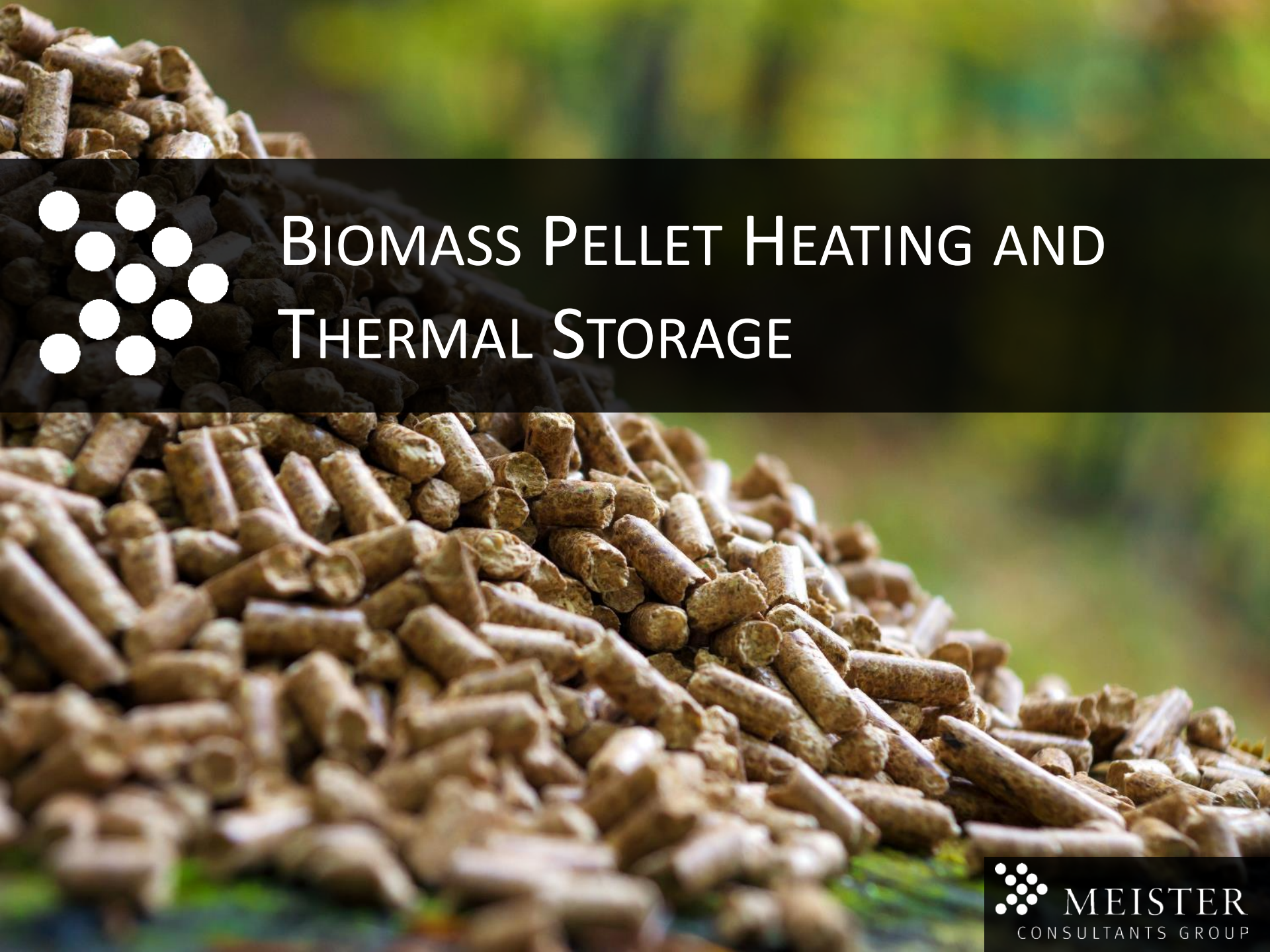
Biomass Pellet Heating and Thermal Storage



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Prepared for the Heating the Northeast Conference

