GUIDEBOOK

Wood Pellet Heating

A Reference on Wood Pellet Fuels & Technology for Small Commercial & Institutional Systems

Massachusetts Division of Energy Resources

Prepared for the

Massachusetts Division of Energy Resources

By

Biomass Energy Resource Center

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How to Use this Book

This guidebook is intended to be a reference for potential owners of institutional- or commercial-scale wood pellet heating systems. Although developed for the Commonwealth of Massachusetts, much of the information is applicable to similar-scale facilities in other regions.

This guidebook will be useful to the following groups:

- Municipal, state, or federal building owners
- School boards or other school executives
- Business owners
- Developers and owners of newly constructed space
- Any others interested in applying wood pellet heating technology to commercial- or institutional-scale facilities

The guide is both a general and a technical resource. Introductory information is provided under each subject heading and new terms are defined in a glossary on page 22 that can be linked to by clicking on the term. A "back" arrow following each term in the glossary will return the reader to where the link originated.

The How To sections were designed to help building owners with the more technical decision necessary for installing a wood pellet heating system. Technical experts such as engineers or system vendors can assist building owners with the processes outlined in these sections of the guidebook.

Contents

Wood Pellets

Wood pellets are a common type of biomass. Biomass is any biological material that can be used as fuel—including grass, corn, wood, and biogas as well as other forestry and agricultural residues.

A Good Choice for Heating

Many building owners use fossil heating fuels, such as oil or propane, for space heating. These fuels are often expensive and unstable in pricing, and are threatening the global climate and sustainability of communities. Proven alternatives to fossil heating fuels exist and are already in use across North America: Biomass fuels are a local, renewable resource for providing reliable heat.

Wood pellets are a common type of biomass. Biomass is any biological material that can be used as fuel—including grass, corn, wood, and biogas as well as other forestry and agricultural residues.

WOOD PELLETS

One biomass fuel that has gained national attention with rising fossil fuel prices is wood pellets. Wood pellets are compressed by-products from the forest products industry, often woodchips and sawdust. They are a locally available and a cost-effective heating fuel with several advantages over other types of biomass.

Wood pellets are a condensed uniformly sized form of biomass energy, making them easier to store and use than many other biomass fuels. Pellet heating technology is also quite simple, minimizing operation and maintenance requirements. These heating systems can be easy to plan for and install and can save a building owner thousands of dollars in energy costs over time while providing significant local economic and environmental benefits.

ADVANTAGES TO HEATING WITH BIOMASS

Using biomass fuels helps mitigate such environmental issues as acid rain and global climate change. Perhaps the greatest advantage of biomass fuels, however, is that they cost on average 25-50 percent less than fossil heating fuels and are more stable in pricing. It is unlikely that any future carbon or energy taxes will increase the cost of biomass fuels and are more likely to raise the cost of heating with fossil fuels. The technology is becoming well established in the North American market and the choice to heat with biomass fuels can be as simple as choosing a traditional fossil fuel heating system.

In addition, wood pellets:

- are convenient and easy to use, and can be bulk stored in less space than other biomass fuels
- have a high energy content, and the technology is highly efficient compared to other biomass fuels
- are a clean-burning renewable fuel source
- are produced from such waste materials as forestry residues and sawdust
- are price stable compared to fossil fuels

Who Should Consider Wood Pellet Heating?

There are currently about 800,000 homes in the United States using wood pellet stoves or furnaces for heating, according to the Pellet Fuels Institute. Wood pellets are manufactured in the US and Canada, and are available for residential use in 40-pound bags from feed stores, nurseries, and other supply outlets.

Increasingly, heating with wood pellets is becoming common on larger scales—in municipal or federal buildings, educational facilities, housing complexes, office buildings, and other businesses. While the majority of installations of this size are in Europe, a growing number are in North America, including New England. The greater heating requirements of these larger buildings differ from those of residential settings, thus requiring different technology (boilers rather than stoves) and fuel supply infrastructure (bulk wood pellet supply rather than bags).

There are several demonstrations in New England of wood pellet boilers replacing fossil fuel heating systems, reducing reliance on fossil fuels, and saving building owners money.

