Energy Success Stories

On-Farm Heating with Biomass

River Berry Farm

Fairfax, VT • www.riverberryfarm.com

Highlights: 220,000 BTU/hr biomass boiler • $13,000-21,000 installed cost • 12-14 year payback period • 5,910 pounds of CO_2 avoided • Advanced pollution controls in new boilers reduce emissions

David and Jane Marchant of *River Berry Farm*—an organic vegetable and fruit producer in Fairfax—were early adopters of biomass heating when they installed a corn and pellet furnace in one of their greenhouses in 2008. The furnace required manual lighting and, whenever a strong wind blew, the fire could be snuffed out, making it a real labor burden. Although it was rated for 165,000 BTU/hr input and had a relatively low initial installation cost of $5,200, the furnace never seemed to actually produce a reasonable amount of heat. The Marchants also had a variable load in the greenhouse that peaked at night and was non-existent during the middle of a sunny day inside the greenhouse. This made for a frustrating relationship with the appliance. "I kept thinking, there has got to be a better option," recalls David, "It was a real labor burden, and you couldn't count on it."

This biomass heating demonstration was part of a *UVM Extension project* aimed at trialing several furnaces in agricultural heating applications with funding support provided by the *High Meadows Fund*. According to Chris Callahan, Ag Engineer with UVM Extension who assisted with some of the design and performance assessment, "The main lessons learned from these early installations were to buy high quality fuel, seek improved automatic ignition controls, invest in a good chimney and install it well, and know the actual heat output rating of the unit." Modern biomass heating appliances generally include a fuel storage bin, an auger for feeding fuel to the appliance, the appliance itself (boiler or furnace) with an ignition system, a combustion chamber, a heat exchanger, and a heat distribution system. They also incorporate some means of controlling combustion, fuel feed rate, and air flow and often include emissions control measures and automated ash removal.

Boilers Can Provide Advantages Since Hot Water Can be Used in Many Applications

Based on their early experiences and bolstered by a commitment to long-term sustainability and reduced fossil fuel dependence, the Marchants hosted another demonstration project on their farm. This time, they opted for a higher-rated *boiler* rather than a furnace. Boilers produce hot water, rather than hot air, which allows more options for distributing the heat.

The Central Boiler Maxim 250 boiler installed at River Berry Farm in Fairfax, VT. These boilers may look like outdoor wood boilers common around Vermont, but they are EPA Phase II qualified due to improved emissions controls.

The new system also had an automated propane ignition system. The selected boiler was a *Central Boiler Maxim 250* with a 250,000 BTU/hr input rating, efficiency of 87.8%, and EPA Phase II Hydronic Heater qualification. "The boiler makes hot water which we can use in multiple greenhouses by plumbing it to them in insulated PEX piping. Once in the greenhouse, we convert to hot air with a hot water fan coil, put it in the ground for root-zone heating or on the benches in our mat-heating system for starts," says David, "I like it. I keep trying to find something wrong with it, but I can't. The payback period is a bit longer due to higher initial costs, but you have to expect that."

The basic system cost was approximately $13,000 for the boiler, bin, pad, and plumbing to a hot water fan coil. The other heat distribution systems included in-ground PEX, heat exchange, and plumbing for a bench heat system and added approximately another $5,000. The system is more automated and reliable than the earlier furnace was, but the higher initial costs and the fact that the system is only used 3 months out of the year do prolong the payback period to about 12 years when compared with a propane furnace. If the system was used for 6 (space heating) or even 12 months (wash water, pasteurization) of the year the payback would be halved or quartered, respectively.

"In addition to the financial payback, the carbon emissions avoidance is also of interest to many people," says Callahan, "In River Berry Farm's case, the Maxim is helping them avoid 5,910 pounds of net CO_2 emissions per year which is about equivalent to 5,000 miles car travel or the CO_2 sequestered by half an acre of pine forest." The *EPA Phase II qualification* of the unit refers to the emissions of criteria pollutants (e.g., sulfur oxide and nitric oxide). The same analysis that shows the net CO_2 emissions reduction also suggests the net criteria pollutant emissions are also reduced when using the biomass boiler compared to propane.

Biomass heating is being used in other greenhouses as well. Paul Betz was interested in using his woodlands to fuel his greenhouses at High Ledge Farm in Woodbury. With the installation of a Central Boiler eClassic 2300 cord wood boiler he is doing just that. "Despite what the sales people will tell you, they are finicky to get lit, and require some babysitting for longer, reliable burn times," cautions Paul, "Once it is going, it does what it's supposed to do, which is burn clean and make hot water." **The system cost about $21,226 and saves about $1,500 per year resulting in a payback period of about 14 years.**

Paul Betz uses the Central Boiler eClassic to heat two greenhouses with cord wood.

