Energy Efficiency Considerations

The Future of the Hardwood Lumber Industry Conference

Princeton, WV

November 3, 2016

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WERC
WOOD EDUCATION AND RESOURCE CENTER

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Energy · Environment · Enterprise

Presentation Overview

- CHP opportunities
- Boiler opportunities
- Steam distribution system opportunities
- WERC Wood Energy Technical Assistance Team

Menominee Tribal Enterprises Biomass CHP District Energy System

- $3.8 M project cost
- $0.5 M annual savings
- 85,000 mmBtu/yr wood use (100% of demand)
- 1,000 MWh renewable electric generated (24% of demand)
- 115 tons PM reduction

- ~2,000 lf underground steam and hot water piping
- 7 buildings / 150,000 sf connected / 6 dry kilns
- 25 and 9 mmBtu/hr biomass boilers
- 190 kW backpressure steam turbine

Key project components

Residual storage (bark, dust, chips)

residuals

8.5 mmBtu/hr boiler

270# steam

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190 kW turbine/generator

20# steam

electric

MTE Menominee Tribal Enterprises

MTE Menominee Tribal Enterprises

Thermally-led CHP can provide electric at <$0.02/kWh (energy cost)

Commercially Available Closed Cycle Biomass Power Generation Options

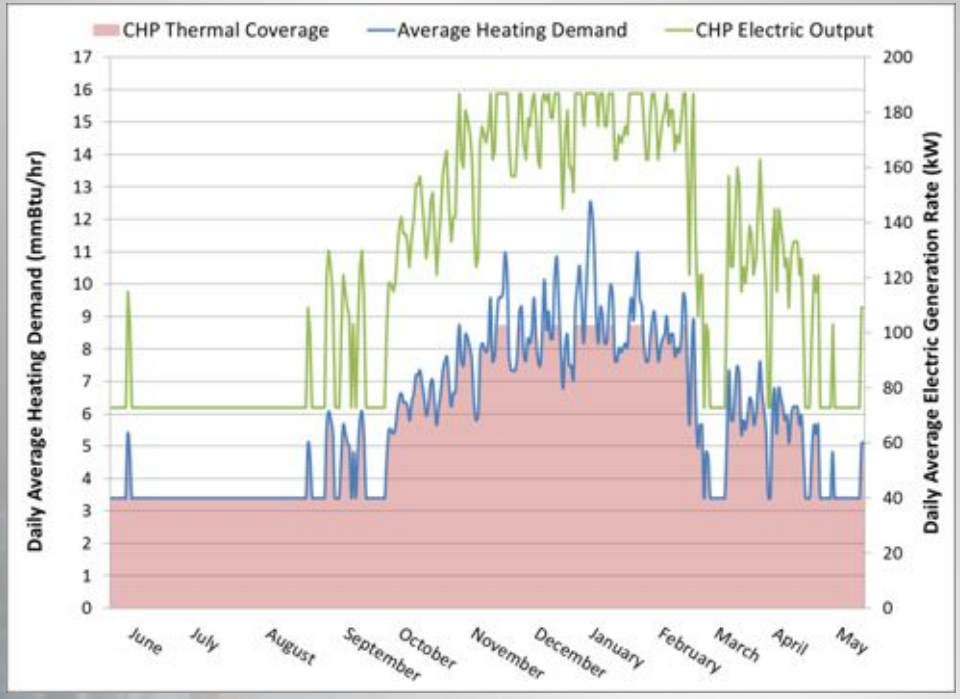
- Backpressure steam (~5-10% electrical efficiency)
- Organic Rankine Cycle (~15-20%)

