Sizing Impacts on Wood Combustion Performance

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NYSERDA Background

Biomass R&D

Activities and Objectives:

- Evaluate energy-efficiency and emissions and compare to oil-fired systems
- Develop advanced commercial and residential technologies
- Demonstrate advanced technologies in representative applications
- Evaluate feedstocks (energy, ash, moisture, trace elements)
- Evaluate the net effect of emissions on local air quality
- Evaluate emission control technologies
- Provide updated information for the NEI
- Provide objective scientific information for the development of high-efficiency and low-emission biomass heating initiatives in NYS

Boilers

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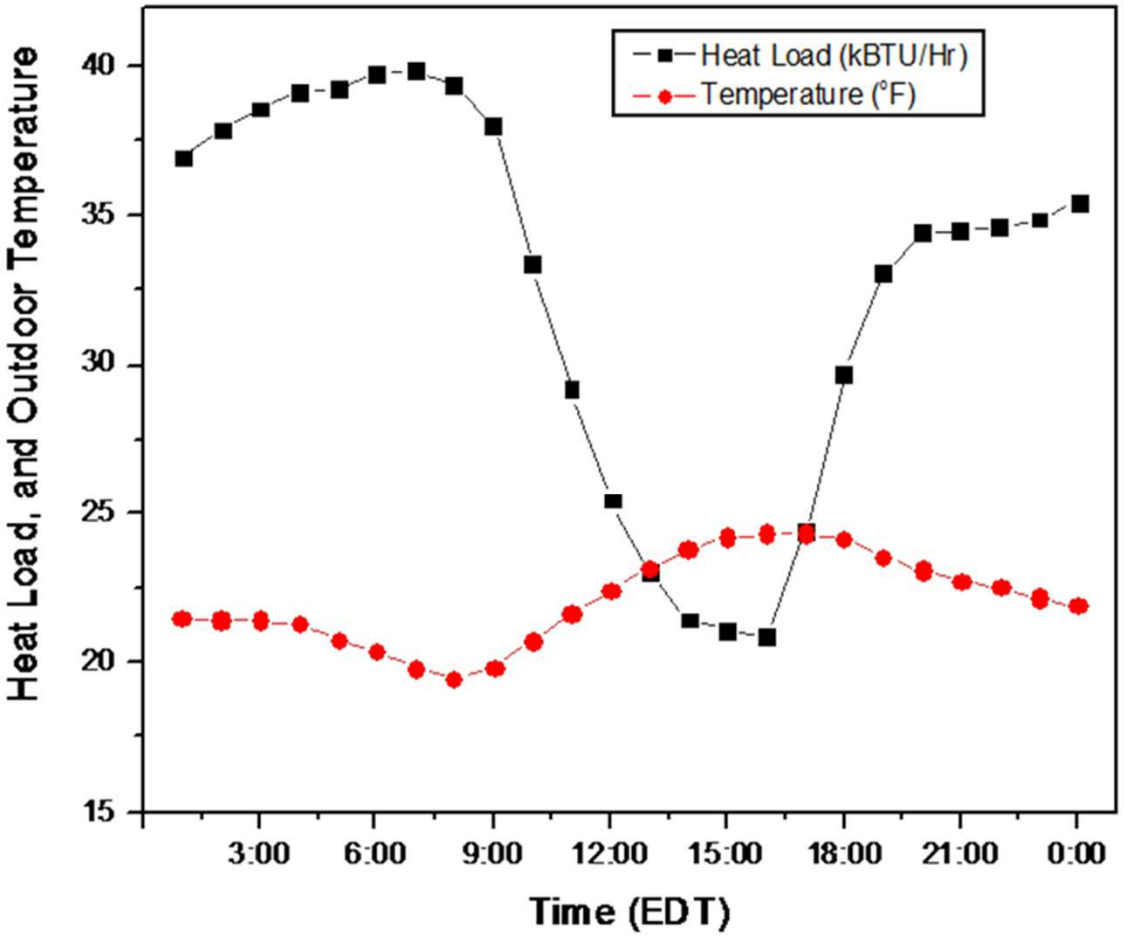
Determine the Heat Load

Method	Details	Accuracy
Manual J, Energy 10, DOE 2 etc	Insulation, solar gain, internal gains, temperature, infiltration, weather data etc	High
Square footage	How big is the house?	Low
Previous system	What was the output of the previous system?	Low

-Over sizing is very common

-NYSERDA programs require a Manual J (or equivalent) calculation to determine proper HVAC equipment sizing.

