam blow through in TMP Refiners	>100%
			TMP	5	Use Heat Recovery to Generate Hot Water	400%
			TMP	6	Use Heat Recovery to Generate Steam	250%
			UTL	1	High Solids Black Liquor	7 to 14%
			UTL	2	Hi-Temp Video	100%
			UTL	3	Incinerate VOCs	10%
			UTL	4	Modified Sootblower Operation	300%
			UTL	5	Powerhouse Energy Management System	TBD
			UTL	6	Air Heater Tube Replacement	TBD
			UTL	7	Upgrade Boiler Burner	100%
			UTL	8	Reduct Forced Draft Fan Inlets	200%
			UTL	9	Distributed Control System	TBD
			UTL	10	Optimize Bark Boiler Steam Generation	Very large
			UTL	11	Automate Boiler Blow Down Controls	200%
			UTL	12	Recover Heat from Boiler Blow Down	67 to 100%
			WY	1	Automated Chip Handling	15to20%

APPENDIX B

The following are key Energy Best Practices within common systems in industrial facilities. For more information on these Best Practices, free technical support to estimate the Best Practice energy savings for your systems, and possible project incentives call the Focus on Energy - Industrial Program at 800-762-7077.

Best Practices for Common Systems

System	Best Practices	System	Best Practices
Compressed Air			Use VSD instead of bypass control
	Reduce system pressure	**Area Comfort Heating**	
	Repair leaks		Reduce waste heat
	Single verses two stage		De-stratify heated air in plant
	Variable inlet volume		Control heating to desired temperature
	Variable speed control		Use infrared heating
	Energy efficient motor		Optimize CFM air exhausted
Lighting			Automatic temperature control
	Light meter used to verify levels		Minimize heat to storage areas
	T-8 or pulse start MH lighting are considered	**Comfort Cooling**	
	Occupancy sensors		Install removable insulation
	Lights off during process shutdown		Minimize unnecessary ventilation
	Task lighting is maximized		Minimize moisture released
	Night lighting is turned off		Higher efficiency AC
	L.E.D. lamps in exit signs		Optimize room air temperature
Motors		**Dehumidification**	
	Premium efficiency motor vs. repair		Reduce humidity load
	Cogged belts vs. V-belts		Accurately controlling humidity
	Premium efficiency motors specified		Optimize ventilation
Pumps			Desiccant dehumidification
	Trim impeller to meet maximum Load		Minimize reheat energy
	Use VSD instead of throttled control		

Best Practices for Common Systems

Refrigeration		**Fan Systems**	
	Thermosiphon		Reduce excess flow
	Evaporator fan control		Eliminate flow restrictions
	Floating head pressure		Correct poor system effects
	Scheduled maintenance		Optimize efficiency of components
	- Clean filters		Correct leaks in system
	- Low refrigerant charge		Optimize fan output control
	Automatic air purge	**Process Cooling**	
Steam Systems			Use variable frequency drives
	Reduce steam pressure		Float head pressure
	Steam trap maintenance		Use of free cooling - fluid cooler
	Minimize blowdown		Use of free cooling - cooling tower
	Insulate pipes		Match chilled water pumps
	Improve boiler efficiency		Insulate pipes and vessels
	Heat recovery for boiler blowdown		Process to process heat recovery
	Increase condensate return	**Process Heating**	
	Stack economizer		Optimize combustion air fuel ratios
	Recover flash steam		Preheat combustion air
Ventilation			Insulate pipes and vessels
	Direct fired make-up units		Schedule cleaning of heat exchangers
	Better ventilation management		Condensing heat recovery
	De-stratified air		Process to process heat recovery
Wastewater			Ultra filtration for condensation
	Fine bubble diffusers	**Vacuum**	
	Automatic controlled DO sensors/VSDs		Optimize total cost for conveying
	Heat recovery on anaerobic digester		Choose appropriate vacuum pump
	Unneeded aeration basins are shut off		Optimize vacuum pressure
			Eliminate vacuum leaks

APPENDIX C

Pulp & Paper Best Practices Team Member Contact Information

Masood Akhtar
President
Center for Technology Transfer
2809 Fish Hatchery Road
Madison, WI 53713
608-661-4081
makhtar@cttinc.org

John Nicol
Industrial Program Manager
Wisconsin Focus on Energy
SAIC
5609 Medical Circle, Suite 201
Madison, WI 53719
608-277-2941
John.l.nicol@saic.com

