Using Common Sense and Emerging Technologies to Reduce Energy Use

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Abstract: Some paper companies have done an excellent job of benchmarking energy performance and reducing energy use. Several new technologies are being applied in pulp and paper mills to reduce energy use. Cost of energy ranges from ten to forty percent of total manufacturing cost with an average of 18 percent. This paper compares energy costs for five major paper grades for paper mills in the United States. The Wisconsin Focus on Energy program works with paper mills to benchmark energy performance and identify opportunities to reduce energy use. New technologies are monitored and recommended to paper mills where new concepts can provide significant reductions in energy use. The Focus on Energy program provides economic incentives to evaluate and install new technologies.

Some paper companies have done an excellent job of benchmarking energy performance and implementing changes to reduce energy use.[1] For example:

- International Paper reduced fossil fuel use by 40% between 2005 and 2015 in their mills. IP has an excellent corporate energy program with strong support by top management and dedicated funds for cost-reduction.
- Graphic Packaging participated in the Department of Energy (DOE) Save Energy Now program and reduced total energy use in their mills by over 25% between 2006 and 2016.
- Several paper mills in Wisconsin have achieved significant energy use reductions with technical assistance and financial incentives from Focus on Energy and DOE. Some paper mills would have shut down without implementing recommended energy reduction projects. Focus on Energy is Wisconsin utilities' statewide energy efficiency and renewable resource program funded by the state's investor-owned energy utilities and participating municipal and electric cooperative utilities.

On the other hand, high energy consumption and cost have been key factors in some paper mills being unable to sustain profitable operation. The fossil fuel energy spike in 2008 resulted some mills seeing steam cost over $15 per 1,000 pounds and elevated electricity rates. One mill evaluated in New England in 2008 was using number 6 fuel oil and steam cost was $25 per 1,000 pounds while electricity cost was $0.15 per kilowatt hour. At the same time, the mill was generating steam very inefficiently and wasting steam and electricity compared to energy best practices. An energy audit team identified annual energy savings opportunities of over $10 million by following energy best practices followed in top performing mills producing similar paper grades. Obviously, this mill could not survive even when energy costs went down. Other paper mills had similar fates due to high energy costs, poor energy contracts, and inefficient use of energy.

TAPPI technical information paper 0404-63, paper machine energy conservation,[2] includes energy benchmarks for all major paper grades except tissue and towel. Guidelines for monitoring and reducing energy use are also included. Some performance indices from the TIP are shown in Table 1. A TAPPI survey indicated that average paper machine energy consumption is 20% higher than the guidelines shown in Table 1.[3]

ENERGY PERFORMANCE INDICES
TIP 0404-63

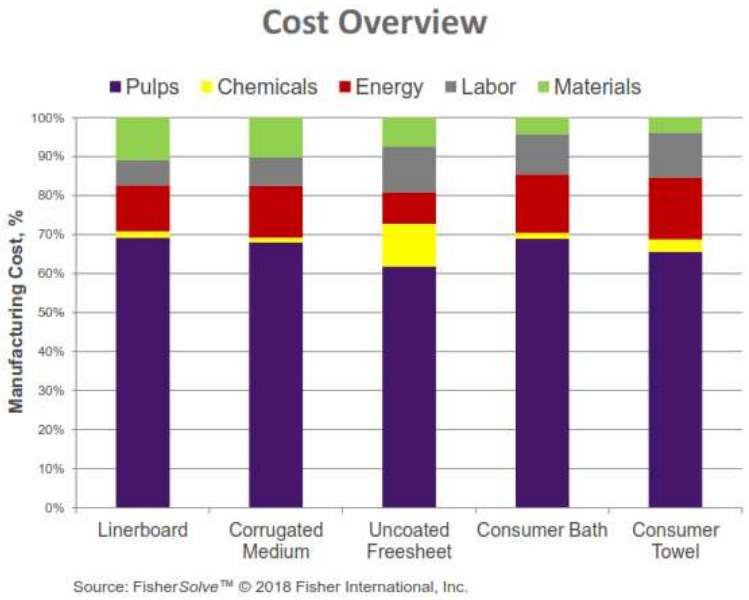
Index	Grade									
	Fine	Bleached board	Liner	Corru-gated medium	Market pulp	Fluff pulp	Recycled paper-board	News-print	LWC	Kraft paper
Uptime, %	95	93	95	95	95	95	93	93	93	94
First quality, %	93	90	97	97	99	97	93	98	85	97
Overall machine Efficiency, %	89	84	92	92	94	92	86.5	92	79	91
Total steam consumption										
lb/ton	4,000	4,000	2,800	2,750	2,000	2,500	2,800	2,800	3,000	5,000
kg/ton	2,000	2,000	1,400	1,400	1,000	1,250	1,400	1,400	1,500	2,500
Electrical consumption										
kWh/ton	350	350	300	300	150	150	300	300	400	400
kWh/tonne	385	385	330	330	165	165	330	330	440	440
Total energy cons.										
MMBtu/ton	6.0	7.0	5.0	5.0	4.0	4.5	6.0	5.0	5.5	6.0
GJ/tonne	7.0	8.1	5.8	5.8	4.6	5.2	7.0	5.8	6.4	7.0
Water consumption										
gal/ton	2,000	2,000	1,500	1,500	1,000	1,000	<1,000	2000	2000	1500
m^3/ton	7.6	7.6	5.7	5.7	3.8	3.8	<3.8	7.6	7.6	5.7
Couch solids, %	22	25	27	27	28	28	NA	21/18	22/18	20/19
Press solids, %	42/45	42	42/50	42/50	50	45	48	43/48	43/49	42/46

Energy consumption varies widely on paper machines in the United States. Energy cost ranges from 10 to 40% of total manufacturing cost. Average energy cost per ton and energy cost as a percentage of total manufacturing cost on some major grades are shown in Table 2 and Figure 1. All charts in this paper are based on Fisher International Fisher*Solve*™ data.