CANDIDATES FOR WOOD PELLET HEATING

The best candidates for wood pellet boilers are buildings between 10,000 and 50,000 square feet (SF) that use heating oil, propane, or electricity to produce space heat and/or hot water. Natural gas is generally a less expensive fossil fuel for space heat, and wood pellet prices are not always competitive. When natural gas prices are significantly higher than the national average price, wood pellets may be the better alternative. Wood pellet heating systems are also a viable option for new construction.

Other important site characteristics to consider include the layout of the building. It should have—or the owner should plan to convert to—a centralized hot water heat-distribution system. There should be adequate space for the wood pellet boiler and storage silo as well as adequate access to the silo for fuel truck deliveries. The distance between the building and the wood pellet distribution center ideally should be no more than 50 miles since the actual cost paid per ton for bulk wood pellets will include a delivery charge that may make wood pellets less cost effective as the delivery distance—and delivery charge—increases.

WOOD PELLET BOILER TECHNOLOGY

Wood pellet boiler technology is becoming well established in the North American market. There are several vendors with proven track records of reliability and performance (vendors and contact information can be found on page 24) and several demonstrations in New England of wood pellet boilers replacing fossil fuel heating systems, reducing reliance on fossil fuels, and saving building owners money.

Two Case Studies

Harris Center

Hancock, New Hampshire

Heated Space: 10,000 SF
Pellet Storage: nine-ton silo
Annual Wood Pellet Use: 10-15 tons
Average Staff Time: 75 minutes per week (during the heating season)
Estimated Fuel Cost Savings: 45 percent

The Harris Center for Conservation Education is an environmental education organization that provides conservation and environmental education programs for all ages. It also serves as a local land trust.

Started as a project focused on promoting environmental health, installing the wood pellet boiler has generated substantial fuel-cost savings. The facility is an excellent example of how a business approach to sustainability can also make good financial sense.

NRG Systems

Hinesburg, Vermont

Heated Space: 46,000 SF on three floors
Pellet Storage: 30-ton silo (one year's worth)
Average Staff Time: 15 minutes per day
Heating Fuel Offset: 4,735 gallons propane (06-07 heating season)

NRG Systems manufactures wind measurement systems for the wind power industry. The building is a model workplace that embodies the company's values by demonstrating the benefits of the latest renewable technologies. While the building's heat load is not typical of most of this size (it is heated with two large residential-sized 140,000 Btu per hour wood pellet boilers), this application of wood pellet heating technology demonstrates a successful model of using a locally available, renewable, and cost-effective resource to provide reliable heat in an office/manufacturing setting.

Wood Pellet Fuel

Characteristics

Wood pellets are a manufactured biomass fuel. They are made from wood waste materials that are condensed into pellets under heat and pressure. Natural plant lignin holds the pellets together without glues or additives. Wood pellets are of uniform size and shape (between 1-1½ inches by approximately 1/4-5/16 inches in diameter), making them as easy to store and use as traditional fossil heating fuels. Wood pellets also take up much less space in storage than other biomass fuels because they have a higher energy content by weight (roughly 7,750 Btu per pound at six percent moisture content) due to their densified nature and low-moisture content (typically between 4-6 percent moisture by weight).

While wood pellets are typically not differentiated between soft and hardwood sources, there are three grades based on the amount of ash produced when they are burned:

- Premium (ash content less than one percent)
- Standard (ash content between one-two percent)
- Industrial (ash content three percent or greater)

Premium and standard grade pellets are suitable for any wood pellet boiler with automatic ash removal, including most institutional- or commercial-scale applications. Industrial grade pellets, or those with ash content greater than three percent, should be avoided due to the high volume of ash produced.

Availability

For the residential market, wood pellets are sold in 40-pound bags at farm or building supply stores. Small commercial- or institutional-scale applications of the type being discussed here, however, require bulk delivery and storage. Several wood pellet manufacturers (see list on page 24) can deliver in bulk. The customer is charged per ton delivered, the price typically including a per-load fee scaled to the distance of the delivery.

Pricing

When exploring the conversion from fossil fuels to wood pellet heat, an important consideration for building owners is the fuel-cost savings from using wood pellets. Because fossil fuels and wood pellets are sold in different units, a price comparison must be based on the amount of energy—in millions of British thermal units (MMBtu)—delivered by each fuel. The basis for comparison then becomes the cost of producing one MMBtu with each fuel being considered.