Jerry Aue
Forest Products Energy Engineer
Wisconsin Focus on Energy
Aue Energy Consulting
314 White Oak Avenue
Plover, WI 54467
715-343-6118
jaue@charter.net

Craig Schepp
Energy Advisor
Wisconsin Focus on Energy
SAIC
5609 Medical Circle, Suite 201
Madison, WI 53719
608-277-2948
craigschepp@focusonenergy.com

David Borowski
President
D&S Design and Engineering
Po Box 12773
Green Bay, WI 54307-2773
920-499-2360
dvalborow@sbcglobal.net

Benjamin Thorp
President
Benjamin A. Thorp Inc.
3800 Cogbill Road
Richmond, VA 23234
804-873-6561
bathorp@comcast.net

Brent English
Director - Commercialization and Grants
Center for Technology Transfer
2809 Fish Hatchery Road
Madison, WI 53713
608-661-4084
benglish@cttinc.org

APPENDIX D

ADDITIONAL RESOURCES FOR THE PULP AND PAPER INDUSTRY

WISCONSIN FOCUS ON ENERGY: www.focusonenergy.com - offers financial incentives to eligible customers for installing qualifying energy efficiency measures. These measures include energy efficient lighting and HVAC equipment, and "custom" projects such as motor and compressed air system upgrades, process improvements and especially implementing the Best Practices that this project worked to uncover. Incentives are also available for maintaining equipment and studying the feasibility of a proposed energy efficiency project. Custom Incentive Partner Guidelines are provided below:

- You must work with a Focus on Energy advisor to obtain approval for custom incentives. If you do not currently have an advisor, please call (800) 762-7077.
- Incentives are available for new projects, not those that have been previously installed. Applications must be submitted before commencement of the project. See the Program Rules and Qualifications at www.focusonenergy.com for more information.
- All custom project incentives are calculated based on first-year energy savings.
- Projects with less than a two year payback are not eligible for custom incentives.
- A $20,000 per application limit has been imposed on lighting-only projects
- A comprehensive bonus incentive of an additional 30 percent may be available for partners who implement multiple projects that increase overall facility energy efficiency.

CENTER FOR TECHNOLOGY TRANSFER, INC.: www.cttinc.org - MISSION: The mission of the Center for Technology Transfer, Inc. (CTT) is to help companies overcome barriers that restrict the commercialization of energy efficient technologies in Wisconsin.

CTT is unique due to its ability to assist in the commercialization of energy efficient technologies by providing capital in the form of loans or equity to companies not typically served by traditional financial resources. This capital, coupled with CTT's technical, business and financial expertise can help bridge the gaps preventing the adoption and commercialization of new technology.

CTT's technology investment funds are aimed at companies with technologies specific to the forest products (paper), metal casting, food processing, printing and plastics industries. CTT will also consider investment in other areas that will have a significant impact on energy use in Wisconsin. Businesses that have technology ready for commercialization in the near term, as well as business with commercialized technology that is not currently offered in Wisconsin, are especially encouraged to contact CTT. Examples of specific CTT programs include:

- **Funding for New Energy Technologies:** To reduce energy usage on a long term basis, CTT can provide up to $250,000 to fund demonstrations of new emerging technologies and to commercialize new energy efficiency technologies. The funds can be provided to the company developing the technology either in the form of equity or loans. The funds can be leveraged with other financing and a variety of payback models are available, including shared savings.

- **Provide Energy Education and Training:** CTT, with financial support from Focus, The Wisconsin Division of Energy and the US Department of Energy is conducting a project to deliver $170,000 in energy efficiency training with industry associations and other non-profits. The funds are available through a Requests for Proposals available on the CTT website www.cttinc.org. Projects in the $5,000 to $25,000 range will be considered, with an anticipated average award size of approximately $10,000.

- **Green Tier Assistance:** Green Tier is an innovative, voluntary program that allows the Wisconsin DNR to create incentives for companies to "go beyond" standard environmental compliance. Through a grant from the US Department of Energy, and in cooperation with the DNR, CTT provides free assistance to companies negotiating Green Tier contracts that will deliver superior energy and environmental results.

US – DEPARTMENT OF ENERGY – ENERGY EFFICIENCY AND RENEWABLE ENERGY (EERE) - EERE offers valuable tools and publications to help industrial companies improve productivity and energy efficiency. These resources are listed below, you can learn more by visiting the Best Practices website at www.eere.energy.gov/industry/bestpractices or by calling the EERE Information Center at 877-337-3463.