Table 2

Grade	Total Energy Cost, $/Ton	Fuel Cost, $/Ton	Purchased Electricity Cost, $/Ton	Energy Cost as % of Total Manufacturing Cost
Corrugating Medium	65	36	29	18
Linerboard	65	40	25	19
Fine Paper	74	60	14	13
Consumer Bath	150	86	64	16
Consumer Towel	157	75	82	17

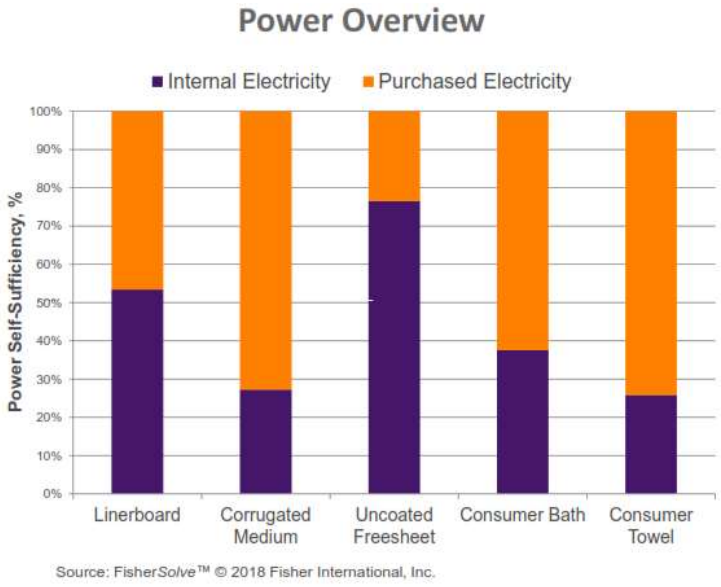
Figure 1



Average energy cost per ton is lowest on corrugating medium and linerboard machines. These machines typically have much higher capacity and lower furnish cost than consumer bath and towel machines. Energy cost as a percentage of total manufacturing cost is lowest on uncoated freesheet machines due to a high level of cogeneration. Paper machines with higher than average energy cost as a percent of total manufacturing cost can benefit by completing comprehensive energy evaluations

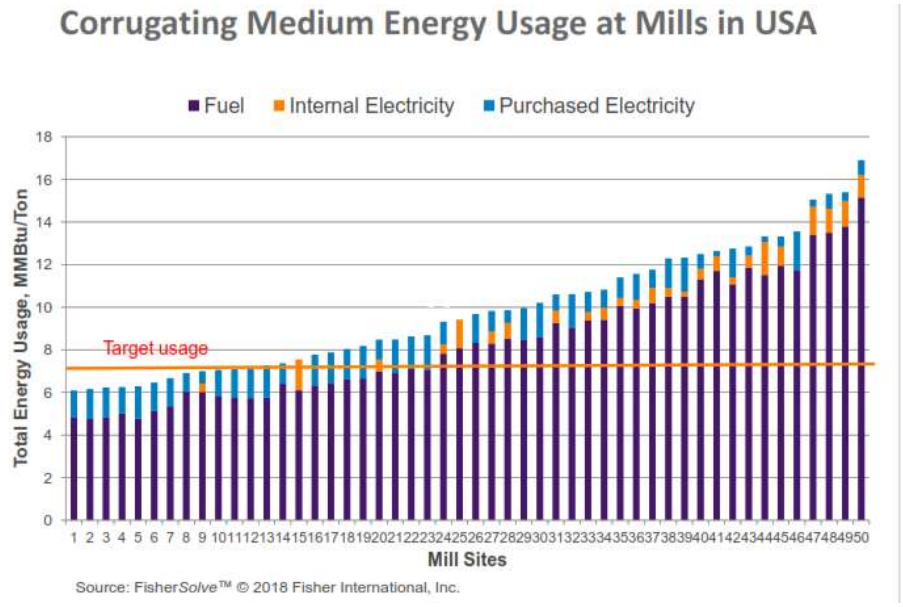
Figure 2 shows internally generated and purchased electricity for major grades. Uncoated freesheet mills have the highest percentage of internally generated electricity. Many uncoated freesheet mills have pulp mills with recovery boilers and turbine generators.