Several other factors affecting the true cost of heating with any fuel include the energy and moisture content and the efficiency of the heating system used to burn each fuel. Figure 1 shows the various equivalencies of each fuel after accounting for these factors.

FIGURE 1.

FUEL EQUIVALENCIES

For heating, one ton of wood pellets equals…

- **120 gallons of heating oil**
- **170 gallons of propane**
- **16,000 ft^3 of natural gas**
- **4,775 kilowatt hours (kWh) electricity**

Paying $200/ton for pellets is the same as paying…

- **$1.67 per gallon for heating oil**
- **$1.18 per gallon for propane**
- **$12.50 per (1,000 ft^3) for natural gas**
- **$0.04 per kWh for electricity**

The comparisons above show, for example, that the heat provided by one ton of wood pellets is equal to the heat provided by 120 gallons of heating oil, and paying $200 per ton for wood pellets is the same as paying $1.67 per gallon of heating oil.

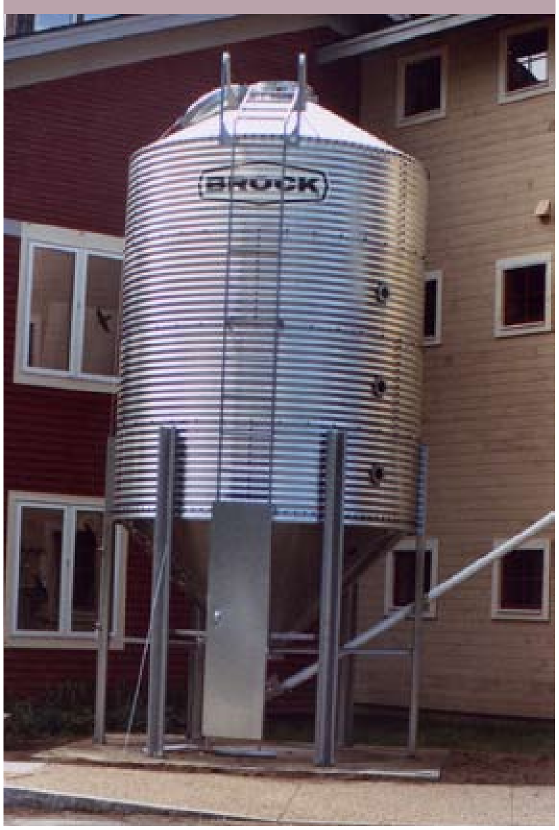
The savings in fuel costs using wood pellets can be figured out by comparing the actual price of the current heating fuel to the price equivalent given in the table. A building owner paying $2.30 per gallon of heating oil would save $.63 per gallon displaced (the difference between $2.30 and $1.67), or 27 percent, representing a yearly savings of $2,700 on a $10,000 annual fuel bill.

In general, space heating with wood pellets is less expensive than with fossil fuels. Natural gas is the only heating fuel that is not always more expensive (on a MMBtu basis) than wood pellets. That is why buildings that currently heat with natural gas are not always good candidates for converting to wood pellet heating.

HOW TO

SIZE A WOOD PELLET STORAGE SILO

A good rule for sizing a fuel storage silo is to choose one that is somewhat larger (maybe 1.5 times) than the capacity of the fuel delivery truck used by your supplier. Since there always will be some pellets remaining in the silo at the time of next delivery, this sizing will maximize delivery efficiency, particularly since delivery charges for wood pellets are often per load rather than being based on the actual quantity. If the supplier uses a 10-ton delivery truck, the silo should be 15 tons or more. Silos should be sized in increments of 10, 15, 25, or 35 tons. For small commercial- or institutional-scale boiler systems, the silo should have a storage capacity of at least 15 tons.



Securing a Fuel Supplier

When selecting a pellet manufacturer (also referred to as "supplier") capable of making bulk deliveries to your area, there are other points to consider in addition to price:

- **Delivery Distance.** Wood pellets are most cost effective when the distance by road between the manufacturer/distributor and the customer is fewer than 50 miles.
- **The Bulk Market.** It is best to go with a supplier that is committed to the development of the bulk market and will favor meeting orders for bulk deliveries over producing bags for residential sale.
- **Guaranteed Supply.** Look for a supplier that guarantees an available and reliable supply.
- **Source Material.** Look for wood pellets that were produced from green woodchips or sawdust and avoid wood pellets that were made from construction and demolition (C&D) waste. The ash produced from burning pellets made from C&D wood waste may not pass Commonwealth of Massachusetts rules on hazardous waste materials. The ash from green woodchips and sawdust, however, is likely to comply with the Commonwealth's solid waste management rules. You can obtain a written statement of the source of wood being used from your pellet manufacturer.