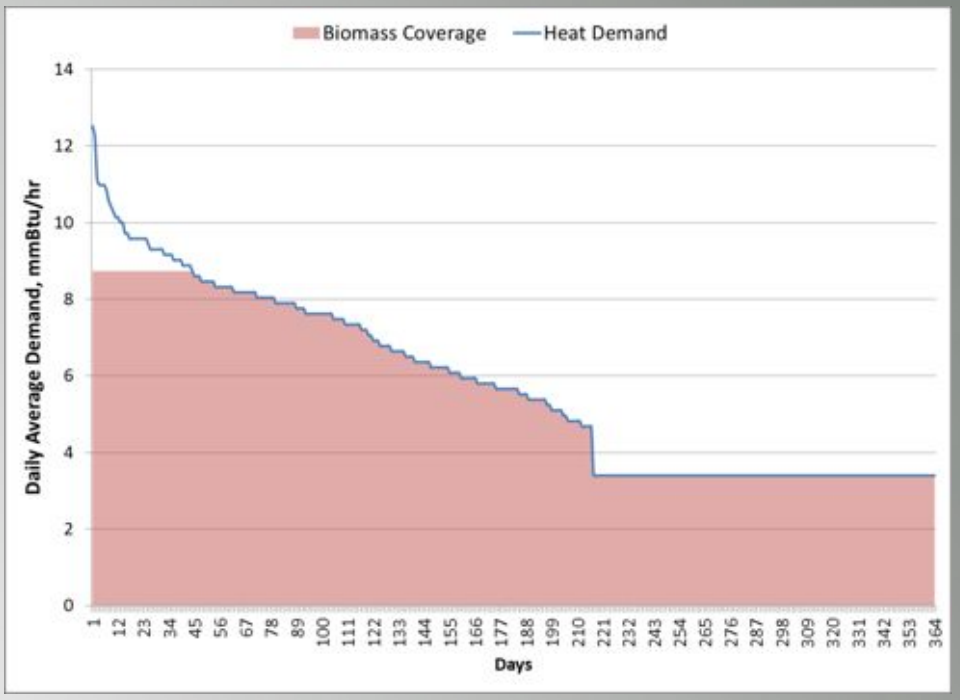
Courtesy Turboden

Tips:

- Use behind the meter to maximize value of electric generated
- Year-round load helpful to economics
- Lower quality heat needed onsite = better CHP potential

Sizing based on detailed load modeling





Daily average thermal demand (mmBtu/hr) is typically what can reasonably be modeled with available data.

Useful data:

- Fuel use records/bills
- Recorded heat production
- Portable Btu meter
- Building or process model
- Operating parameters
- Local weather data

CHP word of caution - oversizing

- Many idle turbines at plants
- BPS turbine trips out when dropping below ~25% of capacity
- Sizing needs to understand this

Boiler Opportunities

- Improve efficiency to save money, reduce emissions
  - Combustion controls
  - Boiler tunings
  - Minimize operating pressures
- Fuel flexibility
  - Use the least valuable residual

What is wood?

Constituent	% by Weight (dry basis)
Carbon (C)	47.1 – 51.6
Hydrogen (H)	6.1 – 6.3
Oxygen (O)	38.0 – 45.2
Nitrogen, Potassium, Calcium, Phosphorous, Sulfur, Magnesium, etc.	~1.0

Approximately 76-86% is volatiles (e.g. methane, other hydrocarbons)

Wood Boiler Tunings
Goal Is Two-Stage Combustion

- Gasification Stage = low O2/temp
  - Flue gas recirculation
  - Control of air / temp
- Combustion Stage = high O2/temp
  - Time / Temp / Turbulence
  - Control of air / temp