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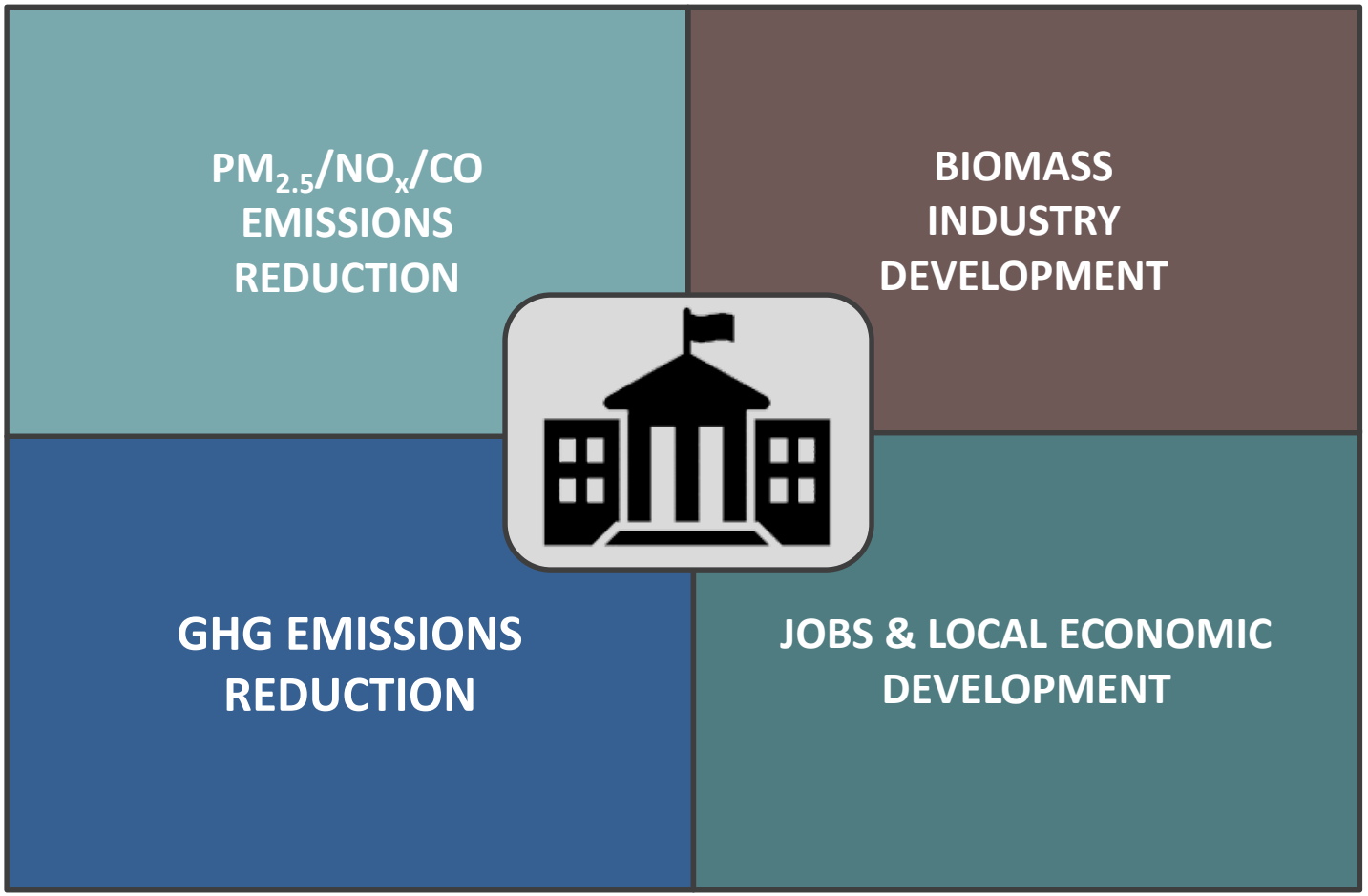
CESA study on thermal storage

- Focus on residential, advanced pellet heating systems
- Review publicly available literature on thermal storage
- Conduct interviews with industry leaders, policymakers, and other experts
- Summarize results in concise document

Types of questions we asked the experts

- What are benefits and drawbacks of thermal storage?
- In addition to thermal storage, what design considerations can most affect efficiency and emissions?
- What data is available to compare the efficiency of modulating and non-modulating systems with and without thermal storage?
- What are the additional capital costs for integrating thermal storage into a residential system?
- What are current state policies for thermal storage? What policies or best practices should be considered?

Policymakers face competing policy objectives to drive growth in the biomass heating market



Diverse policy approaches among states reflects different considerations and uncertainty around thermal storage

Summary of residential pellet boiler rebate requirements

			
Storage requirement	None ("strongly encouraged")	Required unless certain requirements are met	Required in all circumstances
Incentive amount	40% of project costs up to $10,000; adder for larger bulk storage	45% of project costs up to $10,000; $2,000 max adder for storage (with income adders)	45% of project costs (max of $10-36,000 depending on size)
Efficiency requirement	80%+ thermal efficiency rating	85%+ thermal efficiency rating	85%+ thermal efficiency rating
PM emissions requirement	≤0.10 Total PM lbs./MMBtu heat output	≤0.08 lbs. $PM_{2.5}$/ MMBtu heat **input** at nominal capacity (0.03 at sensitive receptor sites); <270 ppm CO at 7% O_2	<0.08 lbs. $PM_{2.5}$/ MMBtu heat output; <270 ppm CO at 7% O_2 and ≤0.03 lb/MMBtu at schools