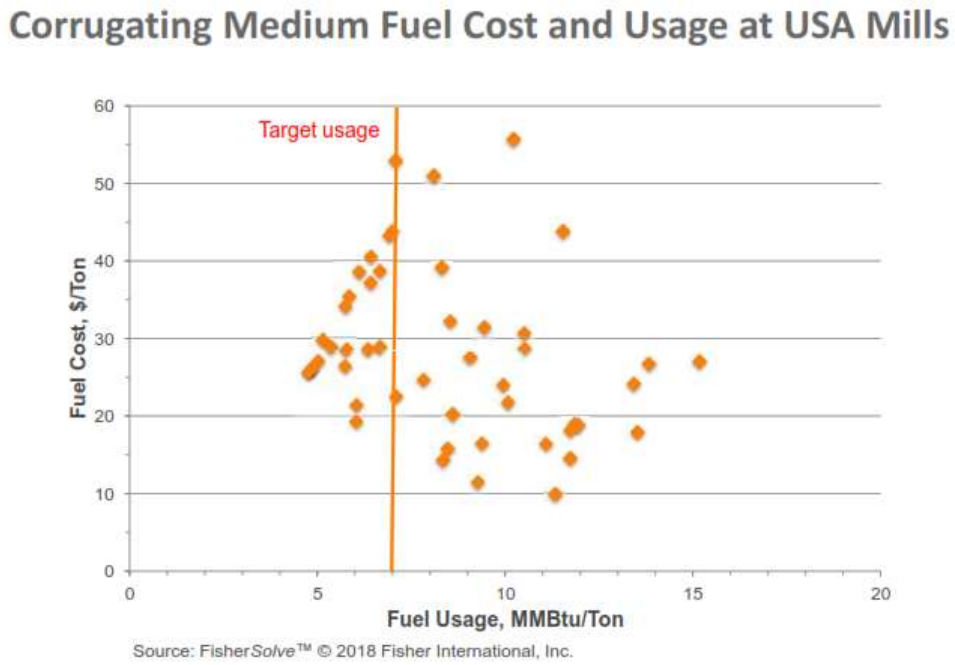
Figure 2



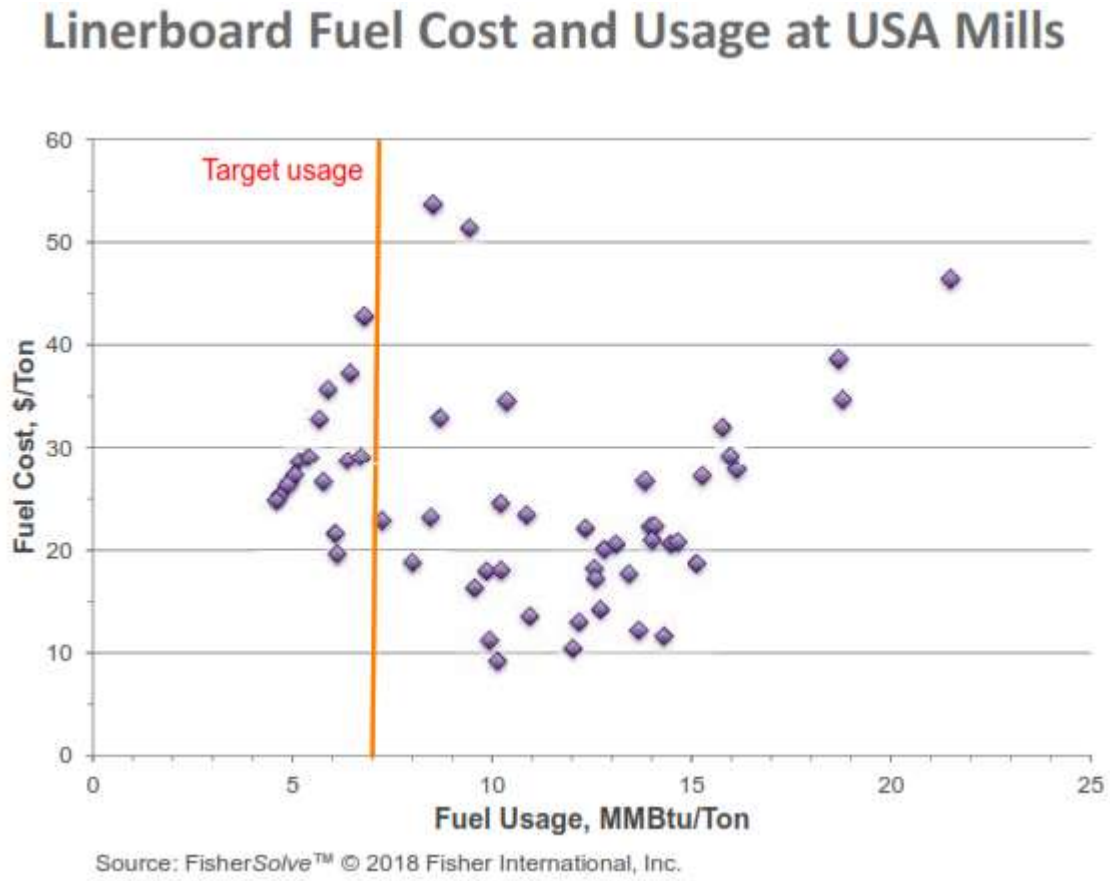
The next ten figures show total energy use and fuel cost and usage for each of the major grades. The total energy use charts for each grade are ranked from lowest to highest energy cost per ton. The fuel cost and use charts do not include electricity cost. There is wide variation in electricity usage and cost between mills and regions of the United States. The target lines on the charts indicate practical energy consumption targets. Any mill with energy use higher than the target lines should actively work on reducing energy use if they want to be competitive.