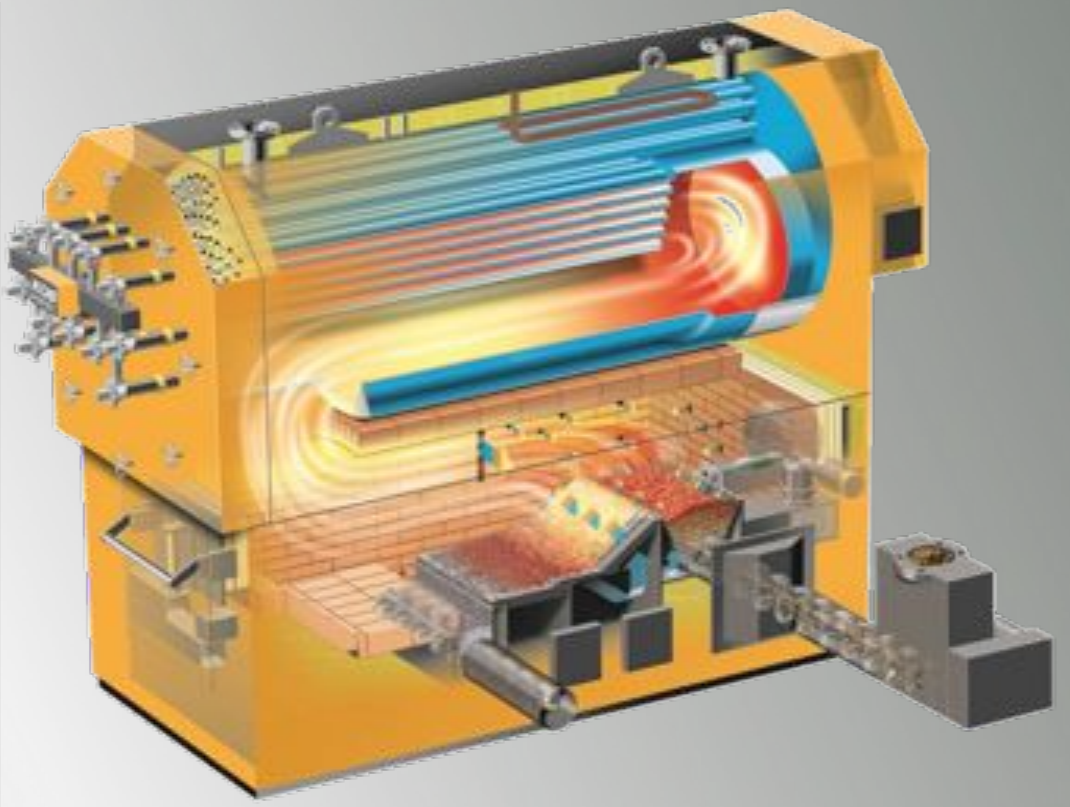


Image courtesy Viessmann USA

WI Sawmill

- Major emissions issues – smoke / permitting issues
- Boiler lacks ability to control combustion – measured efficiency of ~25%
- Lack of automation requires full time boiler operator
- 20,000 tons residuals per year used

Added Boiler Control System for ~$200,000

- Seal combustion chamber and fuel feed (air lock)
- Control fuel feed based on maintaining steam pressure and control air based on fuel feed
- Control ID fan to maintain slight negative pressure in firebox
- Conservative 10% point increase in efficiency by reducing excess air from 1,000% to 100%

- Image of boiler running after system install
- Reduced fuel use by over 5,700 tons/yr
- Savings of $160,000/yr
- Conservatively under 1.5 yr payback

WV Sawmill Situation

- Major emissions issues – black smoke / permitting issues
- Using dust valued at ~$25/ton
  - Bark sold for $6/ton
- Boiler lacks ability to control combustion – estimated efficiency of ~38%
- Safety issues with sparks leaving boiler through stack and out of gaps in combustion chamber

Added Combustion Control for $75,000

- Seal leaks in combustion chamber
- Install new motors and VFDs on
  - fuel feed, ID fan, combustion air fans
- Reduce open tubes in cyclone
- Control scheme
  - Run ID fan to maintain slight negative pressure in combustion chamber (safety fix)
  - Match fuel feed to maintain steam pressure
  - Match combustion fans to fuel feed
- Increased boiler efficiency by 20% points, reduces fuel use from 8,100 to 5,300 tons per year or $70,000 in savings

Boiler tuning and maintenance are important

Follow up tuning two years later showed baffles on cyclone removed, ash blocking combustion air openings in firebox, O2 readings ~20.6%

Wood Boiler Tunings

- Only boilers with ability to control combustion can be tuned and have it stick for a reasonable period of time
- Must be able to match fuel feed to heat demand, and air flow to fuel feed
- Recommended that boiler operators have a combustion analyzer (~$1,000)

Please Note: Efficiency number from combustion analyzer is not efficiency over time.