Daily heat load profile



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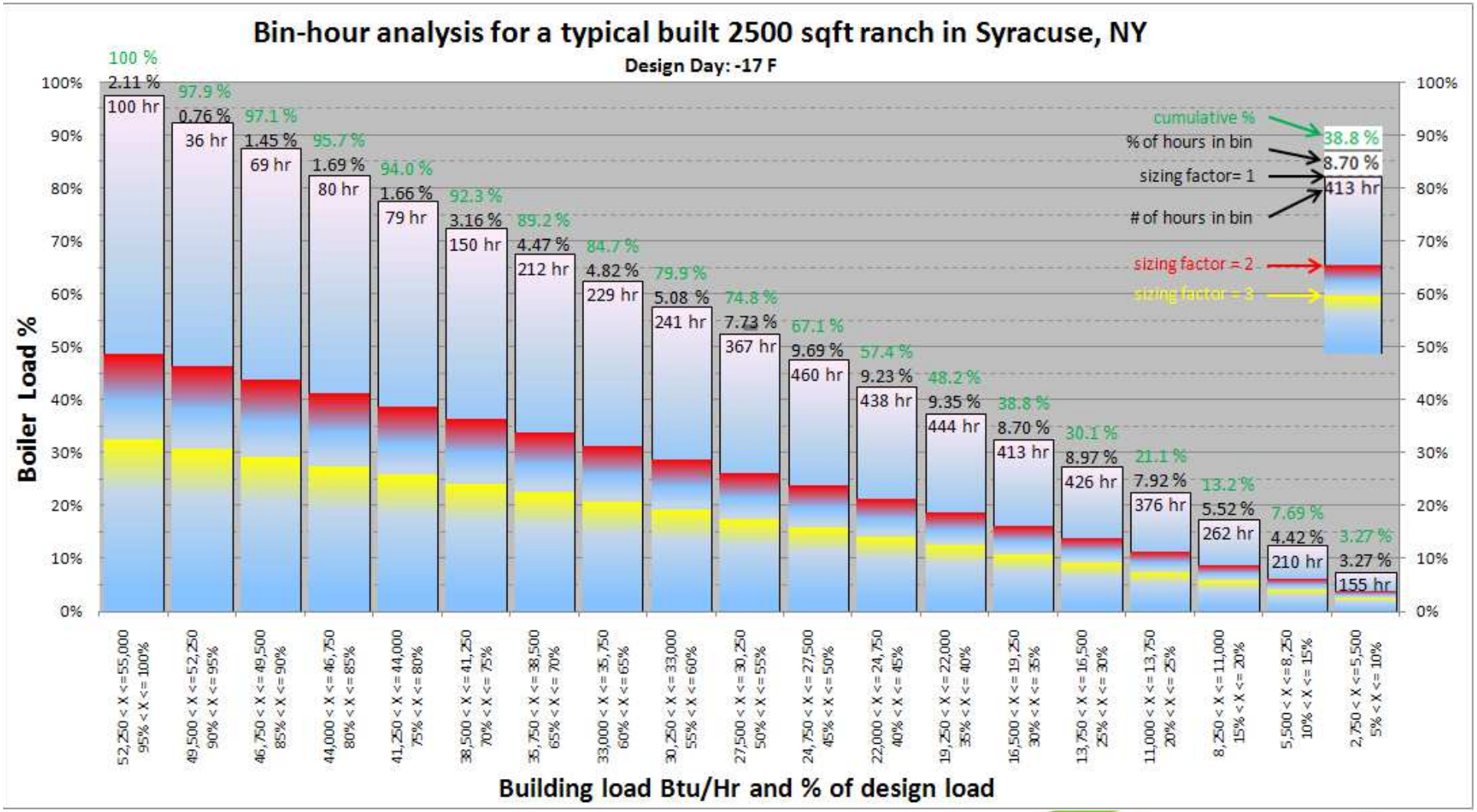
Heat Load Analysis