It is important to keep in mind that while the technology is gaining ground in North America, centralized wood pellet heating at the institutional and commercial scales is still a developing market.

Calculating Potential Fuel Cost Savings

STEP 1

To calculate your potential fuel cost savings, you first need to determine the amount of heating fuel you use per year and multiply that by your average price per gallon. This gives your total heating fuel bill for the year, to which you will compare your estimated fuel bill if you were using wood pellets.

For example, if you typically use 1,120 gallons of propane in a year for space heating (excluding any heating fuel that is used for water heaters or cooking) and your average price over the past year for propane was $1.75 per gallon, your total average annual fuel bill would be $1,960.

_______________ x $ ______________ = $ ________________

Total Units   Price/Unit   Total Annual Fuel Bill

STEP 2

The next step is to estimate how many tons of wood pellets your building requires in a year, using the equivalency factors given in Figure 1. In the case of propane, one ton of wood pellets is equal to 170 gallons of propane. Almost 7 tons (6.6 tons) of wood pellets will be needed to heat for one year (1,120 gallons of propane divided by the equivalent 170 gallons of propane per ton of wood pellets).

If the current price of wood pellets is $200 per ton, your estimated fuel bill using wood pellets would be $1,320 (6.6 tons of wood pellets multiplied by $200 per ton).

________ ÷ ________ = _______ x $ ________ = $ _______

Total Units   Units/Ton   Tons/Year   Price/Ton   Total Bill

STEP 3

The dollar savings from switching to wood pellets this year can be calculated by subtracting an estimated fuel bill using wood pellets from your current annual fuel bill. As you project these savings into the future, those prices would change and the gap would increase, since fossil fuel prices will escalate faster than woody biomass fuels.

An important question for potential owners of wood pellet boilers is the extent to which fuel cost savings justify the cost of the project (see Economic Analysis section on p. 16).

Components of a Wood Pellet Heating System

The Technology

Wood pellet boilers are relatively simple systems that are easily installed and operated. The wood pellets are typically stored in a standard outdoor silo. Pellets are delivered in trucks similar to those that deliver grain. Wood pellet fuel is automatically fed to the boiler via auger systems similar to those used for conveying feed and grain on farms. The pellets are discharged from the silo and conveyed to the boiler using automatically controlled augers set to provide the right amount of fuel based on the building's demand for heat.

