Energy Profiling in Sawmills

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Energy Profiling in Sawmills

- Sawmills are a major sector of the wood industry that transform wooden logs into lumber.
- In West Virginia, there are approximately 200 sawmill facilities, which have contributed over $4 billion annually to the state's economy in the recent past.
- Sawmills have energy costs up to 10% of the total operating costs
- 90% of the energy used will be in the form of electricity.
- The average annual electricity consumption of saw mill in WV is 2,400 MMBtu (703,200 kWh)
- Average annual production of saw mill is 9 million board feet (one Board Feet = 1' length x 1' Width x 1" Thickness)

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Energy Saving Recommendations recommended to a Saw Mill (WV0432)

AR No.	Description	Annual Potential Conservation		Potential Savings ($/Yr)	Resource Conserved	Estmtd. Cost ($)	Simple Payback (months)
		MMBtu	kWh				
1	Replace Natural Gas Boiler with Saw Dust Boiler	15,715		101,575	Natural Gas	193,750	23
			-653,496		Electricity		
		-17,910	-		Saw Dust		
2	Develop a Demand Monitoring System to Reduce Demand Cost	-	-	4,812	Electrical Demand	10,750	27
3	Replace the Existing T12 Fluorescent Lighting with T8 Fluorescent Lighting	-	62,401	3,660	Electricity	3,828	13
4	Repair Compressed Air Leaks	-	23,171	2,762	Electricity	290	2
5	Perform Vibration Analysis on Equipment	-	36,244	2,144	Electricity	2,000	12
6	Preheat Boiler Feed Water Using Stack Gases	193		1,989	NG	16,000	97
7	Implement a Motor Management System	-	36,244	1,677	Electricity	1,775	13
8	Use Outside Air for Air Compressor Intake	-	8,520	1,014	Electricity	1,425	17
9	Replace Drive Belts on Motors with Energy Efficient Cog Belts		8,909	873	Electricity	1,000	14
10	Adjust Air-Fuel Ratio for Boilers	88		762	NG	1,000	16
11	Replace the 400W Metal Halide Bulbs with 360W Metal Halide Bulbs	-	5,796	694	Electricity	-	Immediate
12	Reduce Compressor Pressure Set Point	-	1,734	207	Electricity	25	2
	Total	**15,996**	**-470,477**	**122,169**		**231,843**	**23**

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Need for Research:

- To develop specific energy consumption profiles to manufacture different species and sizes of lumber
- Benchmark the energy consumption of sawmills with the standard energy consumption
- Assess the potential of energy savings for the saw mill

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Typical Sawmill Manufacturing Process