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Nominal Output

12.5.4 Heat Output Capacity Validation. The first test run must produce a heat output rate that is within 10% of the manufacturer's rated heat output capacity (Category IV) throughout the test run and an average heat output rate within 5% of the manufacturer's rated heat output capacity. If the appliance is not capable of producing a heat output within these limits, the manufacturer's rated heat output capacity is considered not validated and testing is to be terminated. In such cases, the tests may be restarted using a lower heat output capacity if requested by the manufacturer.

Heat Loads

	Very Cold	Cold	Moderate
Design Day (DD) Heat Load	65 kBtu/hr	40 kBtu/hr	20 kBtu/hr
Boiler output DD	42%	26%	13%
70% DD	46 kBtu/hr	28 kBtu/hr	13 kBtu/hr
Boiler output 70% DD	29%	18%	9%

- White Tag 8 hour average: 116 kBtu/hr
- 8 hour average, weighted average of outputs at Cat II and III or III and IV
- Assume 8 hour average is 75% of max output of 155 kBtu/hr

Weighting Factors

Weighting factors using Syracuse profile and M 28 OWHH categories									
Sizing Factor --->	M 28 OWHH	1	2	3	4	5	6	7	8
cat I <15%	0.437	0.077	0.301	0.482	0.799	0.923	0.971	1.000	1.000
Cat II 15-24%	0.238	0.134	0.370	0.410	0.201	0.077	0.029		
Cat III 24-50%	0.275	0.459	0.329	0.108					
Cat X 50-95%		0.308							
Cat IV 95-100%	0.05	0.021							

Weighting factors using Syracuse profile and SR revised categories									
Sizing Factor --->	SR	1	2	3	4	5	6	7	8
Cat I <35%	0.5	0.388	0.892	1	1	1	1	1	1
Cat II 35-53%	0.4	0.360	0.108						
Cat X 53-95%		0.231							
Cat III 95-100%	0.1	0.021							