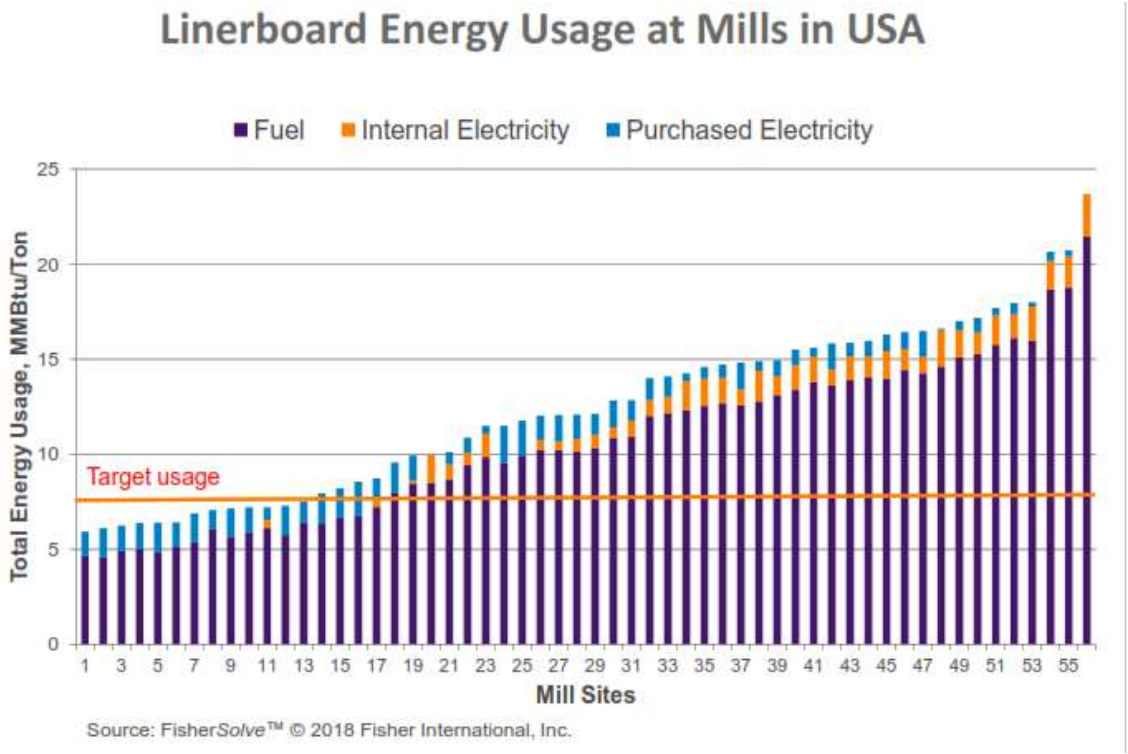
Figures 3 and 4-Corrugating Medium



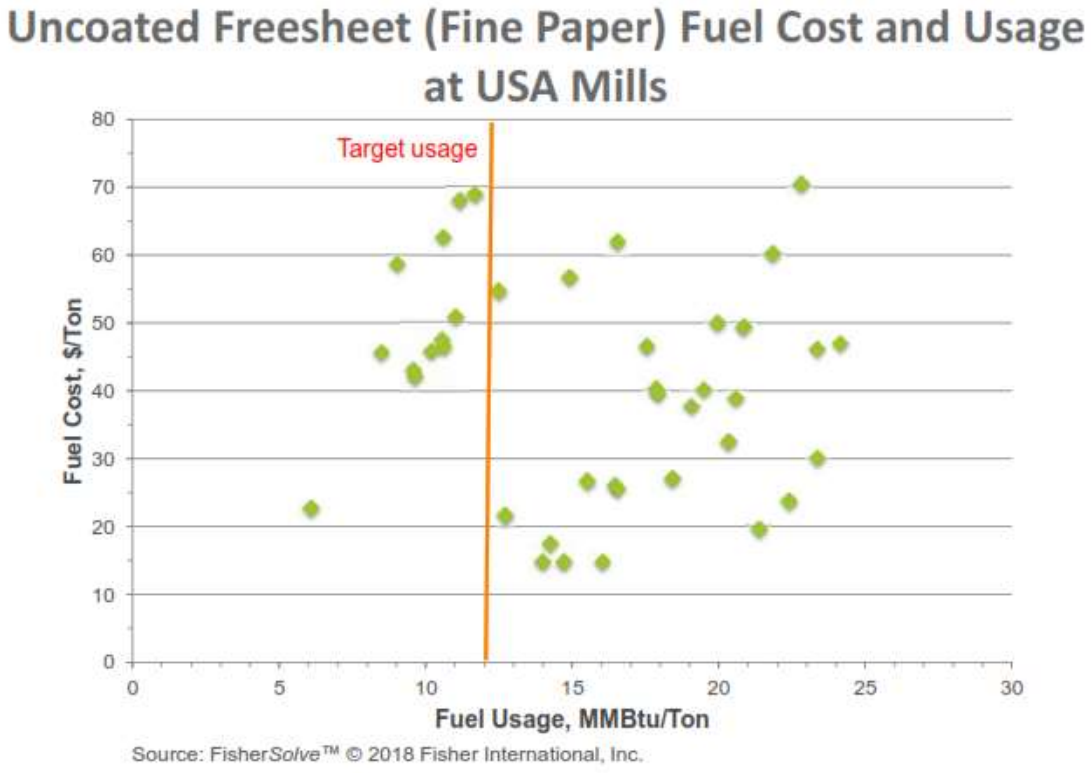


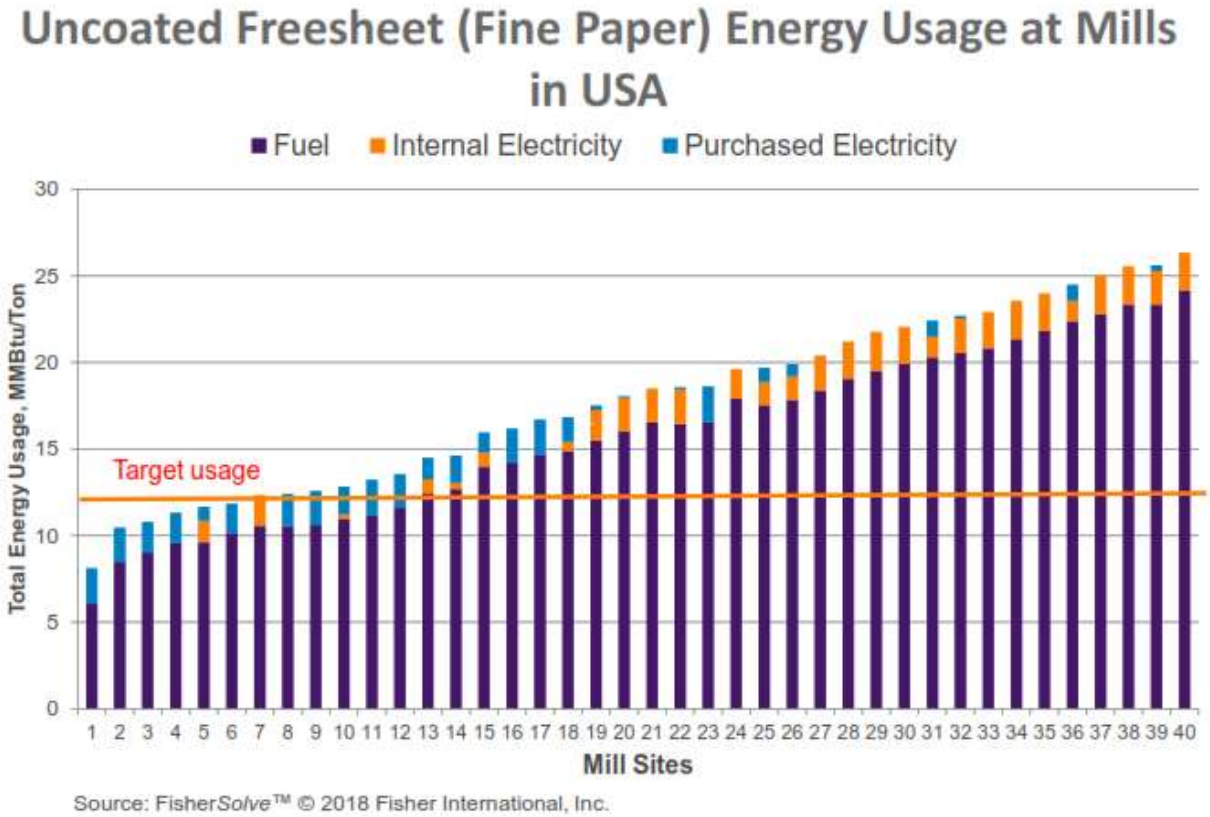
Figures 5 and 6-Linerboard



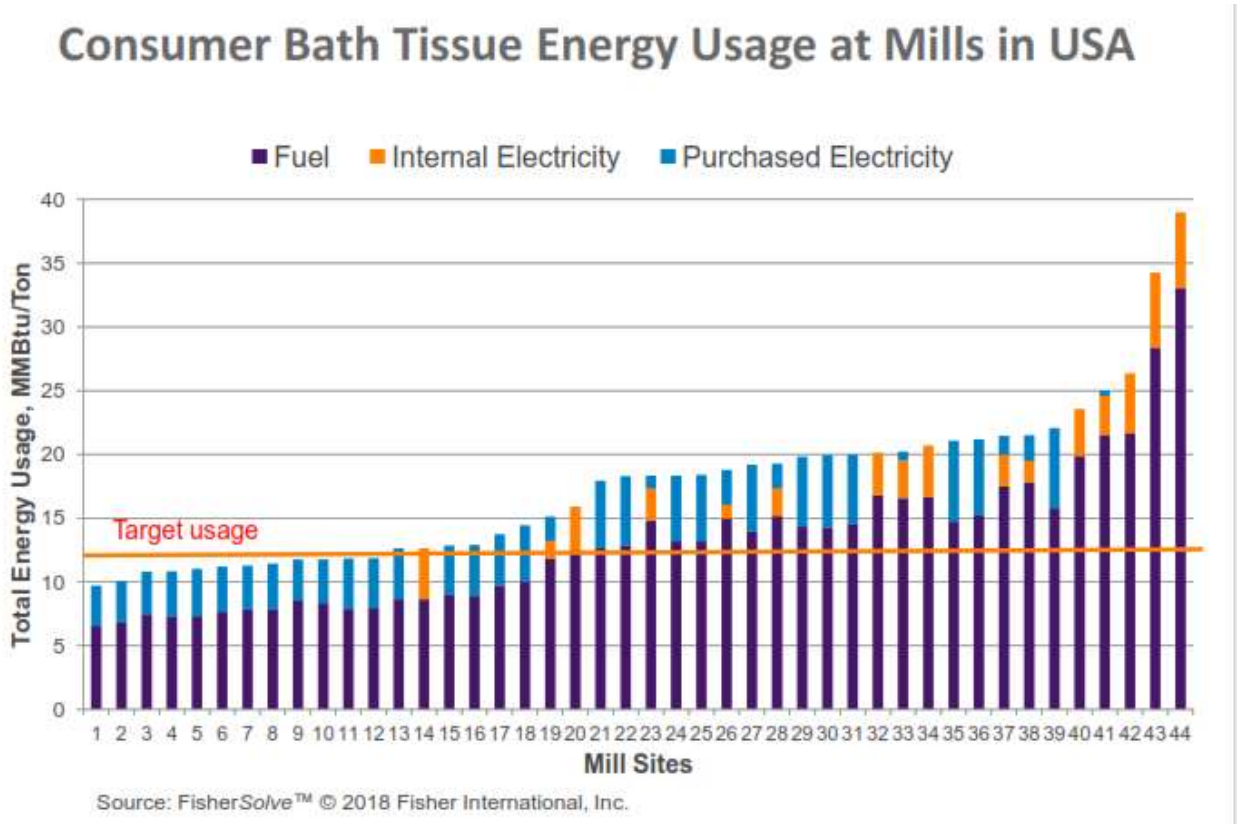


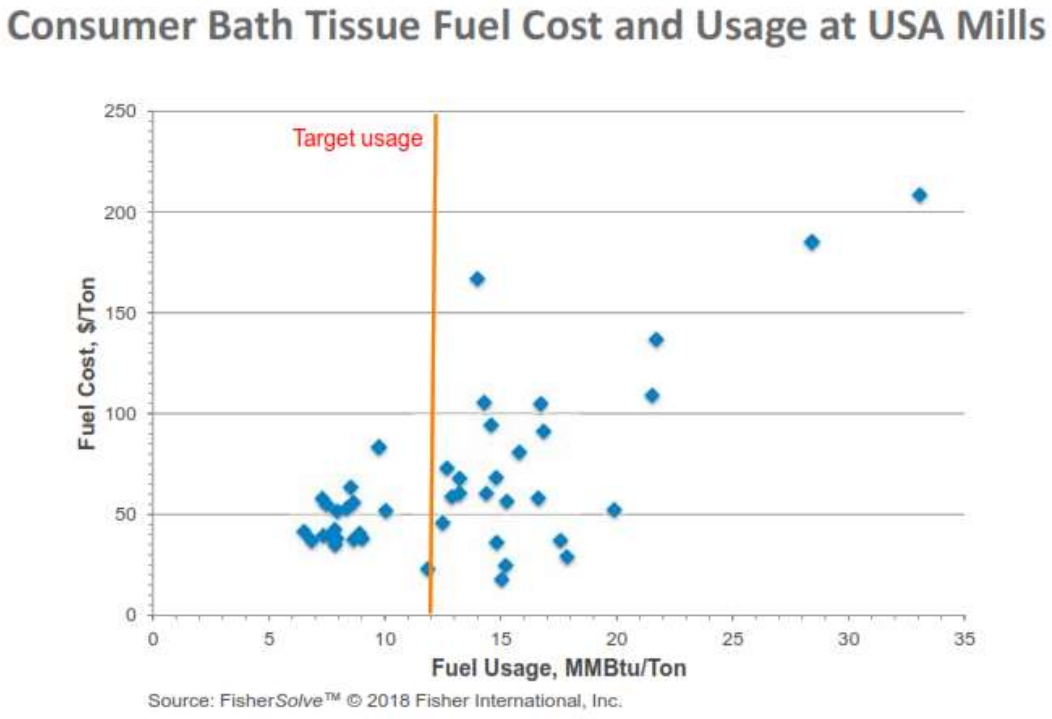
Figures 7 and 8-Uncoated Freesheet



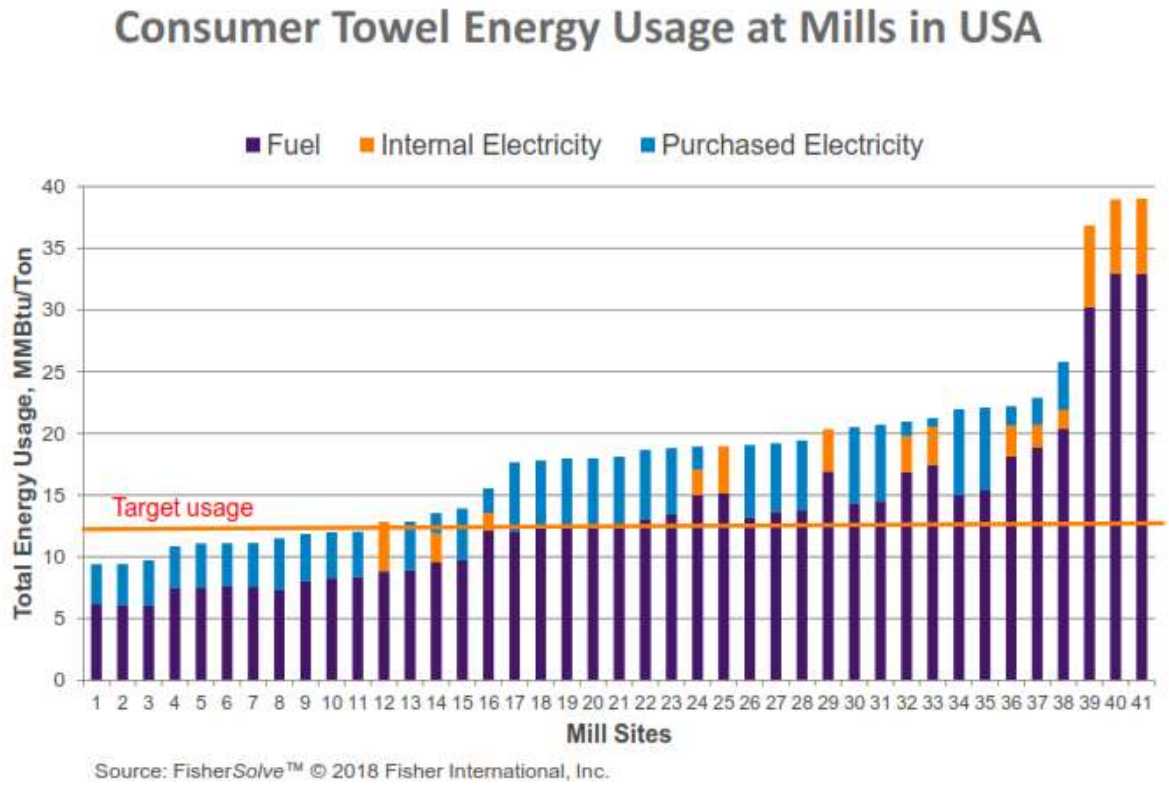


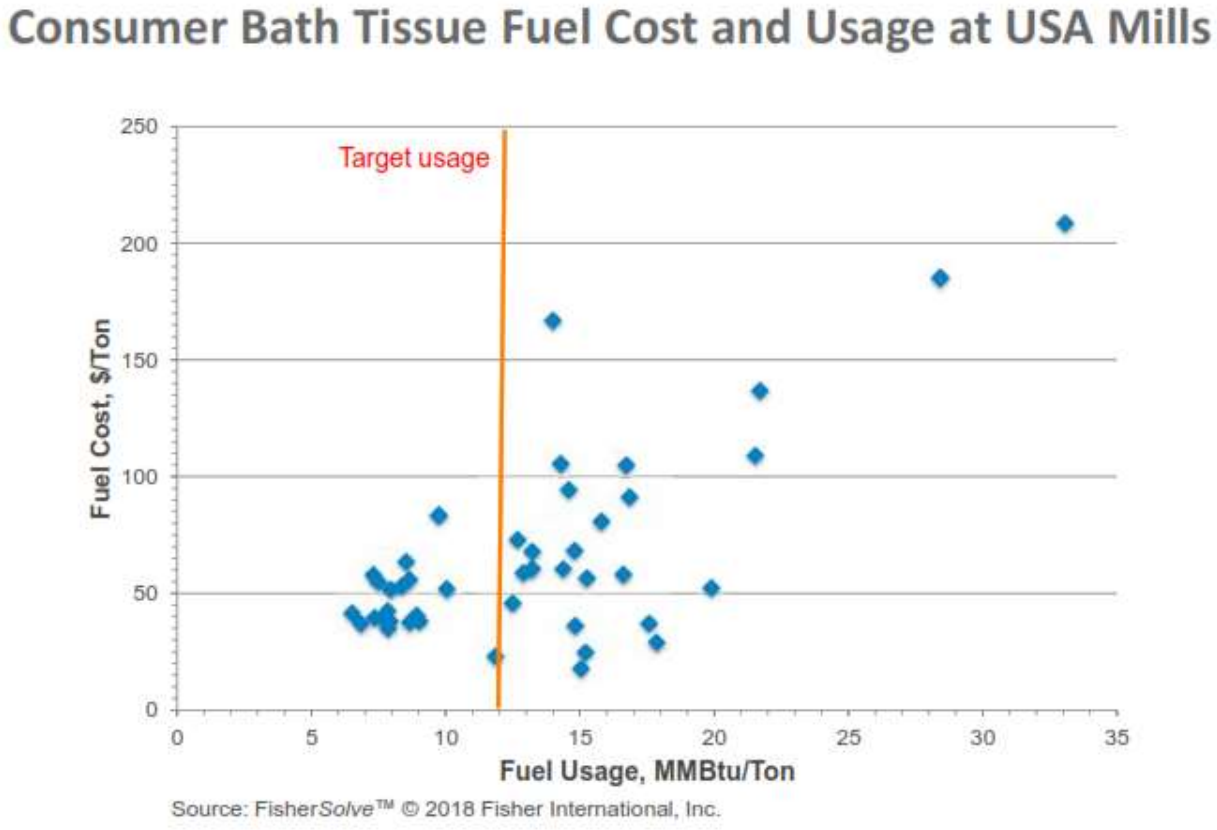
Figures 9 and 10-Consumer Bath Tissue





Figures 11 and 12-Consumer Towel





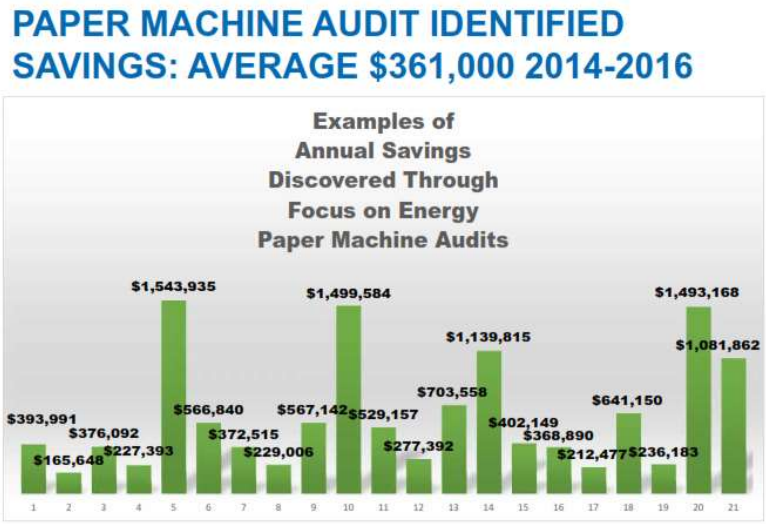
Wisconsin Focus on Energy has assembled a team of paper industry energy experts to conduct energy evaluations in pulp and paper mills. The team has completed energy evaluations in most pulp and paper mills in Wisconsin. Energy performance is benchmarked against TAPPI guidelines and practical recommendations for reducing energy use have been developed. Annual energy savings opportunities identified have ranged from $100,000 to $5 million