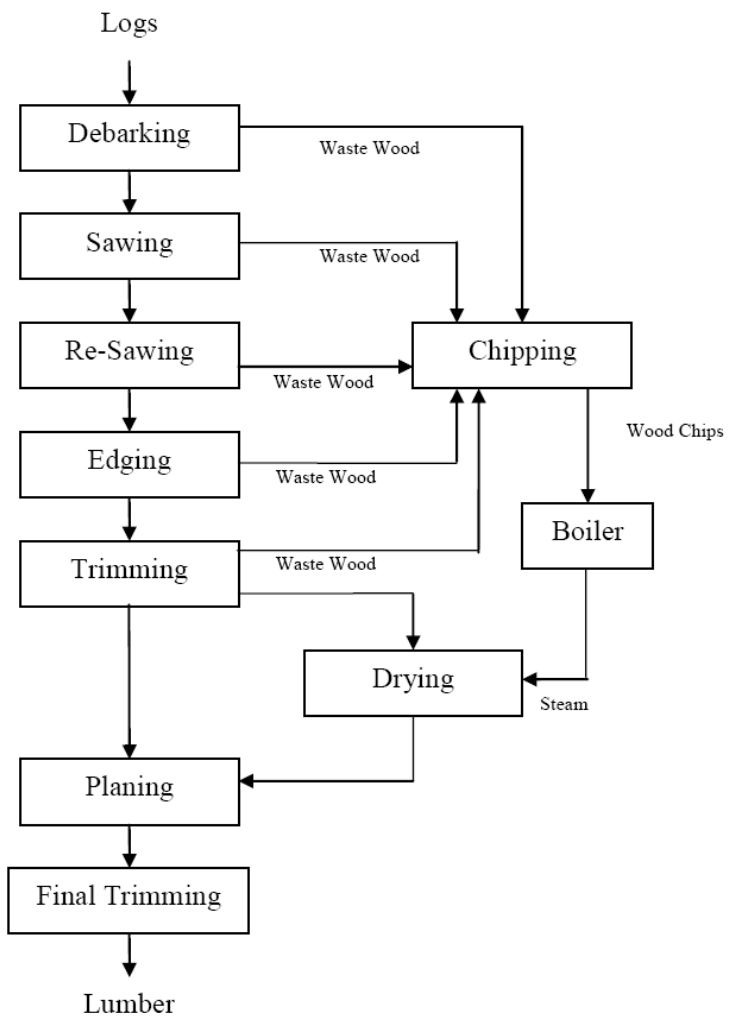

Figure 1-1: Process flow diagram for sawmill operation

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Debarker:

- The process of removing the bark from wooden logs is known as debarking

Debarker

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Head Saw:

- Band saws and Circular saws are the most commonly used equipment for sawing the wood.
- Wood logs from the debarker are first sawn using a band saw or a circular saw into cants (Cant is a log having rectangular cross section after sawing its sides in Head Saw).

Cant

Band Saw

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Head Saw Cont'd:

- Circular saw is another kind of saw used for sawing logs.
- For logs larger than 60 inches, another circular saw on the top is added instead of using a single saw of larger diameter.

Circular Saw

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Resaw:

- The cant is further cut into boards using another band saw or a circular saw down the line. This saw is called as Resaw

Resaw

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Edger:

- Edging is the process of cutting the lumber lengthwise into narrower widths.

Edger

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Trimmer:

- The process of cutting the lumber across the width to form straight ends is known as trimming.

Trimmer

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Chipping:

- In addition to producing lumber, sawmills also produce a valuable byproduct in the form of wood chips.
- Wood chips can be made from wood logs that are not of adequate quality to be processed into lumber, or they can be made from the wood waste at different woodworking processes.

Chipper

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Other Major Energy Consuming Equipment in Sawmill

- Compressor
- Log Turner
- Dust Collector
- Carriage Feed Motor
- Chip Blower
- Conveyors
- Other small motors

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Energy profiling procedure

- Monitor the energy consumption of various equipment in sawmills
- Analyze the logged data to calculate the energy consumption by each sawmill
- Calculate energy consumption to produce one board feet of lumber of a particular species and particular size

Energy Profiling in Sawmills

Data Collection

- Amperage data of various motors was logged every minute for a period of one month
- Production schedule was obtained during the logged time
- Power factor and voltage data were collected by using Amprobe

Equipment used for data logging are

- HOBO Data Logger
- Current Transducer
- Amprobe

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Equipment Used

HOBO Data Logger

It is a device which records the data of different physical parameters by using external sensors over a period of time

- AC Current
- Temperature
- AC and DC Voltage
- CO_2
- 4-20mA
- Relative Humidity
- Light Intensity