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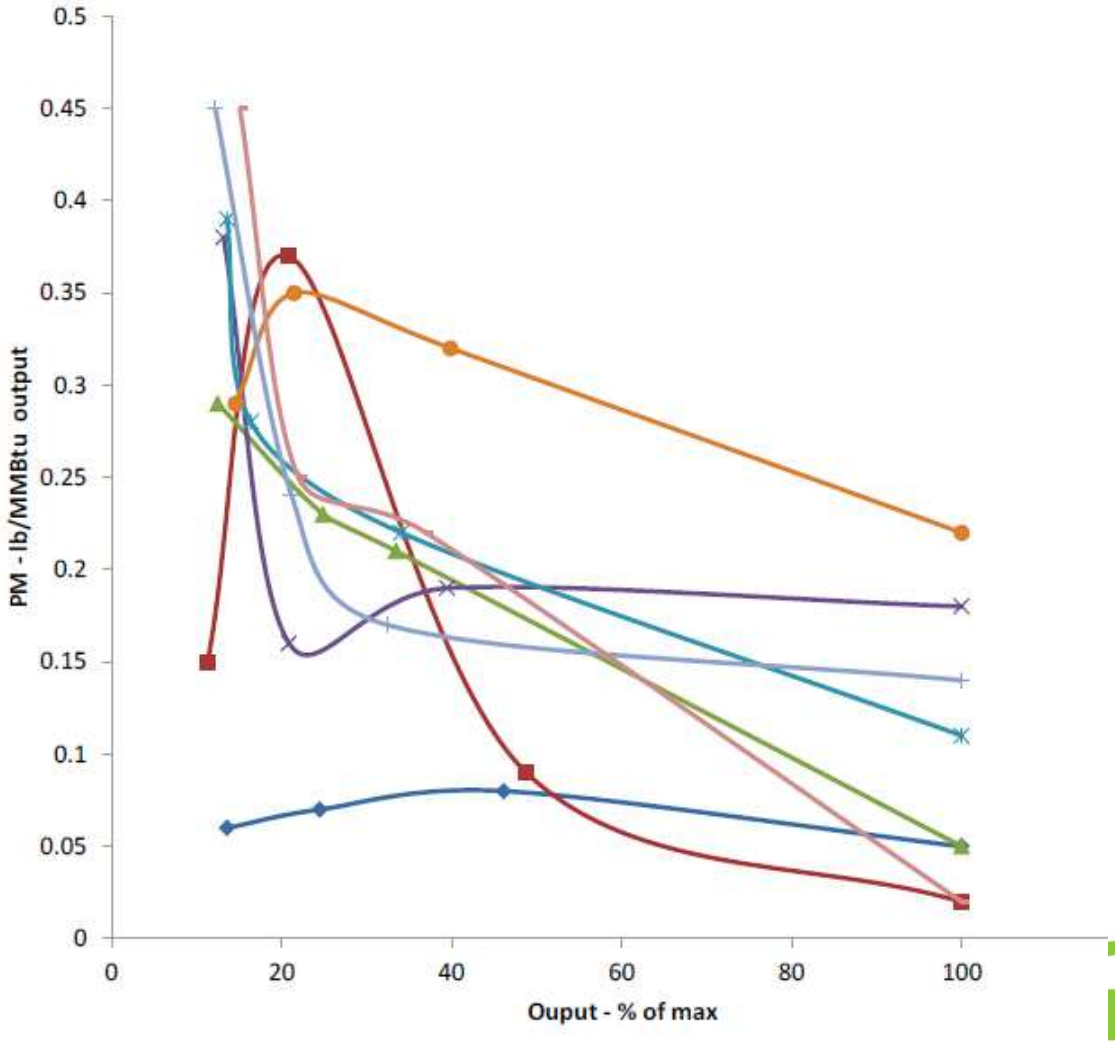
Emissions vs Output



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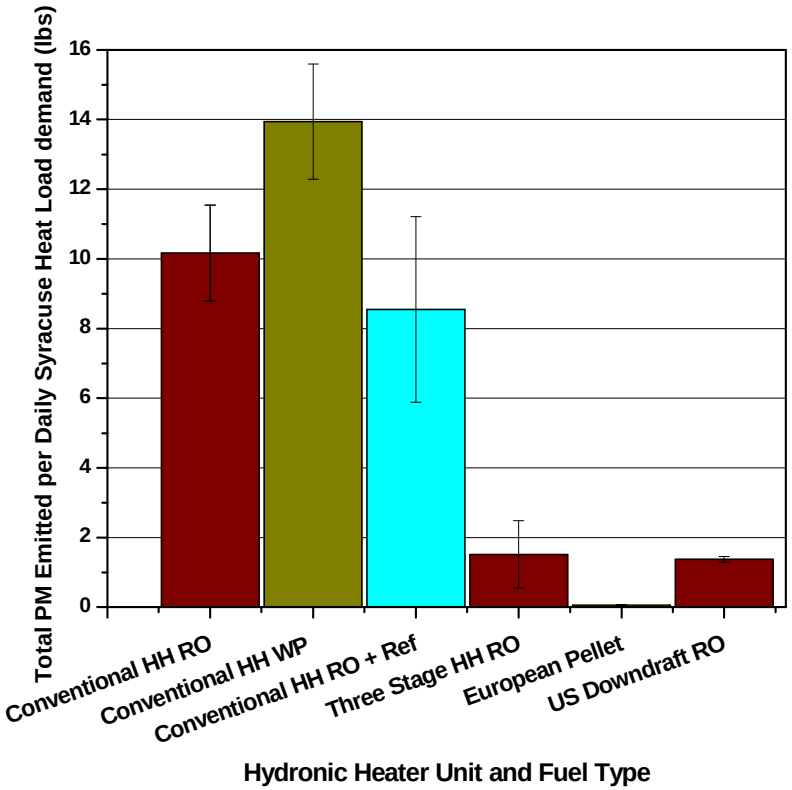
Emissions per Syracuse Day