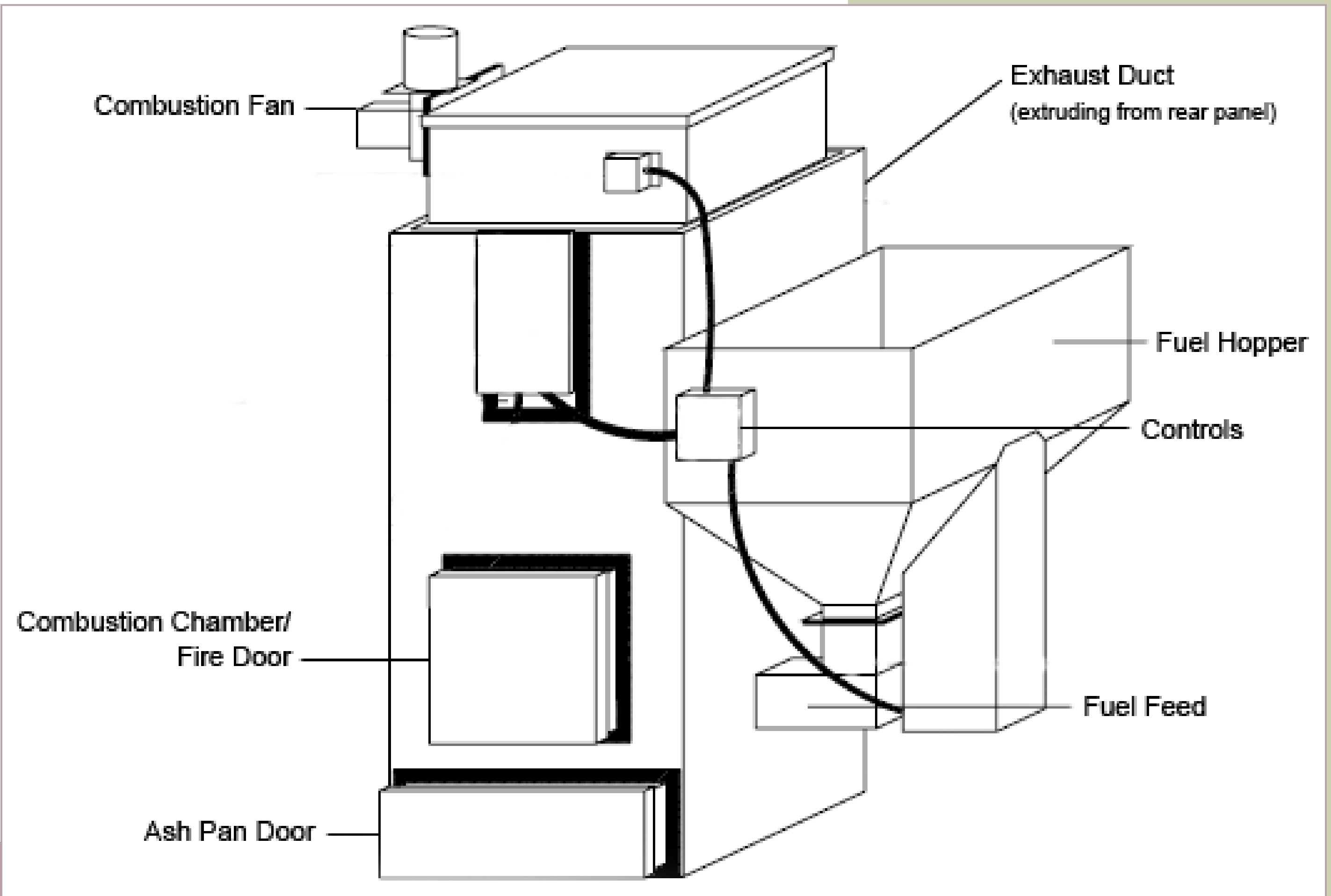
FIGURE 2.

DIAGRAM OF A WOOD PELLET BOILER

A typical system includes a fuel storage silo with an auger system that delivers the wood pellets from the silo to the fuel hopper.

The wood pellets are fed from the fuel hopper through the fuel feed system into the combustion chamber at a rate determined by the control settings. The combustion fan supplies air to the combustion chamber and the exhaust is ducted to the chimney through a port at the rear of the system.

Ash must periodically be removed through the ash pan door.



Explanation of Components

The boiler is usually delivered completely assembled; however, some pieces, like the fuel hopper, may be removed to facilitate the installation of the boiler.

COMBUSTION CHAMBER/FIRE DOOR

The combustion chamber is where the pellets are burned to produce heat. It is accessible for cleaning or maintenance through the fire door.

COMBUSTION FAN

The combustion fan provides air to the fire in the combustion chamber.

PRIMARY CONTROLS

The control unit allows the user to control the flow of wood pellets and combustion air into the boiler based on temperature settings. The unit also gives readings on boiler and exhaust temperatures.

FUEL STORAGE SILO

Wood pellet fuel for the institutional- or commercial-scale market is typically delivered in bulk, where it is stored in the same type of standard outdoor silo used to hold grain or animal feed, or in silos specifically made for fuel pellets.

FUEL HOPPER & FEED SYSTEM

Wood pellets are delivered by automatic conveyors from the storage silo into the fuel hopper. From the fuel hopper, the pellets are delivered into the boiler through the fuel-feed system at a rate determined by the control settings.

EXHAUST DUCT

The combustion exhaust gases are ducted through a port at the rear of the system, which connects to either a new or existing chimney.

Equipment Checklist

When a wood pellet boiler is purchased, the vendor will typically supply not only the pellet boiler, but also the fuel handling equipment, chimney connection and automated controls, and may also supply the fuel storage silo.