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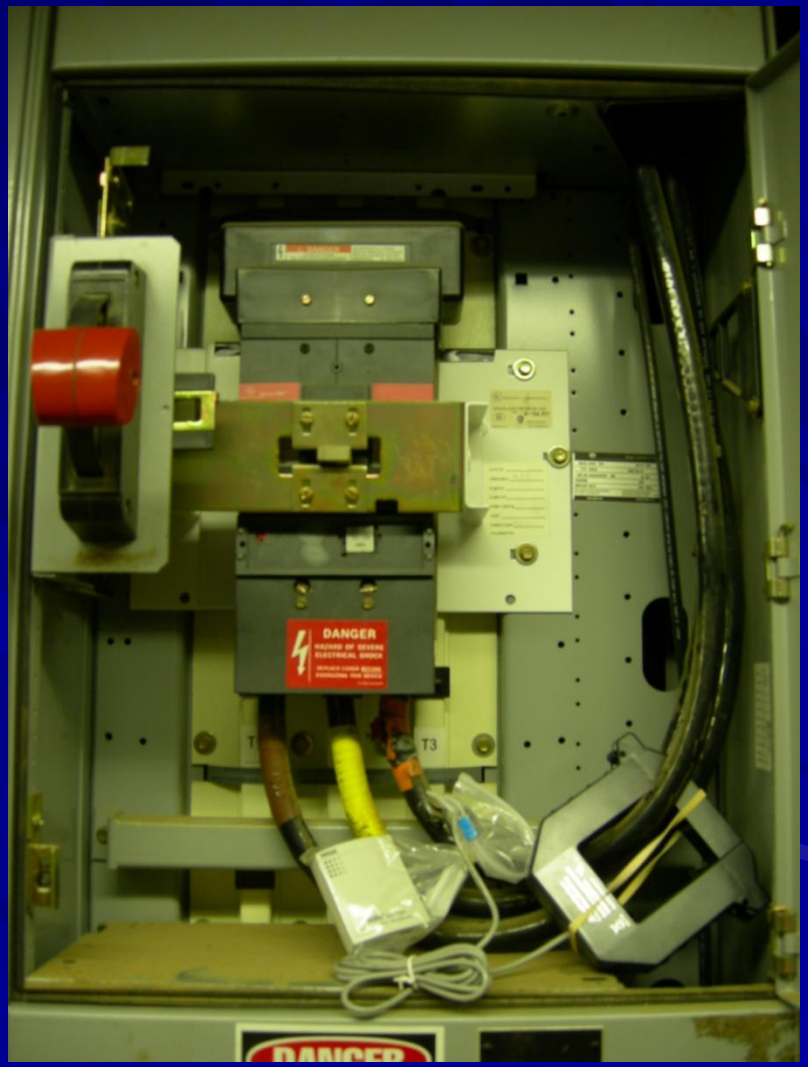
Current Transducer

It is a sensor which measures AC current when placed around the current carrying conductor.

- Measures AC Current from 0-600 Amps



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Amprobe

It is an electrical power monitoring device that measures the following parameters.

- AC Voltage: 0 - 600V
- AC Current:1 - 1000A
- Power:
  - Actual (W),
  - Reactive (VAR)
  - Apparent (VA)
- Power Factor: 0 - 1
- Energy: kWh
- Peak Demand: kW
- Fund. Frequencies: 50/60 Hz

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List of motors used for data collection

Saw mill 1

Motor	HP
Carriage feed Motor	100
Edger	50
Chip blower	30
Chipper	150
Re saw	60*
Debarker	50
Head Saw	200
Top saw	40
Compressor 1	30
Compressor 2	30
Dust Collector	15
Log turner	40
Trimmer Motor	10
Small Motors	160
Total	**965**

Saw mill 2

Motor	HP
Carriage Motor	150
Debarker	50
Hydraulic motor	30
Conveyor	5
Edger	50
Trimmer	10
Chipper	150
Dust Blower	30
Vibrator	5
Main Saw	200
Barn Sweep	5
Conveyor	15
Chip Bin Motors	30
Extra Small Motor	30
Air Compressor	40
Total	**800**

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Energy allocation Methodology

- Energy allocation was done based on the surface area cut for that particular type of lumber in that particular equipment.
- Example: Soft Maple 4/4 size (1" thick x 8" wide x 12' long):

Total board feet cut = 8,334 Bft
Total length cut = 8,334 / ((1/12) x (8/12)) = 150,012 ft

Surface area cut by Resaw* = Total length cut x Width = 150,012 ft x (8/12) ft
Surface area cut by Edger = Total length cut x Thickness = 150,012 ft x (1/12) ft
Surface area cut by Trimmer = Width x thickness x No. of pieces cut
= (8/12) ft x (1/12) ft x (150,012 ft/12 ft)

Rest of the Motors = SA cut by (Resaw + Edger + Trimmer)

*Surface area cut is calculated for Head Saw if it is used for sawing complete log

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- Total kWh energy consumption for each motor was calculated for a particular time period using the logged data as follows:

$$kWh = \sqrt{3} * V * I * \cos\Phi * \text{No. of hours}/1000$$

Where,

V = Voltage

I = Amperage

cos Φ = Power Factor

Example: Resaw for Soft Maple on April 14th (5:30 Am - 2:45 Pm)

$$kWh = \sqrt{3} * 477.6 * 23.92 * 0.25 * 8.42/1000$$
$$= 41.65$$

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Factors Allocation:

- This energy was allocated to Individual size of lumber by a factor that is calculated as the ratio of the surface area cut for a particular size in each machine to the total surface area cut by that machine during that period.