Paul also has two other pointers that will help anyone using a biomass boiler. "Don't skimp on the insulated piping. While I was shocked at the $13.00 a foot price, I should have gone for it. I got some for $6.95, and the insulation is not adequate, and since it's not a filled pipe, if the outer sleeve gets nicked, it will fill with water and defeat the insulation" Regarding heat distribution, Paul notes "When buying the exchangers, be sure to check the BTU ratings carefully. When they are listed they give the ratings for steam, not hot water. The end result is the exchangers can be a little undersized when connected to a hot water boiler."

A less expensive underground insulated PEX tubing option (left) is wrapped in foiled bubble wrap and has space between the insulation on the pipe as well as the outer wall. Cost is approximately $7.00/ft. The solid EPS insulated PEX tube (right) is more expensive at $11.00/ft but has demonstrated reduced heat loss and pipe to pipe heat transfer. Water infiltration is a concern on the foil wrapped version on the left due to the open area that exists.

Photo credits: Chris Callahan

The table to the right compares biomass fuels and other fuels generally used in Vermont. The key considerations when making a fuel choice are generally: Cost per delivered unit ($/gal, $/ton); energy content (BTU/gal, BTU/ton); boiler or furnace availability and cost; system reliability and automation; and emissions. It is important to note that fuel prices can and have experienced high volatility with rapid and significant increases at times. These changes will affect how one fuel compares to another. Using the fuel comparison calculator listed in the Resources can help clarify that impact.

Fuel	BTU Content	Cost	Delivered Heat Cost (per million BTU)	Pros	Cons
Cord Wood	18-20 million BTU/cord	$160 – 200/cord	$11.1 @ 85% efficiency	Readily available & familiar; can generally be sourced on farm.	Manual handling; batch loading
Wood Pellets	8,600 BTU/lb	$294/ton	$20.1 @ 90% efficiency	Automated feeding with auger and bin; available in bags and (in some locations) bulk delivery.	Higher cost per BTU than cord wood; limited bulk delivery options currently
Wood Chips	9.9 million BTU/ ton	$56/green ton	$15.9 @ 65% efficiency	Inexpensive.	Generally high moisture compared to other fuels; limited small scale appliance availability.
Corn	8,500 BTU/lb	$300/ton	$23.9 @ 90% efficiency	Can be grown on farm; automated feeding with auger and bin.	Can form clinkers more easily than other biomass fuels.
Grass Pellets	8,600 BTU/lb	$250/ton	$16.1 @ 90% efficiency	Can be grown on farm; automated feeding with auger and bin when densified.	Relatively high ash content, needs automated removal system; clinkers possible.
Propane	92,000 BTU/gal	$2.80/gal	$33.8 @ 90% efficiency	Common, easy to use; no ash.	Not renewable; net CO_2 and greenhouse gas contributor.
Fuel Oil	129,500 BTU/gal	$4.00/gal	$34.3 @ 90% efficiency	Common, easy to use; no ash.	Not renewable; net CO_2 and greenhouse gas contributor.
Biodiesel	118,296 BTU/gal	$4.18/gal	$39.3 @ 90% efficiency	Fuel oil replacement can be sustainably produced.	Some seals and materials may need to be changed.

Biomass Heating Resources

Penn State, An Introduction to Biomass Heating: www.bioenergy.psu.edu/pdf_files/Fact%20Sheet%20IntroBiomassHeat.pdf

Michigan State University, Heating Buildings and Business Operations with Biomass Fuel: A Planning Guide: http://web2.msue.msu.edu/bulletins/Bulletin/PDF/E3044.pdf

Biomass Energy Resource Center: www.biomasscenter.org/

Maxim M250 Furnace: www.maximheat.com/models

Penn State, Energy Cost Comparison Charts: http://extension.psu.edu/natural-resources/energy/energy-use/resources/making-decisions/comparison-charts

UVM Extension, Biomass Furnaces for Greenhouse Vegetable Growers: http://www.uvm.edu/vtvegandberry/Pubs/Greenhouse_Furnace_Project_Report.pdf

Renewable Energy Vermont: www.revermont.org/main/technology/bioenergy/biomass/

Central Boiler E-Classic 2300: www.centralboiler.com/e-classic2300.html

Prepared by

Chris Callahan

University of Vermont Extension — Cultivating Healthy Communities

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