

FINDINGS #14, JUNE 2014

WOOD-PELLET-FIRED BIOMASS BOILERS

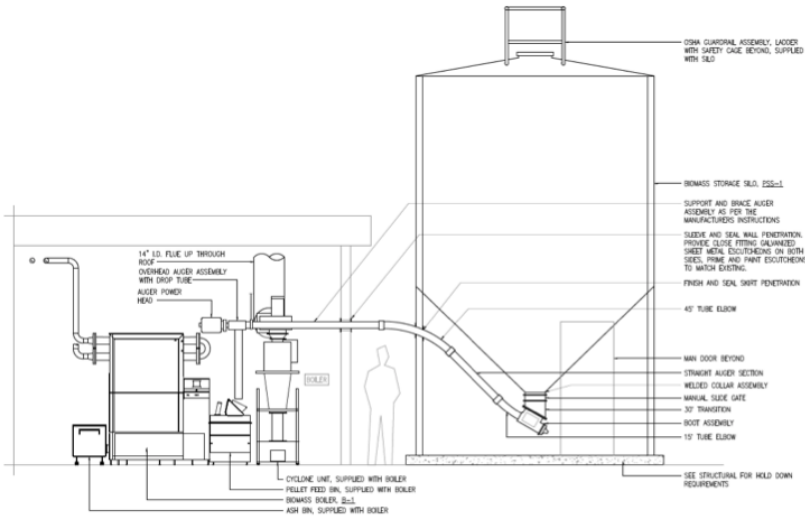


Biomass Boilers Offer Cost-Effective Alternative to Fuel-Oil-Heated Facilities

Advances in pellet combustion and control automation have recently positioned wood-pellet-fired biomass boilers as economical alternatives to traditional boilers. Their targeted use promises distinct benefits to GSA, foremost among them the ability to bring cost-effective heat to facilities that lack access to natural gas. The technology also has the potential to redirect some regional energy economies from fossil fuels to locally sourced renewable energy such as waste wood, which has been accumulating in the nation's forests. This is particularly relevant throughout the western United States where waste wood has been accumulating because of a pine beetle infestation that has killed over four million acres of lodgepole and ponderosa pine.¹

In 2012, GSA's Green Proving Ground (GPG) program leveraged the replacement of an entire legacy heating system at the Ketchikan Federal Building in Ketchikan, Alaska, to evaluate a state-of-the-art wood-pellet-fired biomass boiler. The project demonstrated that wood-pellet-fired biomass boiler systems are an efficient alternative for hot-water-heated facilities where natural gas is unavailable. They will be most cost-effective for buildings in cold northern climates within 50 miles of a biomass pellet mill.

INTRODUCTION



Biomass Boiler and Fuel Bin

Wood pellets are stored in a silo outside of the building and are augered into the building on demand.²

“ Depending on oil-fired boilers alone in remote Alaskan communities can be risky, especially since natural gas isn’t available up here. The wood-pellet-fired boiler has proved to be a straightforward, reliable, and affordable alternative.”

—Michael C. Okoro, CEM, RPA
Branch Chief
Environmental and Energy Branch
GSA, PBS, Northwest/Arctic Region

What is This Technology?

EFFICIENT AUTOMATED HOT-WATER HEATING SYSTEM

The biomass boiler is a mature, widely available renewable energy technology that heats and distributes hot water to meet a building’s heating demand. A fully-automated auger system, similar to those used for conveying feed and grain on farms, delivers pellets from an outdoor silo to the boiler’s hopper. At a rate predetermined by user-controlled settings, a fuel-feed system then delivers the pellets to a combustion chamber. Pellets are burned using staged combustion air injection (a process that reduces NO_x). A cyclone separator knocks out particulate matter that is then removed by an on-line, automated mechanical cleaning and ash-removal system.

What We Did

RESEARCHERS LEVERAGED HEATING SYSTEM UPGRADE TO TEST FUNCTIONALITY AND DEPLOYMENT POTENTIAL OF BIOMASS BOILER

GPG commissioned researchers from the National Renewable Energy Laboratory (NREL) to evaluate the efficiency, cost-effectiveness, and operational functionality of the one-million BTU Ketchikan biomass boiler. NREL gauged the technology’s deployment potential by combining information from GSA’s Energy Usage and Analysis System with independent research to locate wood-pellet biomass sources, estimate delivered costs, and identify additional candidate facilities. Emissions and full system energy savings were not tested as part of the demonstration project measurement and verification (M&V) assessment. After one full year of boiler operation, researchers performed M&V over the course of one day in January 2012 to ascertain biomass boiler operational efficiency. Efficiency was derived by dividing the flow of heat captured in the boiler-heated water by the energy created through the combustion of wood pellets, with heat loss comprising the balance.

PERFORMANCE SPECIFICATIONS

Biomass Boiler Efficiency

ESTIMATED

At Full-Load

85% - 90%

MEASURED

At 45% Partial-Load

85.6%

FINDINGS



HIGH BOILER EFFICIENCY Due in part to mild weather and oversized system capacity, the Ketchikan boiler operated at only 45% of operational load, but still maintained 85% efficiency. Because boilers are typically designed for best efficiency at or near full loads, adjustments to system size will likely result in higher operational efficiency.