Publications : *www.oit.doe.gov/bestspractices/library.shtml*
Whether you're looking for information on how to recover waste heat from your steam system or wondering about the market potential of efficient motors, the Best Practices library has the publication for you:

- DOE G 414.1-2, Quality Assurance Management System Guide – systems for conducting best practices. http://www.directives.doe.gov/pdfs/doe/doetext/neword/414/g4141-2.pdf
- Corporate Energy Management Case Studies - These case studies can help decision makers examine the bottom line benefits that result from successful applications of energy efficient practices and technologies. *www.oit.doe.gov/bestpractices/case_studies_corp.shtml, www.ase.org/section/topic/industry/corporate/cemcases/*
- Case Studies – Profiles of companies and organizations that have made energy savings improvements and how they did it. *www.oit.doe.gov/bestpractices/case_studies.shtml*
- Technical Publications – Materials on buying, maintaining, and assessing industrial systems and components; overviews of the energy-efficient motor and compressed air markets; and specific information on Best Practices tools. *www.oit.doe.gov/bestpractices/technical_publications.shtml#source*
    - Technical Fact Sheets and Handbooks provide "how-to" technical detail on increasing system efficiencies.
    - Tip Sheets provide quick advice on how to keep your systems running at their maximum efficiency.
    - Best Practices Resources provide information on the tools available from the Best Practices portfolio.
    - Market Assessments provide a look at the market for energy efficient industrial systems and components, and offer strategies to influence that market.
    - Sourcebooks provide information on activities, resources, applications, standards and guidelines for increasing industrial energy efficiency.
    - Repair Documents for motors.
- Energy Matters – Best Practices' award-winning quarterly newsletter carries articles from industry experts, tips for performance optimization, case studies and news on current program activities. *www.oit.doe.gov/bestpractices/energymatters/energy_matters.shtml*
- ITP E-Bulletin – Monthly online connection to news and resources from ITP—including announcements about new tools and resources. Subscribe by sending an e-mail to itpebulletin@ee.doe.gov

- Training Materials – A range of materials—notebooks, CDs, viewgraphs—designed to spread the word about the benefits of industrial energy efficiency and how to achieve it. www.oit.doe.gov/bestpractices/training/training_materials.shtml
- Library Links – Links to ITP Allied Partners and industry association colleagues, many have very complete energy efficiency library collections. www.oit.doe.gov/bestpractices/library_links.shtml

Training: www.oit.doe.gov/bestpractices/training/
Best Practices offers system-wide and component-specific training programs to help you run your plant more efficiently. The training is offered throughout the year and around the country.
- End-User Training for compressed air, motor, process heating, pump and steam systems.
- Specialist Qualification Training offers additional training in the use of specific assessment and analysis software tools developed by DOE.

Plant Assessments: www.oit.doe.gov/bestpractices/assessments.shtml
Plant assessment assistance is available to help you and your customers identify opportunities to improve the bottom line by reducing energy use and enhancing productivity.
- Plant-Wide Assessments investigate overall energy use in industrial facilities and highlight opportunities for best energy management practices. Approximately once per year, plants are selected through a competitive solicitation process and agree to a minimum 50% cost-share for implementing the assessment.
- Industrial Assessment Centers (IAC) are aimed at small- to medium-sized manufacturers and provide a comprehensive industrial assessment at no cost. Engineering faculty and students conduct energy audits or industrial assessments to identify opportunities to improve productivity, reduce waste and save energy.

Software: www.oit.doe.gov/bestpractices/software_tools.shtml
ITP's comprehensive suite of software tools can help your organization identify energy savings opportunities. Visit the Web site to learn more and download these tools, free of charge, to improve industrial compressed air, motor, fan , pump, process heating and steam systems:
- ASDMaster evaluates adjustable speed drives and their application
- AirMaster+ assesses compressed air systems
- MotorMaster+ and MotorMaster+ International assists in selecting and managing energy-efficient motors
- Process Heating Assessment and Survey Tool (PHAST) assesses process heating systems
- Pumping System Assessment Tool (PSAT) assesses the efficiency of pumping systems
- NOx and Energy Assessment Tool (NxEAT) assesses and analyzes NOx emissions and applications of energy-efficient improvements
- Steam System Scoping Tool (SSST) profiles and grades steam system operations and management
- Steam System Assessment Tool (SSAT) assesses steam systems
- 3E Plus determines whether boiler systems can be optimized through the insulation of steam lines

