

Perspectives on Hot Water Thermal Storage for Biomass Boiler Systems

9:30 AM ET October 21, 2016



Quick Notes

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Presentation Outline

- I. Introduction Ben Bell-Walker
- II. When is thermal storage beneficial?When is it not? Scott Nichols
- I. The war on boiler cycling Henry Spindler
- **II.** The ÖkoFEN Experience Stefan Ortner
- III. Q & A, Upcoming Events Ben Bell-Walker

[Full presentation will be available online, www.biomassthermal.org/resource/webinars.asp]



Presenters

Scott Nichols, Tarm Biomass





Presenters

Stefan Ortner, ÖkoFEN





Presenters

Henry Spindler, DCM Logic





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Perspectives on Hot Water Thermal Storage for Biomass Boiler Systems Biomass Thermal Energy Council

When is thermal storage beneficial? When is it not?

Scott Nichols October 2016



Thermal storage *usually* benefits biomass boiler operation

- Increases boiler run period duration*
- Increases boiler off period duration*
- Decreases on/off cycling*

•Provides heat during routine boiler cycles for fuel and cleaning

• Especially important for cordwood boiler operation

*More steady state operation results in lower emissions, higher efficiency, and better heating performance.



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When does thermal storage have little benefit for biomass boiler operation? •When a cascaded installation matches the heating load throughout the season.



A single 600,000 Btu/hr. boiler may reduce its output by 70% and operate at 30% of its rated capacity.

A cascaded installation of three 200,000 Btu boilers can operate at 10% of their total capacity.

Thermal storage can still be beneficial, but it has lower utility in a cascade.



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When does thermal storage have little benefit for biomass boiler operation? •When the thermal storage is poorly designed or is too small.



Classic example:

Boiler room is tight. Engineering specifies 3 x 150 kW boilers and the biggest tank that will fit is 500 gallons. In this case the tappings are placed about ¼ of the way from the top and bottom of the tank stranding about 200 gallons. System flow is about 150 GPM on the system side.

The tank is a fat spot in the pipe that reduces supply water temperature to the building.

At this time the boiler cascade control also relied upon 4 sensors mounted vertically on the tank. Readings were useless for the cascade control.



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When does thermal storage have little benefit for biomass boiler operation? •When the boiler output is matched to the load or boiler output is undersized for the load, there is never a chance or reason to recharge. The "cord" (boiler) must always be connected. Why spend for the battery?



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When does thermal storage have little benefit for biomass boiler operation?

•When required system temperature does not allow tank temperature modulation and the system is used improperly with the thermal storage so that temperature stratification is eliminated.







When does thermal storage benefit biomass boiler operation? •When the heating system can use water temperature of 160 F or significantly lower

	Typical Forced Hot Air	The larger the
	Standard Baseboard hot water	radiating surface, the lower the required supply
	Oversized Baseboard hot water	water temperature must be.
	Panel Radiators	
	Radiant tubing under wood	
	Radiant tubing in concrete	





When does thermal storage benefit biomass boiler operation?

•When the boiler output is matched to design load (most common installation scenario) or oversized compared to the design load

Heating Bin Hours vs. Outdoor Temperature, typical US location



4800 hours per year at 55 deg F or lower

3900 hours occur at 25°F or higher

80% of heating output is needed at 50% or less of peak heating load



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When does thermal storage benefit biomass boiler operation?

•When heating loads are variable rather than on and off

•When the thermal storage is adequately sized considering the heating load, boiler output and boiler cycle time

No storage scenario with 30% turndown			r <mark>ndown</mark>	Storage scenario with 30% turndown			
Gallons, appliance	100	Boiler Output Btu/hr.	500,000	Gallons*, appliance and tank	100 + 1,000= 1,100	Boiler Output Btu/hr.	500,000
Pounds / gallon	8/Gal.	@30% reduction	16 5,000	Pounds / gallon	8/Gal.	@30% reduction	165,000
Available Storage @10° F Differential	8000 Btus	Btu/min. @30% reduction	165,000 /60 min. =2,750	Available Storage @10° F Differential	88,000 Btus	Btu/min. @30% reduction	165,000 / 60 min. = 2,750
Time to limit	8,000 / 2,750 = 2.9 minutes		Time to limit	88,000 / 2,750 = 32 minutes			

Scenario = Heat load goes to zero.

1 Btu = Amount of heat required to raise 1 pound of water 1 degree Fahrenheit.

*Tank volume represents 20 gal./10,000 Btu/hr.

MA Legislature Declares War on Cycling—By Thermal Storage or Any Means Necessary!





Henry Spindler, DCM Logic

October 21, 2016



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MA Legislature to DOER: Reduce Boiler Cycling!!

"The [Department of Energy Resources], in consultation with the [DEP], shall set . . . requirements for <u>thermal storage</u> or other means to minimize any significant deterioration of efficiency or emissions <u>due to boiler</u> <u>cycling</u>, if feasible."

[MA Legislature] Acts of 2014, Chapter 251, Section 2(b)iii



Heating Hours Per Start



Time displayed is local time.

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Heating Hours Per Start (HHPS) is the average length of time over a given period that a boiler heats every time it turns on.





Start With the Obvious: Does Sizing of Thermal Storage Separate the Good Guys from the Bad Guys?





Source: A selection of boilers monitored by DCM Logic 2013-2016. Each bar represents one boiler; some boilers have more than one bar.

Egad! "Correctly Sizing" Thermal Storage Has No Effect on Cycling!