in individual mills. Many recommendations do not require capital funds to achieve significant energy use reduction. Other recommendations are focused on improvements with payback of less than two years. The Focus on Energy program offers incentives to assist in funding projects that require capital. Typical incentives are 30% of total project cost.

Paper machine energy evaluations have been conducted for over ten years. Most early energy evaluations were funded by the DOE Save Energy Now program. The Save Energy Now program ended a few years ago. DOE funded development of paper machine energy scorecards in 2008 to help benchmark energy performance and identify energy reduction opportunities.[4, 5] Scorecards are updated regularly and have been translated into French, Spanish, Chinese, and Korean. Some common discoveries during paper machine energy evaluations are shown in Table 3. Energy savings opportunities identified in paper machine energy evaluations conducted in Wisconsin in 2014-2016 are shown in Figure 13.

Table 3-Common Discoveries in Paper Machine Energy Evaluations

- Steam and condensate system design and operation-syphon application, differential pressures, condenser operation, steam venting, condensate leaks, steam traps, etc.
- Low condensate return
- High pocket ventilation system supply air temperatures
- Poor hood balances
- Refining improvement opportunities-plate designs, splined rotors, etc.
- Chest and pulper agitation-applications of energy-efficient rotors and propellers, VFD, etc.
- Vacuum system issues-seal water application, pump condition, etc.
- Press dewatering improvement opportunities-loading, fabric design, conditioning, rewet, etc.
- High fresh water use per ton-use of clarified whitewater in showers, water system balances, heat recovery from effluent, recirculation of some treated effluent, etc.
- Sheet runnability issues
- Variable frequency drive opportunities
- Inefficient pumps-oversized, poor condition, excessive seal water use, etc.
- Compressed air system improvements-system pressures, air leaks, VFD, etc.
- Lighting upgrade opportunities

Figure 13-Energy Evaluation Savings Opportunities



Interactions between the paper mill and other mill areas are also important to optimize overall mill energy performance. For example, pulp mills usually have excess heat and transfer of heat to the paper machines permits reducing steam use to heat whitewater in the paper mill. Interactions with the boiler plant are also important since condensate return from the paper machines and other interactions are important in optimizing steam generation cost. A boiler scorecard was added to paper machine energy scorecards in 2016. Common discoveries in pulp mill and bleach plant energy evaluations are shown in Table 4. Common opportunities found in boiler and power generation audits are shown in Tables 5 and 6.