- Responding to same heat load with no thermal storage except for US downdraft

OWB – 10-14 lb
Pellet – 0.08 lb
Made-in-NY 2-stage – 1.37 lb
ULSHO – 0.00004 lb

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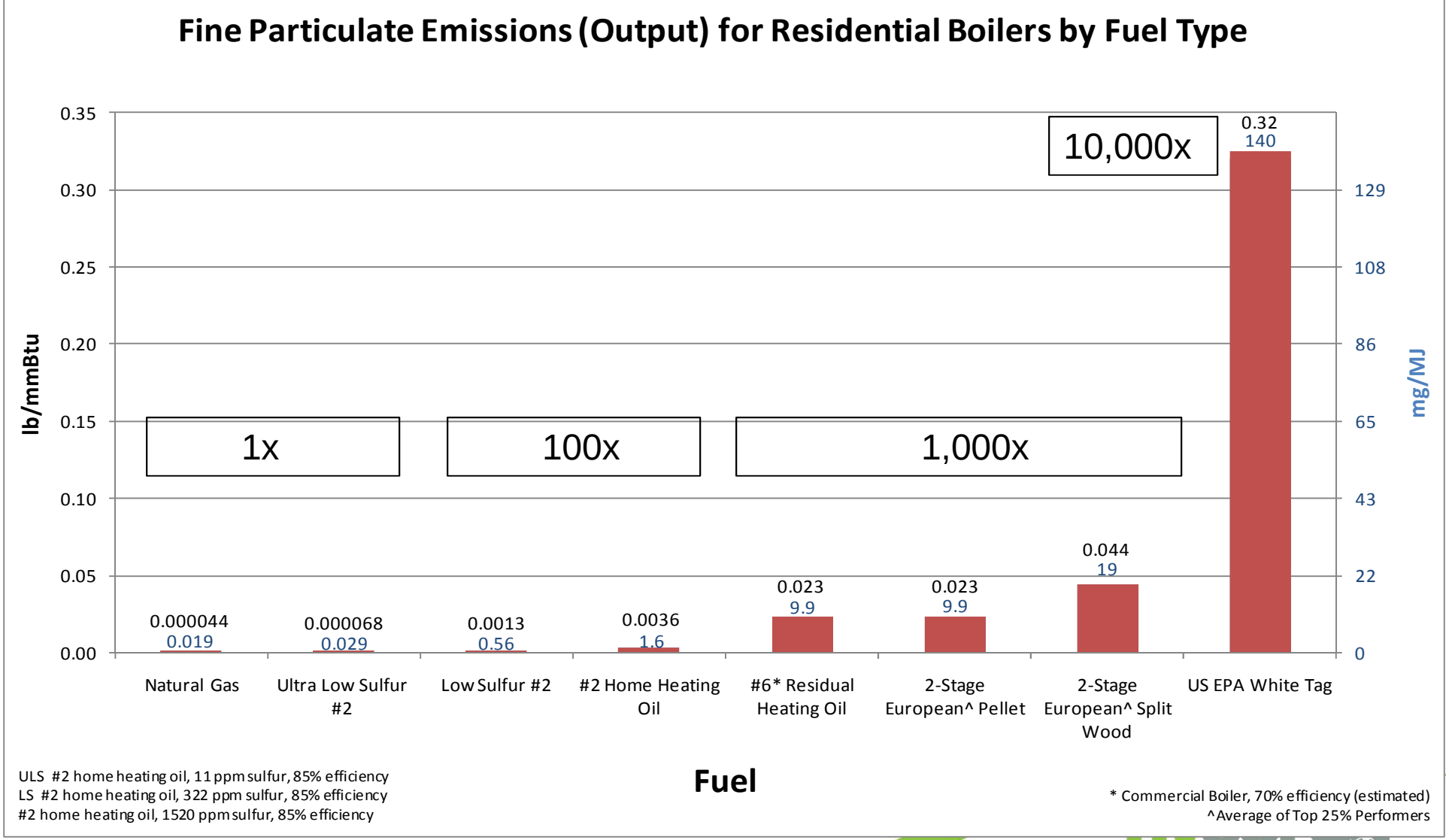
Emissions