Example for Resaw:

Soft Maple:

Date	Time	Board Feet	Size	Surface Area	Total kWh	Factor	kWh Allocated
14-Apr	5:30 Am - 2:45 Pm	8,334	4/4	100,008	41.65	0.274	11.41
		1,728	3" x 8" x 12'	6,912		0.019	0.788
Total*				365,201			

*Total surface area cut includes other sizes that are not shown in the Table.

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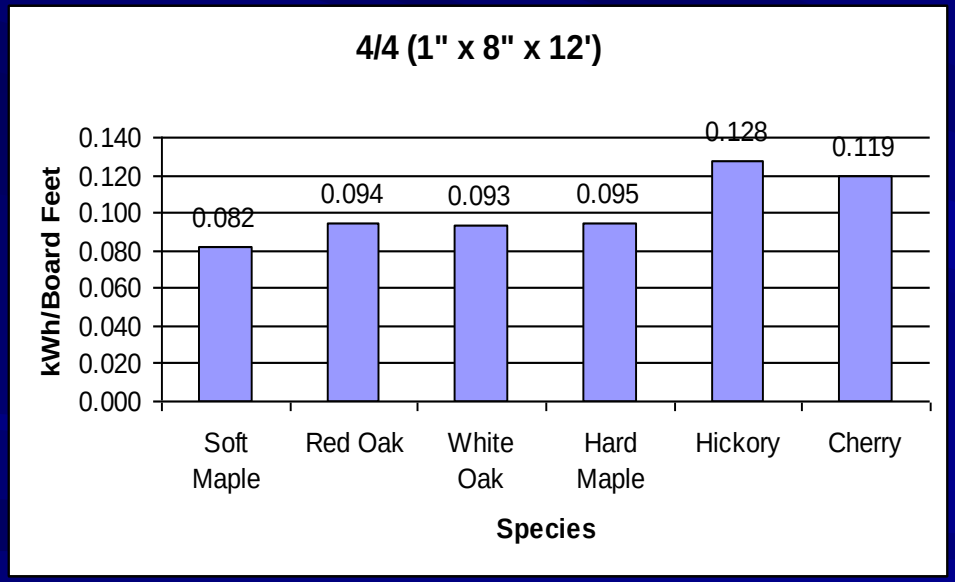
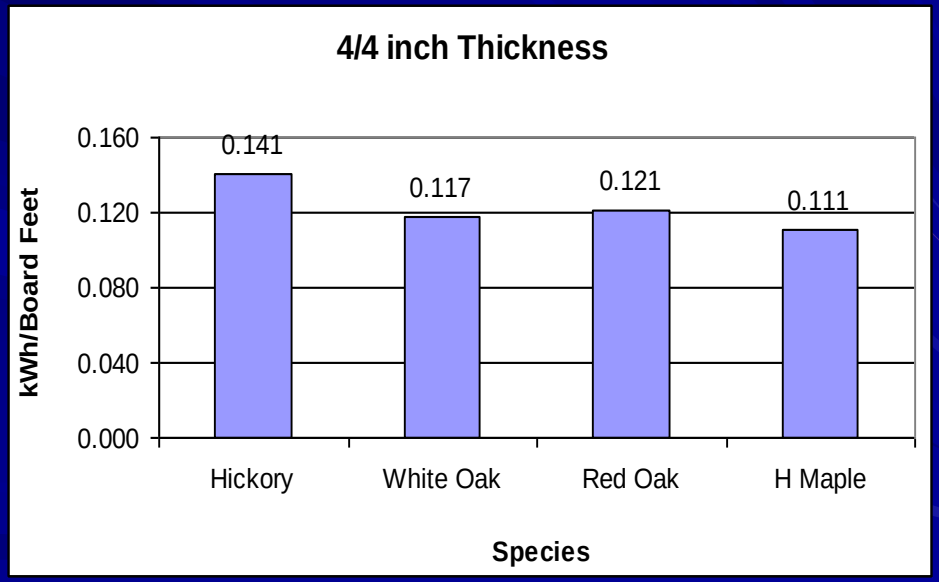
Energy consumption per board feet for 4/4 lumber