Table 4-Common Discoveries in Pulp Mill-Bleach Plant Energy Evaluations

- Inefficient use of high temperature waste heat sources
- Excessive use of hot water resulting in low hot water temperature and high steam use
- Very high bleach plant steam use (hot water heating and steam mixers)
- Waste heat recovery not in series to maximize volume and temperature of hot water generation (too much water and insufficient hot water)
- Evaporator surface condenser cooling water not used efficiently (low temperature and excessive volume)
- Oversized and fouled heat exchangers and condensers resulting in low U-values (poor heat transfer)
- Inefficient batch digester blow heat recovery (tuning, VFD, heat rejection rate, etc.)
- Brown and bleached washer shower flow rates not based on dilution factor control
- Inefficient use of hot water, filtrates and whitewater on bleach plant washer showers and repulper dilution
- Excessive wire cleaning and water doctor shower water on brown stock and bleach plant washers
- Inefficient wintertime waste heat recovery
- Waste heat recovery not optimized to provide hot water to paper mill
- Poor steam stripping column performance requiring high total and effective steam ratio. Also ineffective use of reflux condenser heat recovery and stripped condensate reuse
- Low temperature heat sources going to mid-temperature (135 to 150ºF) and hot water tanks

Table 5- Common Opportunities Found in Boiler Audits

- Recover heat to boiler makeup water
- Recover heat to boiler feedwater
- Recover heat to boiler combustion air
- DA tank or condensate tank vent condenser
- Minimize steam venting
- Optimize boiler blowdown rate
- Recover boiler blowdown heat
- Modify plant processes to reduce steam swings
- VFD on boiler fans and pumps
- Condensing economizer
- Boiler O2 reduction
- Steam and condensate line insulation
- Failed steam traps

Table 6-Common Power Generation Opportunities

- Repair leaky PRV
- Steam feedwater heater
- Steam coil air heater
- Maximize use of low pressure steam
- Thermocompressor
- Reduce turbine shaft leak-off steam
- Turbine modifications for higher efficiency and/or output

Catherine DeVyre, an Australian business consultant, has stated, “The six most expensive words in business are ‘We’ve always done it that way’”. This adage certainly applies in pulp and paper mills. There are many myths related to energy use in pulp and paper mills. Some paper mill myths are shown in Table 7.

Table 7-Pulp and Paper Mill Energy Myths

- It is all about tons
- A little bit is good and more is better
- Hotter wire pit temperatures is always better
- More refining is better
- More chemical additions are better
- More steam use is always better on steam boxes
- Hotter pocket ventilation supply air temperatures are better
- Higher level set points for adding mill water into whitewater chests are better
- Stationary syphons need the same differential pressure as rotary syphons
- Steam boxes can save steam
- Increasing couch solids will provide an equal increase in press exit solids
- Steam in bottom unorun and felt dryers always increases drying capacity
- Superheated steam always increases drying capacity
- Dryer bars save steam
- Steam and condensate system leaks are a fact of life, condensate is cheap

- Steam application efficiency can be as high as two pounds of steam per pound of water evaporated as reported in clothing supplier reports
- Clarified whitewater cannot be used in forming and press section showers without plugging nozzles
- There is no benefit to monitoring press exit consistencies regularly
- Seal water temperature does not affect vacuum pump efficiency
- All vacuum pump repair shops return pump performance to near new performance
- Jordans are required to meet sheet specifications on some paper grades
- The best ways to evaluate clothing performance are days life and cost per ton
- Achieving low unscheduled maintenance lost time is not cost effective
- Reduction in effluent will not reduce energy costs
- We will fix it right tomorrow, next week, next month, next year, etc.
- Corporate purchasing contracts always reduce manufacturing cost per ton
- Variable frequency drives are not cost effective
- It is not cost effective to shut down pulper agitators when the sheet is on the reel
- "We know what is going on, we do not need real-time measurement for that"

Many of these misunderstandings make it easier to find energy reduction opportunities in pulp and paper mills. There have been many good energy reduction case histories developed that were based on limited knowledge of operating principles by mill personnel. Kadant regularly publishes paper drying energy tips that include comments on energy use in paper drying including some of the papermaking myths included in Table 6.[6]

The Focus on Energy pulp and paper team continuously tracks new technologies that have potential to reduce energy use in pulp and paper mills. New technologies are considered emerging technologies if they have not been installed on more than ten percent of potential applications in Wisconsin and have potential application to reduce energy consumption in several pulp and paper mills. Some of the new technologies that have been successfully implemented in Wisconsin pulp and paper mills since 2014 are:

- Kadant high efficiency thermocompressors
- Voith HydroSeal suction roll seal systems
- Kadant RotoFlex whitewater strainers
- Mechanical seals on rotating equipment with tanks to circulate seal water

The goal is to evaluate these technologies and install successful technologies in other pulp and paper mills so they become energy best practices. Special incentives are offered to encourage installation on new technologies.

North Carolina State University developed and maintains a website that tracks energy policies and incentive programs in the United States. The website is www.dsireusa.org Energy programs and incentives can be accessed by entering the zip code of pulp and paper mill sites. The Focus on Energy team is available to conduct energy evaluations in other states.

Summary

There are opportunities to reduce energy use in all pulp and paper mills. Energy use varies widely between mills producing similar grades. This paper includes guidelines for benchmarking energy consumption and suggestions for identifying improvement opportunities. Mill operating personnel often do not fully understand process interactions and their impact on energy consumption. Focused energy evaluations can identify operating changes and capital projects with fast payback to reduce energy use.

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