Conclusion: we lack certainty regarding impact of thermal storage on emissions

State agencies need better information on:

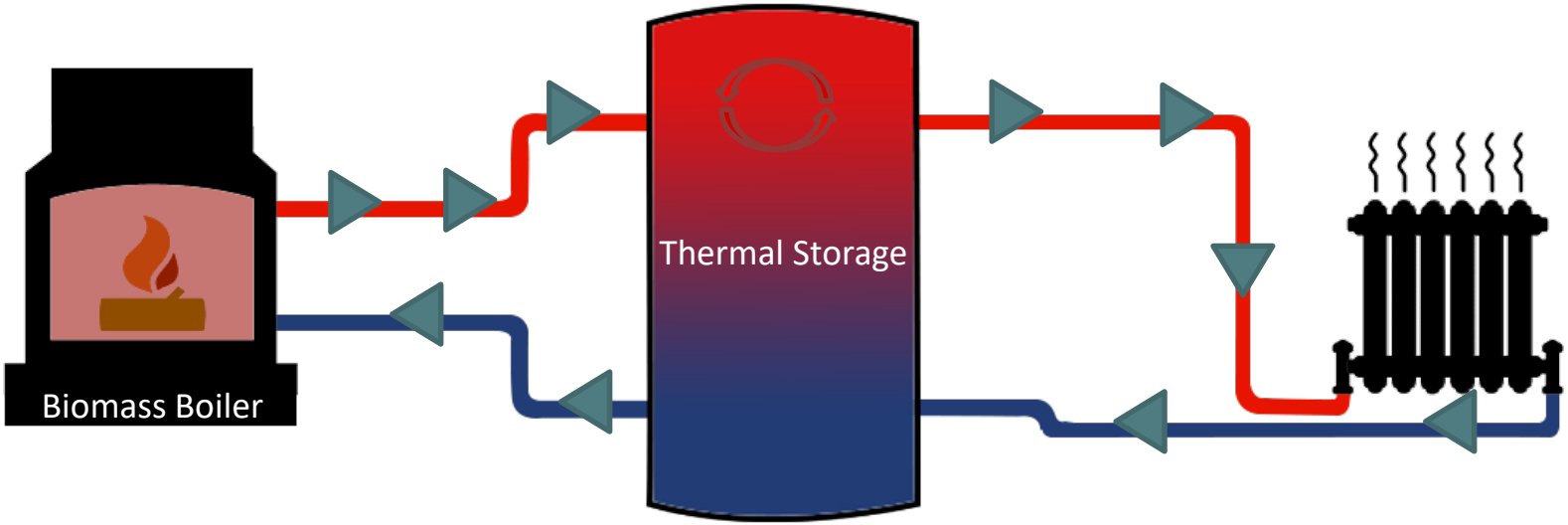
1. **the effect of storage on the daily and annual delivered thermal efficiency and on PM and CO emissions** from central wood pellet heaters
2. **better test method** that represents actual operating conditions of advanced pellet heaters
3. **the tradeoffs on emissions from thermal storage relative to other factors** that influence emissions and efficiency (e.g. modulation, system sizing, controls, etc.).

WHAT DO THE EXPERTS SAY ON THERMAL STORAGE?