Total energy consumption/bft was calculated by adding consumption from all the motors

Saw mill 1



Saw mill 2



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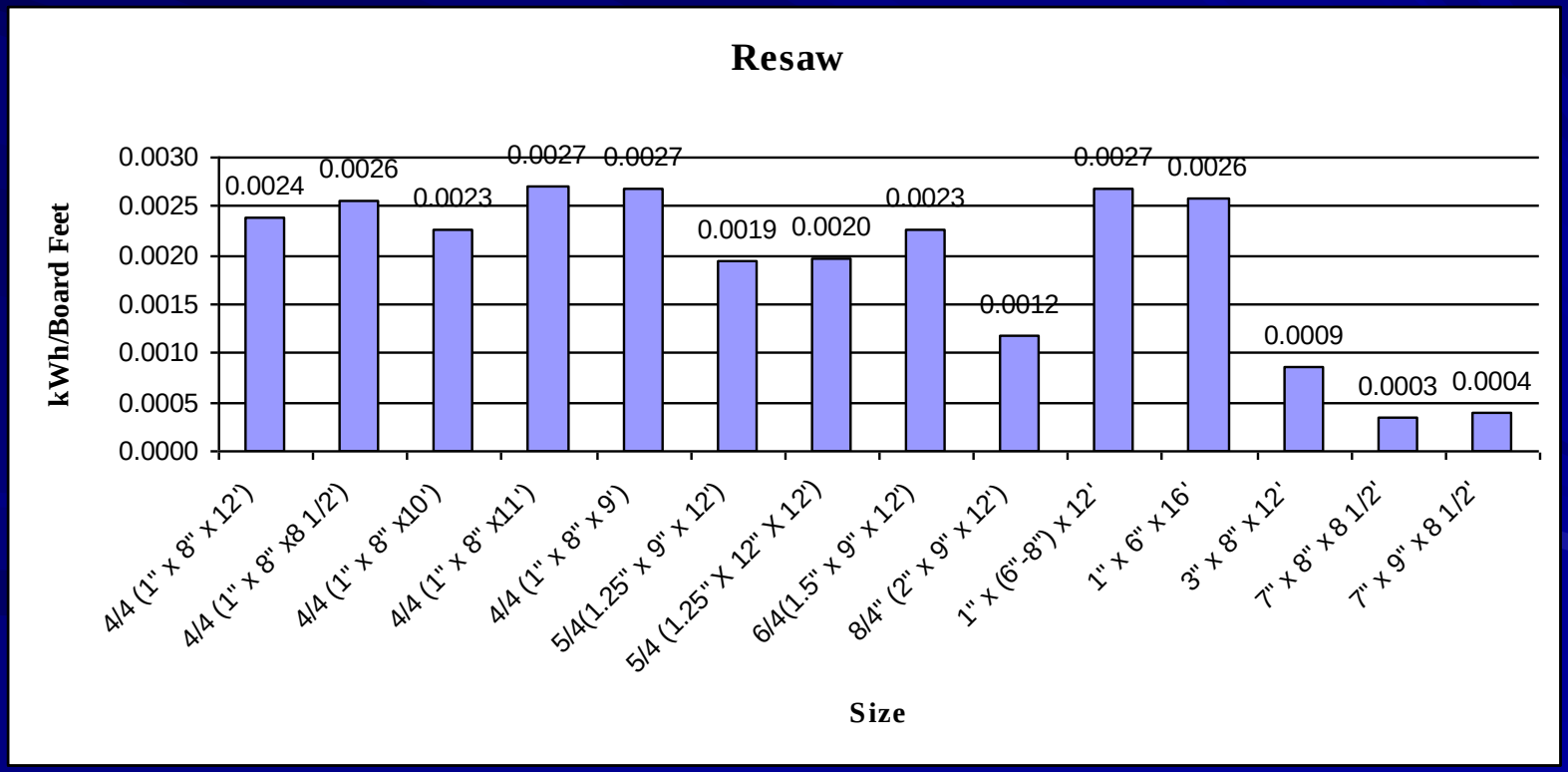
Energy consumption per board feet by Resaw (60 hp)

Saw mill 1:



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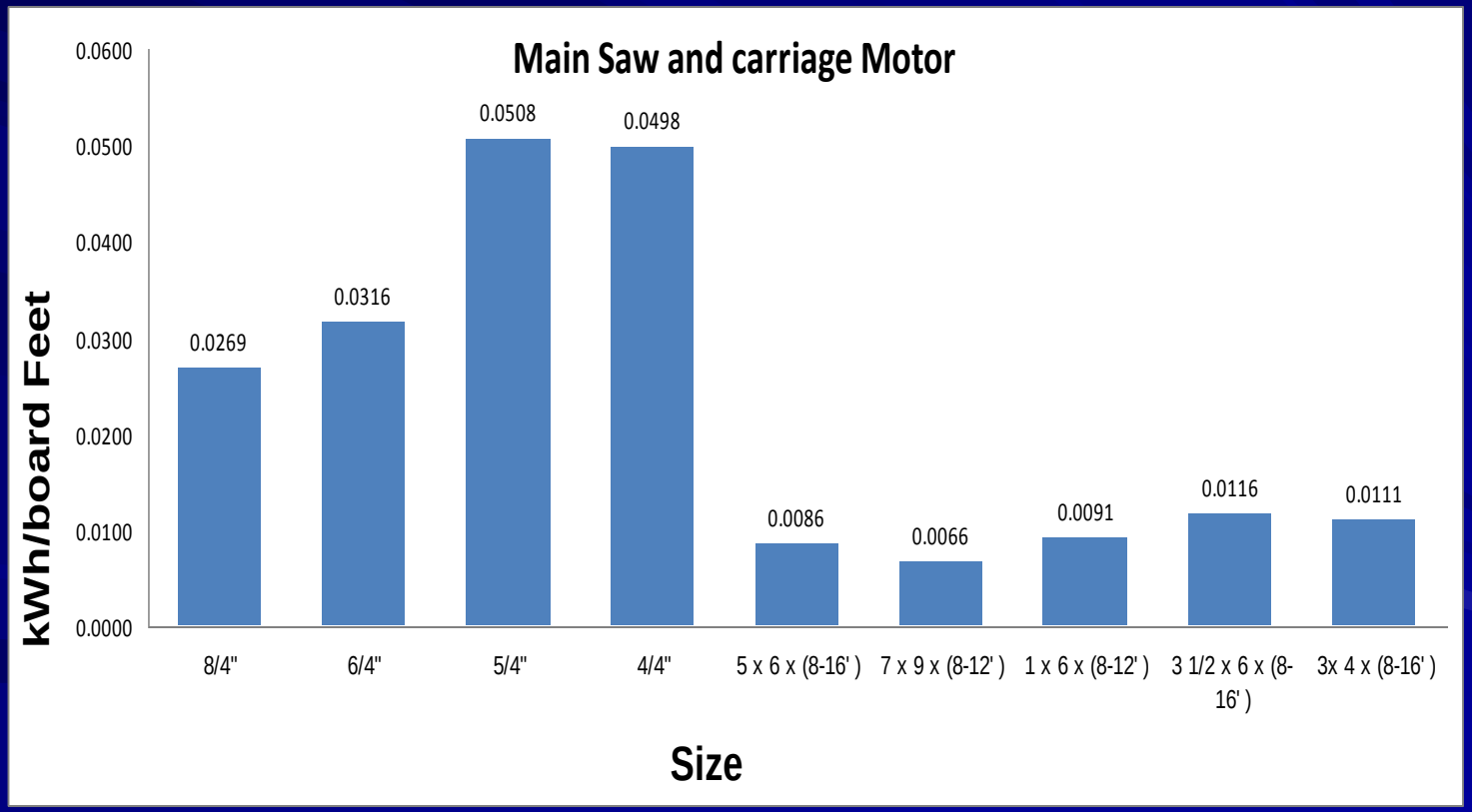
Energy consumption per board feet by Main saw and Carriage Motor (350 hp)

