

Heating System Specs

3 Froling FHG Turbo 3000 wood gasification boilers (total 0.5 mmBTU)

1 Ray-Pak propane-fired secondary boiler (1.5 mmBTU)

2,500-gallon thermal storage tank

District heating system covers 41,255 square feet in 5 buildings.

Cord-wood is harvested on Harvard Forest land, following a long-term plan developed by our staff forester.

3 new pieces of forestry equipment (tractor, wood processor, forwarding trailer) help our Woods Crew process wood safely and efficiently.

Data on boiler temperature and performance and propane use are continually measured and available on the Harvard Forest website.

What's different about heat production with this system?

A substantially more efficient system is heating 120% more space.

The antiquated system that heated Shaler Hall, part of the Archives, and Torrey Laboratory (33,723 sq ft) has been replaced—and now also heats the Community House dorm and renovated pole barn (totaling 41,255 sq ft).

Fuel handling is more efficient. For 70 years, wood production involved a 10-step process, from tree felling by chainsaw to feeding 4-ft lengths of split wood into the boiler. The new system and modern processing equipment have cut this effort by 50%.

Harvard Forest is safer. The wood boiler, fuel oil, and cordwood are removed from Shaler Hall and all oil tanks (8,275 gallons) are out of Zone 1 of our wellhead. The new wood harvesting equipment has improved employee safety and scattered workshop spaces have been consolidated in the efficient, code-compliant pole barn.

How does the system work?

A variable-speed circulator controls water flow in the primary loop between the three biomass boilers and heat exchanger. A second variable-speed circulator sits between the heat exchanger and the thermal storage tank. The main system circulator pushes up to 100 gallons of hot water per minute from the thermal storage tank to the heating loops in the various buildings. The back-up Ray Pak

propane boiler has its own circulating pump and diverting valve to supply hot water to both the thermal storage tank and the building supply loops, each of which is controlled by its own temperature sensor. All systems are digitally monitored and recorded.

How often do the wood burners get fed?

Boilers are fired 4 times on weekdays, and 3 times on weekend days.

How do we cope with extreme cold? The propane boiler augments the wood system as needed.

What do we do on warmer days? In moderate weather, fewer wood boilers are fired.

What happens when we lose electrical power?

The entire system is supported by a propane-powered generator.

What other options did we consider, and why did we end up where we are?

We considered a variety of wood systems for a range of heating scales. The most expensive option (\$3 million) would have covered the entire 9-building main campus, with a chip boiler and chipper in a new building on the sawmill site. A single 0.6 mmBTU wood boiler was considered but was deemed inefficient during the shoulder seasons. We considered a pellet boiler as the back-up instead of





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propane, but were concerned about long-term pellet supply. Consultations with the USDA Wood Education and Resource Center, Wilson Engineering, Harvard EHS, Research Designs Inc., Seaman Engineering, and AFS Environmental Systems helped shape the system as installed.

What heats the rest of our buildings, on and off the main campus?

Five houses have been converted to propane (Schoolhouse; Fisher, Higginson, Benson, and Lyford Houses) and four houses have relatively new oil systems (Bryant, Highway, and Raup Houses; Fisher Cottage). The latter will be upgraded to propane as appropriate.

What's next for this system?

The new system, started on 10/10/13, operates well, and will increase in efficiency with fine-tuning and familiarity in operation. We will seek permission from the Mass. Boiler Board to remove the heat exchanger and pressurize the wood boiler system.

What did the heat distribution system cost?

AFS Heat distribution system	\$405,000
Renovation of Pole Barn	\$300,000
Engineering peer review/design	\$15,000
<u>Forestry equipment</u>	<u>\$110,000</u>
Total	\$830,000

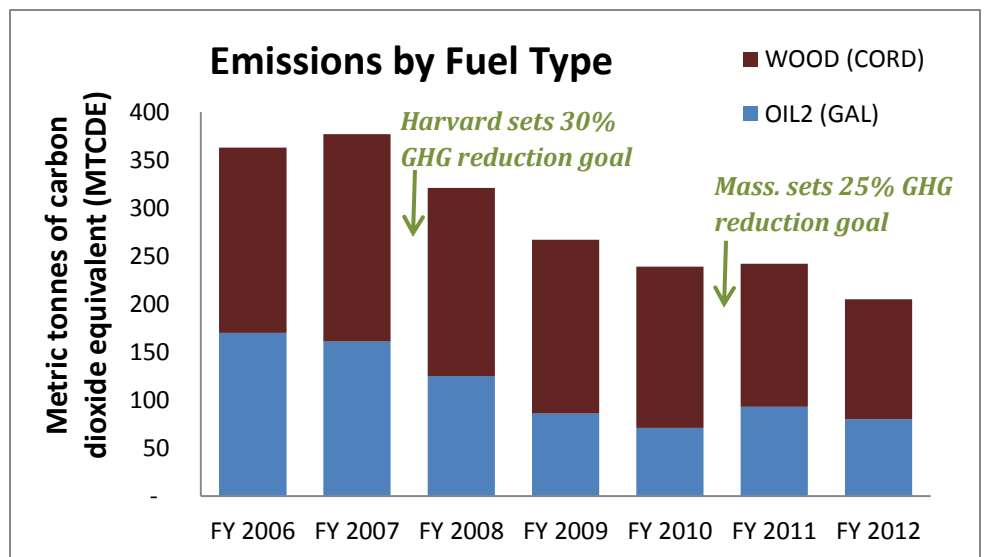
How much of a difference does the new system make?

By summer 2014, we expect to have firm estimates of long-term fuel use, carbon emissions, and operating costs, and plan to monitor key system parameters for 3 years or longer, to meet research and education goals.

What research will be related to the thermal biomass system?

Research by dozens of scientists from across Harvard and the Northeast explores the biogeochemical, ecological, environmental, and social implications of biomass harvesting and burning. Questions include:

- What is the carbon and GHG emission budget for a small-scale biomass heating plant from the forest to the boiler to the atmosphere? How is carbon taken up, stored, and released in association with this process?
- How might viable biomass markets change landowner decision-making and resulting land-use patterns?



Carbon emissions from Shaler complex prior to new heating system.

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