Storage tank size (gallons/kBTUh) of a single boiler in biomass plant

*Averaged for all boilers in plant



Source: A selection of boiler plants monitored by DCM Logic 2013-2016; each point represents one plant. Some plants have more than one point.

Then the True Culprit Behind Cycling <u>Must</u> Be a Lack of Tank Stratification!





Source: A selection of boiler plants monitored by DCM Logic 2014-2016; 20 calendar years of plant data. Some plants have data in both seasons.

Foiled Again! There's Scant Correlation Between Stratification and Cycling



Putting Cycling Aside, Thermal Storage Surely Must Ensure High-Output Modulation?





Tank size = 500 gallons

By Gum, It's Time to Try "Any Means Necessary!!"

"The [MA Dept of Energy Resources], in consultation with the [DEP], shall set . . . requirements for thermal storage <u>or other means</u> to minimize any significant deterioration of efficiency or emissions <u>due to boiler</u> <u>cycling</u>, if feasible."

[MA Legislature] Acts of 2014, Chapter 251, Section 2(b)iii





Undersize Those Boilers, I Say!! Surely that Will Reduce Cycling!



% of peak building load shouldered by a single boiler in biomass plant



Source: A selection of boilers monitored by DCM Logic 2013-2016. Each point represents one boiler; some boilers have more than one point.

Could MA DOER and MassCEC Be Hiding the Answer in Plain Sight?!?



The thermal storage tank must have a minimum of R12 insulation and <u>controls</u> integrating the central heater and <u>decrease the number of central heater starts and stops</u>.

[to]

 \rightarrow It sounds unlikely, but could the <u>quality of controls</u> be a contributing factor in cycling?



Source: <u>Commercial-Scale Biomass Heating Program Program Manual</u>, p. 18. Also found in <u>Alternative Energy Portfolio Standard</u>, <u>Guideline on Biomass</u>, <u>Biogas</u>, <u>and Biofuels for APS</u> <u>Renewable Thermal Generation Units</u> [Draft of June 8, 2016], p. 8.

We've Got It! Quality of Controls is the Determining Factor in Cycling!



Source: A selection of boilers monitored by DCM Logic 2013-2016.

Not So Fast! Isn't Thermal Storage Accepted Industry Practice?!

Our observations and thoughts:

- Thermal storage volume might show a positive correlation with cycle length in fringe-case installations (for North America), but it is not guaranteed.
- For the vast majority of systems,
 - Only effective controls improve cycle length
 - Thermal storage volume (in isolation) is uncorrelated to cycle length
- For a system to achieve long run cycles, it requires:

Good controls

Good controls and thermal storage

(Thermal storage *might* offer second-order benefit on cycle times)

• Storage volume conceivably helps with emissions and efficiency, but no careful studies have yet been done (Kunde study is very limited and lacks a clear message)



MA Legislature Declares War on Cycling—By Thermal Storage or Any Means Necessary!





Henry Spindler, DCM Logic

October 21, 2016



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Europe's Specialist in Pellet Heating

Thermal Storage Webinar BTEC

Stefan Ortner, 21.Aug 2016





Direct Connection vs. Buffer tank

Our guidelines at ÖkoFEN

There is no need for a buffer tank unless:

- you want to use solar thermal
- you have a second heat source (wood log boiler, ...)
- you want to install a Stirling engine

Why?

With the right settings our burner can be operated with very little cold starts. Systems with buffer tanks lose 10-20% of the energy through radiation into the basement.



Under fed burner

Advantages:

- + stable operation pellets are not thrown into the fire
- + soft start and stop
- + very few cold starts (even after one hour the glowing stock can be ignited quickly)
- + quick reacting system due to stainless steel flame tube (no bricks)
- + no periodic emptying of the burner plate for cleaning purposes



www.okofen.com



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It can lower Annual Efficiency

- Theoretical surface losses: 5%
- Field Experience: 10-20% depending on system design, installation quality and control settings
 - Recommended design principle in Europe 2.3 gl per 1000 BTU (= 237 gl. for 100 000 BTU boilers)
 - Insulation of the tank and pipework very important
 - Control strategy and settings have huge impact (temp. zones, time settings, ...)

Intelligent controls

... the future is connected



Example



- Conclusion
 In order to make wood pellets a "standard" way of heating the installation costs for the installation needs to be lowered
- Puffer tanks can make sense but are not necessary with our combustion and control system
- If puffer tanks are installed in the wrong way the operation will be worse
- Therefore there is no single subsidy scheme in Europe demanding it. Only about 25% of ÖkoFEN boilers are running with puffer tanks







PELLET HEATING

FUEL STORAGE

SOLAR PANELS AND PUFFER TANKS

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Save the Date: NEBHX 2017 April 25-27, Burlington, VT

- NEBHX, the Northeast Biomass Heating Expo and Conference, is BTEC's northeast region annual event.
- <u>http://nebiomassheat.com/</u>
- NEW this year
 - Marketing strategies for selling your biomass thermal system
 - Financing your biomass thermal system
 - Communicating the benefits of biomass heating
 - Background on the latest policy initiatives
 - Woodchip and cordwood technologies
 - Boiler plant metrics



- Ask questions using the Questions Panel on the right side of your screen.
- Depending on time we may not get to all questions, but you may contact Ben Bell-Walker <u>ben.bell-walker@biomassthermal.org</u> to follow up with our panelists after the webinar.
- Stay tuned for the next webinar on from the Biomass Thermal Energy Council, *November 2016*