Saw mill 2



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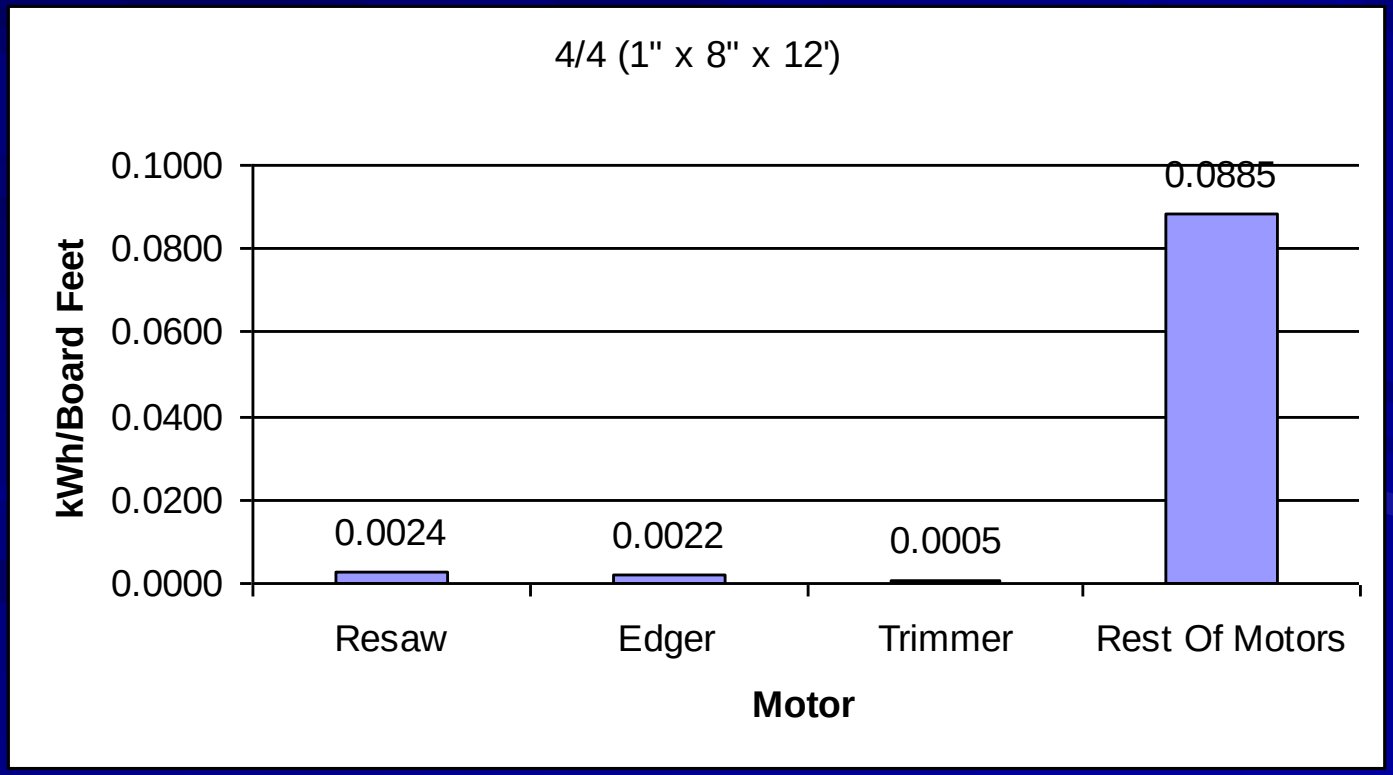
Energy consumption for 4/4 size