FAVORABLE PAYBACK UNDER MANY CONDITIONS Payback for Ketchikan was 30 years, due in part to the system being oversized. Over the course of a year, the boiler installed at Ketchikan is capable of generating 8,760 million BTUs but estimated use in 2011 was 1,150 million BTUs, or 13% of full capacity. Under more favorable conditions, including but not limited to appropriate system sizing, simple payback can be less than 5 years.



HIGH OPERATIONAL FUNCTIONALITY, LOW O&M COSTS Biomass boiler technology requires minimal maintenance or attention during normal operations. Automated monitoring and control systems run all aspects of the boiler, including feed, load reduction, and tube cleaning, and continuously adapt as system conditions change. Fuel handling is straightforward, given the uniformity of pellets. Operational stability enables small-scale operations with small maintenance support teams, thus reducing labor costs.



DEPLOYMENT SHOULD TARGET HOT-WATER HEATED FACILITIES USING FUEL OIL Wood-pellet-fired biomass boilers should be considered at all hot-water-heated facilities where natural gas is unavailable. Deployment should target facilities that have an extended heating season and where pellet fuel is available within 50 miles.

Payback Varies by System Size and Pellet Cost

Savings are greatest with larger systems and lower fuel costs

	Pellet Cost (\$/ton)					
	\$400	\$350	\$300	\$250	\$200	
	PAYBACK IN YEARS					
500,000	30.7	10.7	6.5	4.7	3.6	< 2
1,000,000	24.1	8.4	5.1	3.6	2.8	< 3
1,500,000	20.9	7.3	4.4	3.2	2.5	< 5
2,000,000	18.9	6.6	4.0	2.9	2.2	< 10
2,500,000	17.5	6.1	3.7	2.6	2.1	10+
3,000,000	16.4	5.7	3.5	2.5	1.9	
3,500,000	15.6	5.4	3.3	2.4	1.8	
4,000,000	14.8	5.2	3.1	2.2	1.8	

Diesel Price \$3.63/gallon; 75% capacity factor

(At a 50% capacity factor, the payback period increases 30%)

CONCLUSIONS

These Findings are based on the report, “Wood Pellet-Fired Biomass Boiler Project at the Ketchikan Federal Building,” which is available from the GPG program website, www.gsa.gov/gpg

For more information, contact Green Proving Ground gpg@gsa.gov



Footnotes

¹USDA, <http://www.fs.usda.gov/barkbeetle>

²Wood Pellet-Fired Biomass Boiler Project at the Ketchikan Federal Building, (NREL) Gregg Tomberlin, April 2014, p. 9

³Wood Biomass Market Report (WBMR) <http://www.forestbusinessnetwork.com/15962/wood-biomass-market-report-begins-reporting-prices-for-premium-grade-wood-pellets>

⁴<https://bioenergy.ornl.gov/faqs/index.html#pg2>

⁵Wood Pellet-Fired Biomass Boiler Project at the Ketchikan Federal Building, (NREL) Gregg Tomberlin, April 2014, p. 22

What We Concluded

150 GSA-OWNED BUILDINGS ARE SUITABLE FOR BIOMASS BOILERS

At the Ketchikan Federal Building, the biomass boiler performed reliably and efficiently with minimal O&M costs. Results from this study support the conclusion that biomass boilers are a viable alternative for any hot-water-heated building where natural gas is unavailable. Biomass boilers will be most cost-effective for facilities with high heating loads and close proximity to locally sourced, renewable wood-pellet fuel. Of the more than 1,500 GSA-owned buildings, researchers identified approximately 150 assets as potential candidates for biomass heating technology.

Lessons Learned

MANY VARIABLES AFFECT PAYBACK

Variables affecting payback for a biomass boiler include the following:

- **Biomass fuel cost:** Pellet prices vary across the U.S. by region. In 2012, highest costs were in the northeast, and lowest costs were in the south, with a nationwide average of \$169/ton.³
- **Biomass fuel delivery costs:** Delivered fuel cost is a function of local diesel fuel prices and proximity to a pellet manufacturer. Being within a 50 mile radius is recommended.⁴ Transportation costs average \$0.15 per ton-mile.⁵
- **Heating oil costs:** On average, the fuel content of one ton of wood pellets is equal to 120 gallons of heating oil. To produce the same amount of energy, biomass pellets cost about half as much as heating oil and their pricing is more stable.
- **Heating oil consumption:** Greater efficiencies are realized in cold climates where the biomass boiler is operating at a full heating load with high annual hours of operation.
- **Economies of scale:** Because of economies of scale, larger systems have better payback. Mechanical engineers use the “six-tenths rule” to estimate boiler costs, such that as size increases, cost increases by an exponent of six-tenths: $\text{cost}_1/\text{cost}_2 = (\text{size}_1/\text{size}_2)^{0.6}$.
- **Proper boiler sizing:** As a rule of thumb, systems should be designed to meet 60% of peak load.

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