The components for a pellet boiler system are:

- Storage Silo
- Fuel Conveyor/Auger System
- Fuel Hopper and Feed System
- Combustion System (Boiler)
- Electronic Controls
- Connection to Existing Chimney
- High Temperature Chimney (if there is not an existing chimney to connect to)
- Plumbing Connections (to the building's hot water heat distribution system)

Optional components:

- Ash Removal System
- Automatic Soot-Cleaning System

Wood pellet boilers are relatively simple systems that are easily installed and operated.

HOW TO

SIZE A BOILER

The wood pellet boiler should be sized to meet the peak heating demands of the building. The boiler should be capable of providing enough heat to keep the building warm during the coldest hour of the year. The peak heating demand depends upon both the efficiency of the building and the climate in which it is located .

A wood pellet system vendor or a mechanical engineer can recommend a system with the right capacity for your building's heating needs. Information useful to have on hand prior to contacting these professionals includes:

- An energy loss analysis for your building to determine its ability to retain heat and quantify its peak heating requirement, if available
- Several years of heating bills showing monthly fuel consumption
- Total fuel consumption in a typical year, with monthly fuel consumption during peak winter months
- Data on your area's climate, such as the number of heating degree days

A mechanical engineer, system vendor, or other design contractor will be able to help you with collecting and analyzing this information and assist you by recommending an appropriate boiler size for your facility's heating needs. Typical engineering and design fees can range from 10-15 percent of the total project cost, although system vendors may not charge directly for this service.

Operation & Maintenance Requirements

Wood pellet boilers are relatively simple biomass heating systems. Because wood pellets are generally uniform in size, shape, moisture and energy content, fuel handling is very straightforward. Nevertheless, there are some ongoing maintenance requirements for these systems.

A wood pellet boiler will take more time to maintain and operate than a traditional gas, oil, or electric heating system. At the institutional or commercial scale, however, many of the maintenance activities can be cost-effectively automated by installing off-the-shelf equipment such as soot blowers or automatic ash removal systems. Some of the typical maintenance activities required for wood pellet systems are:

WEEKLY

- Emptying ash collection containers
- Monitoring control devices to check combustion temperature, stack temperature, fuel consumption, and boiler operation
- Checking boiler settings and alarms, such as those that alert to a problem with soot buildup

YEARLY

- Greasing augers, gear boxes, and other moving parts
- Checking for wear on conveyors, augers, motors, or gear boxes

When considered on a daily basis, the total time required for maintaining the wood pellet boiler system equates to roughly 15-30 minutes per day over the entire heating season.

FREQUENTLY ASKED QUESTIONS

WHAT IS THE DIFFERENCE BETWEEN A WOOD PELLET STOVE AND A WOOD PELLET BOILER?

A wood pellet stove is sized for residential settings. The heating needs of an average-sized home are typically much lower than those of commercial or institutional settings like small schools, municipal buildings, or small businesses. A wood pellet boiler, on the other hand, is sized for these larger commercial heating loads. There are also other differences between pellet stoves and boilers in the degree of automation and fuel storage and handling, based on the different needs of residential and commercial users.

WHAT ARE THE BEST USES FOR A WOOD PELLET BOILER?

While a wood pellet stove is sized and sold for homes (or anywhere a space heater can be used for a small heat load), wood pellet boilers are more appropriate for small commercial- or institutional-sized applications. Examples of successful projects (lists can be provided by system vendors) include greenhouses or other agricultural settings, smaller educational facilities, conference centers, businesses or office buildings, housing complexes, and state- or town-owned buildings. In general, those facilities between 10,000 and 50,000 SF, that have boilers with heat output ratings between .25 and 1.5 MMBtu per hour, and heat with fuel oil, propane, or electricity, are good candidates for heating with wood pellets.

DO WOOD PELLET BOILERS REQUIRE MORE OPERATOR ATTENTION AND DAILY MAINTENANCE?

On average, wood pellet boilers require 15-30 minutes per day of operator attention. The typical general maintenance tasks include emptying the ash bin about once per week and checking the boiler settings. In addition, all of the moving parts and motors need to be greased on an annual basis and checked for wear.

ARE WOOD PELLET BOILERS NOISY OR MESSY AND DO THEY SMELL LIKE BURNING WOOD?

Wood pellet boilers run as quietly as any other furnace or boiler would. Wood debris, dust, and allergens are minimal. Due to the highly efficient combustion, and the well-dispersed exhaust through the chimney, the smell of burning wood is usually undetectable.