Wood Boiler Tunings - Savings

- A 10% change in excess air is 1% point efficiency
- Example
  - Assuming increase from 60-70%
  - 10,000 tons at $20/ton = $200,000/yr boiler fuel
  - Drops to 8,570 tons = $171,400/yr boiler fuel
  - ~$29,000 savings
- If boiler does not have combustion controls, regular tuning can save more than this

VA Manufacturing Plant with Dry Kilns

- Manual control of fuel feed to maintain steam pressure at boiler ~90 psig
- ID fan set high to match full fuel/air rates
- Steam pressure immediately reduced by PRV to 30 psig and sent to kilns (600,000 fbm)

Lack of Control Results

- Relief valves on boiler blowing off (see pic)
  - Estimated 4.8 mmBtu/hr or ~$20/hr
- Higher steam pressure than needed
  - ~2% points eff
  - $6,000 lost per year
- Operator time spent in boiler room
- Excess air is too high virtually all the time (big loss, but difficult to estimate)

Residual value is $28/ton for 15% MC wb dust (14.6 mmBtu/ton)

Steam Distribution Opportunities

- Reduce operating pressure
  - 40°F of stack temp = 1% point efficiency
- Steam leaks typically paybacks well under 2 years
- Condensate leaks typically have paybacks well under 4 yrs
- Insulation of steam piping typically has a payback on the order of 1 year
- Insulation of condensate piping typically has a payback on the order of 2 years

Uninsulated condensate tank, with openings in the top

Energy loss of $4,600 annually, cost of fix at $8,000 ($20-25/ton residuals) at SC veneer mill

It is expensive NOT to track efficiency indicators!

Relatively Simple Things to Track

- Makeup water metering
- Fuel use tracking (can be tough)
- Combustion analyzer spot checks
- Boiler feed water metering (flow and temp)

WERC Wood Energy Technical Assistance Team

- Help Facility Owners Evaluate and Implement Wood Energy Projects

- Technology and Vendor Neutral

http://www.na.fs.fed.us/werc/

WERC Wood Energy Technical Assistance Team Results

Item	Annual Value	25-yr Value
Projects Implemented	45	45
Annual Energy Usage Evaluated, mmBtu	1,015,967	25,399,183
Fuel Oil Gallon Equivalents, gallons	*7,256,909*	*181,422,735*
Heating Cost for Evaluated Facilities	$9,349,033	$233,725,830
Combined Costs of Projects	$66,299,462	$66,299,462
Operational Savings Achieved	$5,857,346	$146,433,642
Electric Generated/Offset, kWh	6,306,972	157,674,300
Woody Biomass Utilization Achieved, green tons	84,081	2,102,019
Direct Impact to Local Forest Products Industry ($35/green ton)	$2,942,826	$73,570,649
Net CO2 Reductions, mtonne/yr	36,614	915,351

- Driver of efficiency in commercial wood energy systems
- Driver of district energy and combined heat and power
- Driver of improved hydronic design practices
- Driver of improved emissions profiles

Example Steam Leaks

Leak	Estimated Loss Rate			Energy Loss		Annual Cost of Makeup Water	Annual Cost of Steam
	pph	gpd	gpy	mmBtu/hr	mmBtu/yr		
Safety Valve Blowoff	4,000	11,511	172,662	4.76	1,712	$691	$7,239
Keeler Boiler Room Header	29	83	30,460	0.03	301	$122	$1,272
PRV Bypass	5	14	5,252	0.01	51	$21	$215
DA Vent / Relief Valve	75	216	78,777	0.09	780	$315	$3,298

Example Condensate Leaks

Leak	Estimated Loss Rate			Energy Loss		Annual Cost of Makeup Water	Annual Cost Energy Loss
	gpm	gpd	gpy	Btu/hr	mmBtu/yr		
IBC Boiler Trim	0.5	720	262,800	0.0006	5	$1,051	$21
Combined Leaks Kiln Control	0.5	720	262,800	0.0006	5	$1,051	$21