Saw mill 1

Total Consumption = 0.094 kWh/Bft



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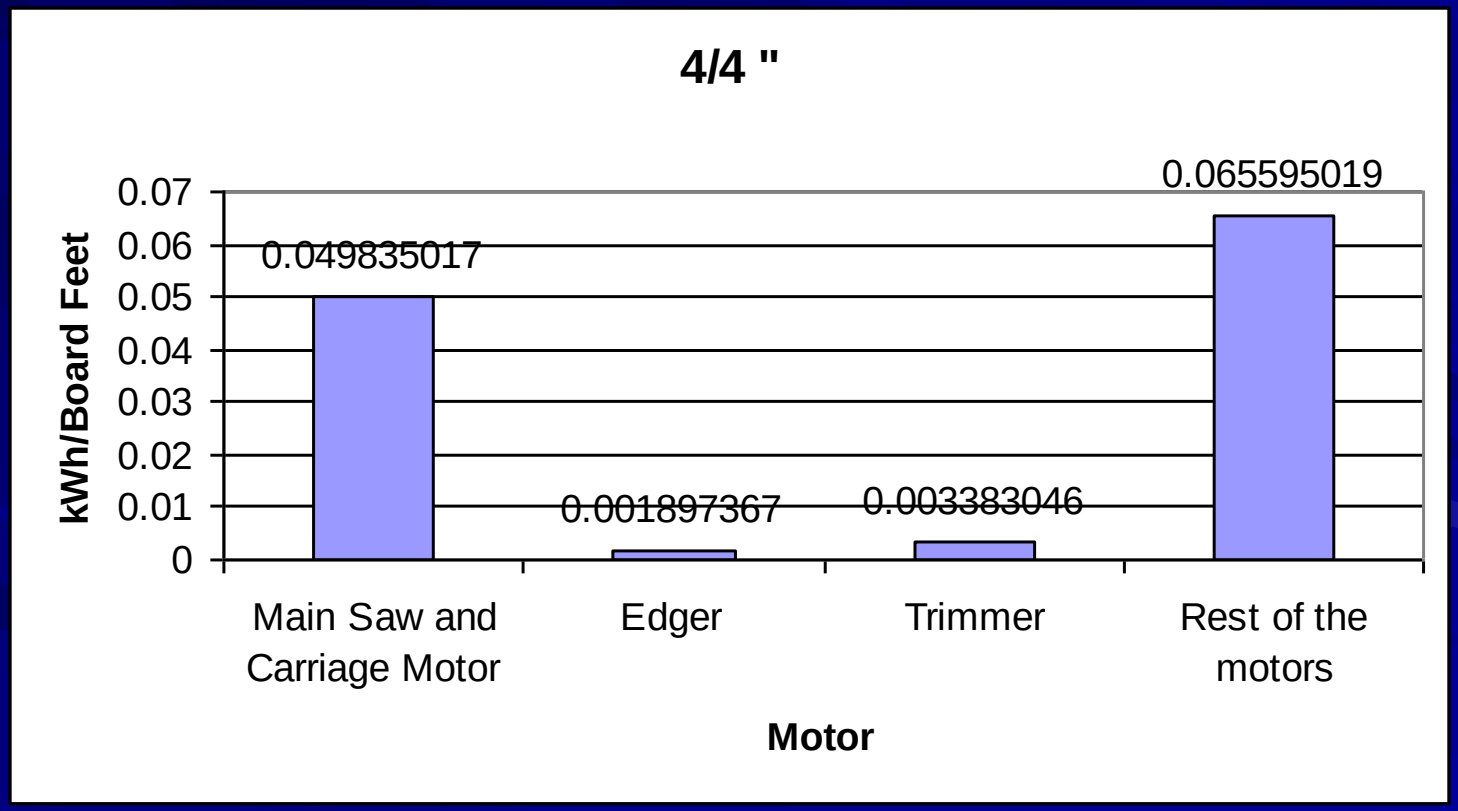
Energy consumption for 4/4 size

Saw mill 2

Total Consumption = 0.119 kWh/Bft



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Findings

Saw Mill 1

- Total Energy Consumption for 4/4 size = 0.094 kWh/Bft
- Total Lumber Sawn in 15 days = 460,994 Board Feet

Saw Mill 2

- Total Energy Consumption for 4/4 size = 0.119 kWh/Bft
- Total Lumber Sawn in 23 days = 420,687 Board Feet

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Discussion

1. The energy consumption per board feet for sawmill 2 was more than sawmill 1 due to difference in the manufacturing process
   - In sawmill 1, Main saw (300 hp) and Resaw (60 hp) are used to cut the logs where as in sawmill 2, only main saw (350 hp) is used
   - Since major portion of the lumber is cut by resaw in sawmill1, it consumes less amount of energy compared to sawmill2 where all the log is cut by main saw.
   - Sawmill 2 can save energy by re-designing its manufacturing process.

2. Load Factor's of motors in Sawmill 1 are very low. Hence, Sawmill 1 can still reduce its energy consumption by resizing its motor's capacity.

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Future Work

- Developing equations to predict energy consumption for different species and size of lumber using the physical properties of the wood and lumber production parameters.

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Questions?