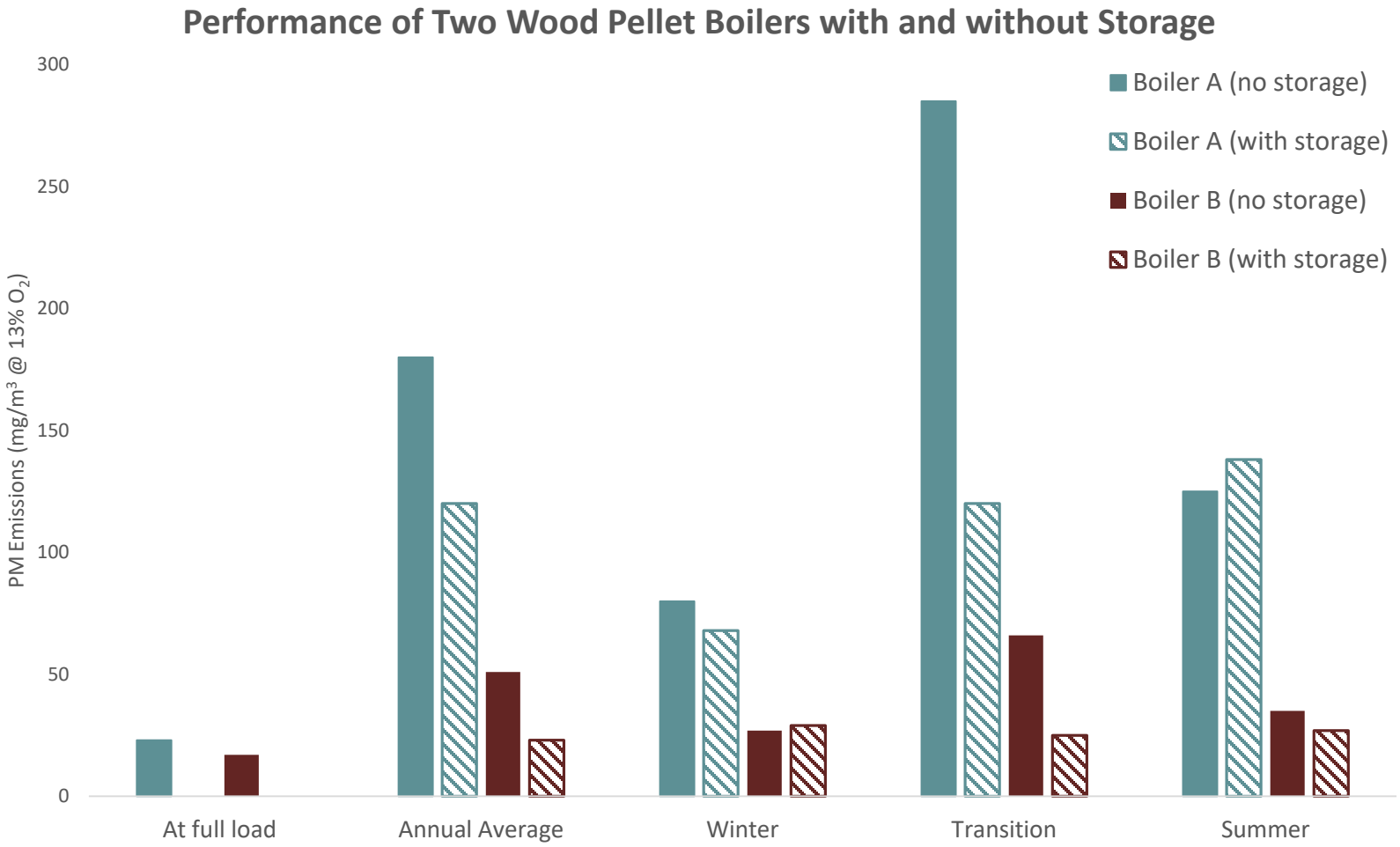
Many experts point to benefits of thermal storage

Because the storage acts as a buffer between the combustion system and the heat load, it can reduce the negative effects of oversizing and system cycling.

- Improves efficiency of combustion
- Reduced emissions from $PM_{2.5}$, NO_x, CO and other air pollutants
- Reduced wear and tear (increased system life, lower maintenance)
- Enables smaller systems to serve load (potentially lowering installation costs)



Kunde study (2013) suggests that storage has the largest impact during the shoulder season



Source: Kunde et al. 2013

Controversy remains among policy and industry stakeholders regarding efficacy of thermal storage

Other design factors can also influence efficiency and emissions for advanced residential biomass heating:

- pellet heater sizing
- the ability of pellet heaters to modulate (or turndown) at part load;
- fuel quality
- integration of heaters with the existing hydronic distribution system, and use of system controls

However, the tradeoffs between these different approaches – and their impacts on emissions – are not well understood.

OPTIONS FOR POLICYMAKERS?

Summary: key issues related to emissions and thermal storage

- Suboptimal hydronic system design, boiler oversizing, and poor installation practices seem to be prevalent, which impacts efficiency and emissions of residential wood pellet heaters
- There is insufficient (publicly available) real-world operational data concerning wood pellet system performance (with and without storage)
- EPA is taking a valuable first step in establishing emission requirements and requiring third-party testing, but more needs to be done
- Without more and better research on factors impacting emissions of wood pellet heaters, policymakers lack the data necessary to refine policies

Summary: issues and options for future studies

- **Conduct field and lab research using a "whole systems" approach.**
  Heating systems are complex and thermal storage is only one component of the whole system.
  - More research is needed to assess how the home heating system functions as a whole and impacts on emissions.
  - This should include an analysis that measures impacts of system sizing, distribution temperature, controls, modulation rate, thermal storage, as well as thermal mass and zoning of distribution system.
- **Conduct field and lab research on thermal storage use in the U.S.**
  Research and analysis of thermal storage systems in representative North American homes are needed. Such analysis should encompass:
  - Desktop modeling to assess cycling, fuel consumption, emissions with and without thermal storage, modulation impacts, and start up/shut down periods;
  - Laboratory–based performance testing of efficiency and emissions for pellet boilers with and without storage on a representative residential heat load duty cycle; and
  - Performance of "field units" that measure how advanced wood pellet heating systems operate with and without thermal storage.

THANK YOU!

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