Databases: www.oit.doe.gov/bestpractices/databases.shtml
ITP's on-line databases can help you make contact with best practices service providers, review results of plant assessments, and find a variety of additional tools.
- Allied Partners Database contains information on private companies, organizations, and government agencies that provide equipment, assistance, or services to manufacturers. www.oit.doe.gov/bestpractices/cfm/database_allied.cfm
- The Industrial Assessment Center (IAC) Database contains the actual results of approximately 7,000 assessments conducted by the IACs. The database includes details including fuel type,

base plant energy consumption, and recommended energy efficiency improvements, in addition to projected energy savings, cost savings, implementation cost, and simple payback. *http://iac.rutgers.edu/database/*

- The National Inventory of Manufacturing Assistance Programs (NIMAP) database provides an extensive listing of organizations that offer assistance to industrial firms. NIMAP links industrial customers to potential resources to help them address energy management responsibilities, including operations, maintenance, and training issues, as well as equipment sourcing and financing. *www.oit.doe.gov/bestpractices/nimap/*

OTHER

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APPENDIX E

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John Graf
Packaging Corporation of America
Engineering & Technical Superintendent
N9090 County Road E
Tomahawk, WI 54487

Bruce Ridley
Mill Manager
Packaging Corporation of America
N9090 County Road E
Tomahawk, WI 54487
715-453-2131 x499
715-453-0459 fax
bridley@packagingcorp.com

Tom Scharff
Stora Enso North America
Director of Power and Energy
Chetek Brundridge
Energy Analyst
P.O. Box 8050
Wisconsin Rapids, WI 54495-8050
(715) 422-3073

Mr. Paul McCann
Appleton
P.O. Box 359
Appleton, WI 54912-0359
Phone: 920-991-8828
e-mail: pmccann@appletonideas.com

Ron Swanson
President and CEO
Badger Paper
200 W. Front Street
Peshtigo, WI 54157-0149
Phone: 715-582-5210
Fax: 715-582-5242
E-mail: res@badgerpaper.com

Bill Ward
Procter and Gamble
P.O. Box 8020
Green Bay, WI 54308-8020
Phone: 920-430-2707

Jim Wise
Project Manager
Baisch Engineering
809 Hyland Avenue
P.O. Box 440
Kaukauna, WI 54103

Pete Schomin
Metso Paper
Product Manager
2111 North Sandra Street
P.O. Box 2339
Appleton, WI 54912-2339

Chuck Schultz
Vice President
Harris Group Inc.
Forest Industries
14 Tri-Park Way
Appleton, WI 54914-1658
(920) 749-4600

Gerry Ring
Chairman
Department of Paper Science
Room 274
UW-Stevens Point
Stevens Point, WI 54481
(715) 346-3928

Paul Scheihing
Team Leader, Chemical and Enabling Technologies
Office of Industrial Technologies
Office of Energy Efficiency and Renewable Energy
U.S. DOE
1000 Independence Ave. SW, EE-2F
Washington, DC 20585
(202) 586-7234

Peter Salmon-Cox
Office of Energy Efficiency and Renewable Energy
U.S. DOE
1000 Independence Ave. SW, EE-2F
Washington, DC 20585

Dr. JunYong (JY) Zhu
Supervisory Research General Engineering
USDA Forest Service, Forest Products Laboratory
One Gifford Pinchot Drive
Madison, WI 53726
Phone: (608) 231-9520
Fax: (608) 231-9538
E-mail: jzhu@fs.fed.us

Pat Schillinger
Executive Director
Wisconsin Paper Council
250 N. Green Bay Road
P.O. Box 718
Neenah, WI 54957-0718
920-722-1500
920-722-7541 (fax)

Sharon Kneiss
Vice President of Regulatory Affairs
American Forest and Paper Association
1111 Nineteenth Street, NW
Suite 800
Washington DC 20036
202-463-2580

Mary Beth Cornell
Publishing Director
Solutions! for People, Processes, and Paper
TAPPI JOURNAL
TAPPI
15 Technology Parkway S.
Norcross, GA 30092
770-209-7210
fax: 770-209-7400
email: mcornell@tappi.org
www.tappi.org
www.solutionsmagazine.org

Ellen Roeder
Marketing Program Manager - Business Programs
Wisconsin Energy Conservation Corporation
211 South Paterson Street
Madison, WI 53703
Phone: 608.249.9322 x336
Fax: 608.249.0339
ellenr@weccusa.org

APPENDIX F

Case Studies

At present, no Focus on Energy Best Practice Case Studies have been completed, but many are under development. To receive case study updates from Focus on Energy call 800-762-7077 to ensure that you are on the Pulp and Paper Energy Best Practices Guidebook update distribution list.