HOW ARE WOOD PELLETS MADE?

Wood pellets are made from densified wood waste material, typically from logging, sawmill, or packaging residues. Wet sawdust is pressed into pellets under high heat and pressure. There are no additives in wood pellets, therefore they burn cleanly.

HOW ARE WOOD PELLETS DELIVERED?

Bulk wood pellets are brought to the site in a truck that delivers directly into the storage silo using either compressed air or a pneumatic conveyance system.

HOW MUCH WOOD PELLETS WILL I NEED AND WHERE WILL I STORE THEM?

The amount of wood pellets required—measured in tons—can be estimated based on the amount of fuel currently being used to heat your building. Commercial wood pellet suppliers and other experts can assist with these calculations. The amount of storage space required will be dependent on the amount of wood pellets needed. Typically, wood pellets are stored in a silo (similar to those housing grain) or other type of bin. The storage tank must provide good access for the fuel delivery truck. Wood pellets can be conveniently stored for up to one year. Wood pellet boiler vendors or other experts can assist with determining an appropriate size for your pellet storage (see How To Size a Boilern on previous page).

CAN I CONNECT MULTIPLE BUILDINGS TO ONE WOOD PELLET BOILER?

A small district energy system, connecting several buildings in close proximity to one heating plant, can be a good project. The buried pipe system connecting the buildings to the pellet boiler can be costly to install, however, a larger heating demand can mean a larger potential for savings on heating fuel costs. It is imperative that the boiler be sized to meet the combined heating needs of all the buildings connected to the system.

Environmental Considerations for Institutional- or Commercial-Scale Wood Pellet Boilers

Air Emissions

There have not been any independent emissions tests performed in North America on institutional- or commercial-scale wood pellet boilers, although efforts are underway. While the actual data is not available for wood pellet boiler technology (with the exception of a partial dataset from a Danish system vendor), test results are available for other modern institutional- or commercial-scale wood-burning technologies, particularly school-sized woodchip boilers.

It is well known that the emissions from wood-burning boilers are different than emissions from such traditional heating fuels as heating oil, propane, or natural gas. All heating fuels—including wood—produce particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NO_x), and sulfur dioxide (SO_2) in varying amounts. Burning wood in a modern and well-maintained woodchip boiler, for example, produces more particulate matter than burning any of the fossil fuels, but less SO_2 than oil or propane. As shown in Figure 3, full test data is not available for pellet boilers.

FIGURE 3.

EMISSION RATES FROM WOOD & FOSSIL FUELS[1] (lbs/MMBtu)

	PM10	CO	NO_x	SO_2
Wood Pellet Boiler (Test Report)[2]	n/a	0.51	0.272	n/a
Woodchip Boiler[3]	0.1	0.73	0.165	0.0082
Oil Boiler	0.014	0.035	0.143	0.5
Propane Boiler	0.004	0.021	0.154	0.016
Natural Gas Boiler	0.007	0.08	0.09	0.0005

[1] Without emission control equipment with the exception of PM10. Emissions given on a heat input basis.

[2] Emissions rates, given in pounds of pollutant per MMBtu (million British thermal units), were provided by the Danish Technological Institute and performed on a Danak pellet boiler. PM10 and SO_2 were not tested.

[3] Emissions rates, given in pounds of pollutant per MMBtu, were provided by Resource Systems Group in a report titled, Air Pollution Control Technologies for Small Wood-fired Boilers (2001). These emissions rates characterize wood fuel in general, with a specific focus on woodchips. The emissions from wood pellets may differ from the emissions rates given here.

It is hoped that future emissions testing of wood pellet boiler technology will rely on independent third-party testing (following USEPA-approved testing methodology) rather than emissions testing conducted by wood pellet boiler vendors or other stakeholders in the wood pellet heating industry.

PERMITTING FOR PELLET BOILERS IN MASSACHUSETTS

The Commonwealth of Massachusetts has set regulations on the emissions of the air pollutants discussed on the previous page. Any equipment, such as a boiler, that is a potential source of these emissions needs to have state approval for operation. A boiler that is larger than 3 MMBtu/hour (heat input rating) will be required to obtain an operating permit, issued by the Commonwealth. Wood pellet boiler applications within the size range being considered here (less than 3 MMBtu/hour), however, are not large enough to require an operating permit.