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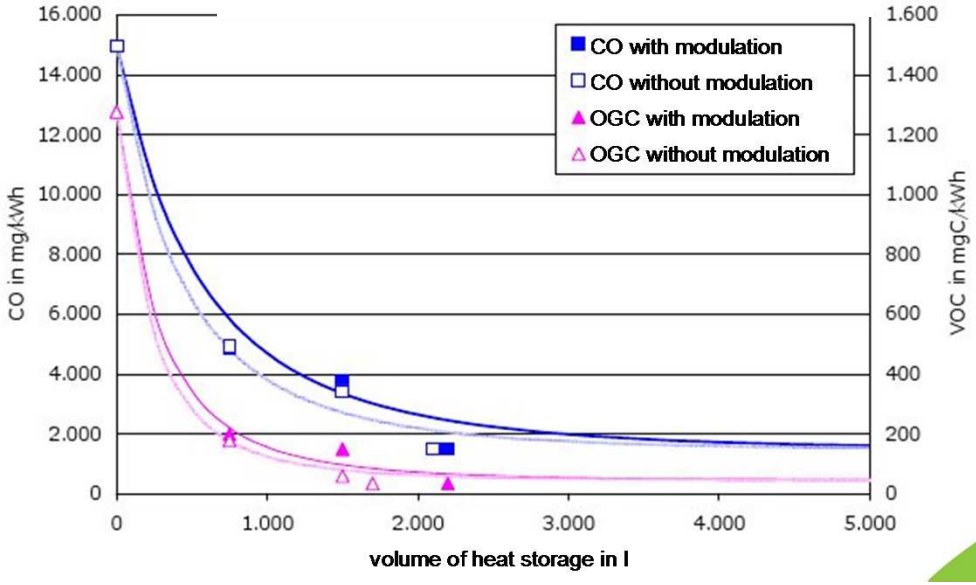
Thermal Storage

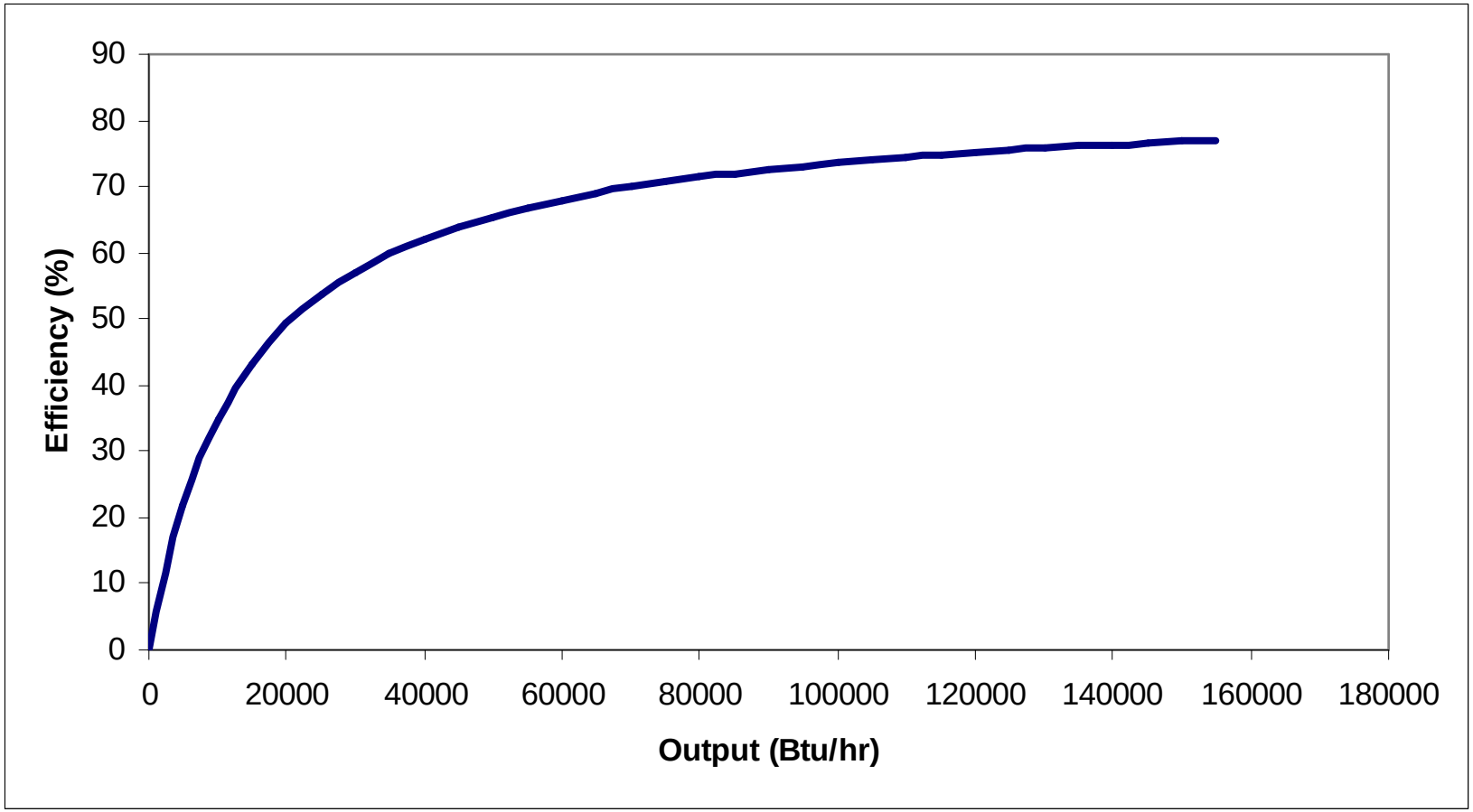
- Peak performance at steady state and full output
- Mandates the use of thermal storage
- Guidelines vary:
  - 6 gallons per 1,000 Btu/hr nominal output
  - Enough to take full charge of wood
  - ~ 300 gallons for 100 kBtu/hr

$$V_{AT} = 4.5 \cdot T_B \cdot Q_N \cdot \left(1 - 0.3\frac{Q_H}{Q_{min}}\right)$$

V_{AT}	Accumulator tank capacity	l
Q_N	Nominal heat output	MBtu/h
T_B	Burning period	h
Q_H	Heating load of the premises	MBtu/h
Q_{min}	Minimum heat output	MBtu/h



Pellet Boiler Efficiency vs Output



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Take home

- Sizing a problem for all boilers- especially challenging for solid fuels
- More challenging with larger fuel charge
- Auxiliary thermal storage serves as a major efficiency measure for staged combustion units resulting in lower emissions
- Pellet boilers also benefit from smaller buffer tanks

Thank
You!

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$2.5 Million Biomass R&D

PON 2652

- Air quality and health effect studies
- Product development
- Energy efficient retrofits
- Wood chip drying
- Pellet trucks
- Pellet demonstrations
- Grass combustion

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