Massachusetts Department of Environmental Protection (DEP) (see contact information on page 26) may require plan approval for the installation of boilers within the size range being considered here. Any building owner who is considering a conversion to wood pellet boiler heating should contact the DEP to determine if plan approval is necesary and, if so, begin the process. Plan approval should be sought prior to purchasing or installing a wood pellet boiler and may require the inclusion of emissions control technology in the system plan.

WOOD PELLETS & GLOBAL CLIMATE CHANGE

Carbon dioxide (CO_2) is an air pollutant currently not regulated by Massachusetts or the federal government despite it being a major contributor to global climate change. Because replacing fossil fuels with biomass for space heating results in a significant net reduction in CO_2 emissions, it is a meaningful way to begin reducing environmental impacts.

Wood fuels are often referred to as "carbon neutral." This refers to the natural carbon cycle where CO_2 emitted when wood is burned continues to be a part of the overall flux of carbon, while burning fossil fuels releases *new* carbon to the atmosphere that had been locked away underground. Trees capture and store (sequester) carbon. Although the carbon is released when the wood is burned, if harvested and burned at the rate it grows in the forest, no net carbon is released. Thus, burning fossil fuels for space heating increases the net amount of carbon in the atmosphere, while burning wood does not.

Ash from Wood Pellet Boilers

One by-product of burning wood pellets is ash, a non-combustible residue. While the ash produced by burning wood pellets is automatically removed from the boiler in the systems of many manufacturers, the container in which the ash is collected must periodically be emptied and disposed of manually.

Massachusetts requires a "beneficial use determination" from the DEP Bureau of Waste Prevention-Business Compliance Division before approving any use of the ash from pellet boilers. While many wood boiler operators use their ash as fertilizer for lawns or athletic fields, there are other useful ways to handle wood ash material, such as composting and amending soil. The ash is not known to adversely affect humans or plant and animal life when dispersed in this way, although, it may over time lead to increased nutrient runoff into streams, rivers, wetlands and other water bodies. A local water-quality regulator with the Massachusetts DEP (see contact information on page 26) can help determine if any potential effects on local water resources may be significant.

This ash can also be disposed of at any state landfill or other permitted solid waste management facility. Massachusetts considers wood ash from commercial or institutional sources to be a solid waste, thus potentially subject to the state's hazardous waste rules. In reality, the only type of wood pellets that may not meet Massachusetts standards are those made from construction and demolition (C&D) waste wood material, thus making it important to obtain a written statement from your supplier verifying the source.

HOW TO

ENSURE THE CHIMNEY IS THE CORRECT HEIGHT

State air quality regulators with the Massachusetts Department of Environmental Protection or an engineer can assist building owners with determining an appropriate chimney height for your site (see contact details on page 26). Such factors as local topography, wind movement patterns, and neighboring buildings should be taken into consideration when sizing a chimney. The chimney should be high enough to disperse the exhaust—and any pollutants it contains—into the prevailing winds.

Economic Analysis of Wood Pellet Heating Systems

A primary advantage to using wood pellets for space heating is the savings in heating costs that are generated by replacing expensive fossil fuels with less expensive wood pellets.

Cost Effectiveness of Wood Pellet Heating Systems

A primary advantage to using wood pellets for space heating is the savings in heating costs that are generated by replacing expensive fossil fuels with less expensive wood pellets. These savings can be calculated on a first-year basis, or the savings can be projected into the future over the expected life of the wood pellet boiler. An important question for potential owners of wood pellet boilers is the extent to which the fuel cost savings justify the cost of the project.

WHEN ARE PELLET BOILER SYSTEMS COST EFFECTIVE?

Life cycle cost (LCC) analysis can be used to inform a building owner's decision to convert to wood pellet heating. In calculating potential fuel cost savings, the LCC analysis considers several economic variables, such as estimates of fuel price and average inflation rates. The LCC analysis compares the projected costs of an existing fossil fuel boiler system to the projected costs of a new wood pellet boiler system, and shows the net present value (NPV) of savings over the life of the system.

Spreadsheet-based LCC analysis tools are available from:

- Biomass Energy Resource Center
- Natural Resources Canada (RETScreen)
- Universities of Wisconsin and Alaska
- Select architects or engineers

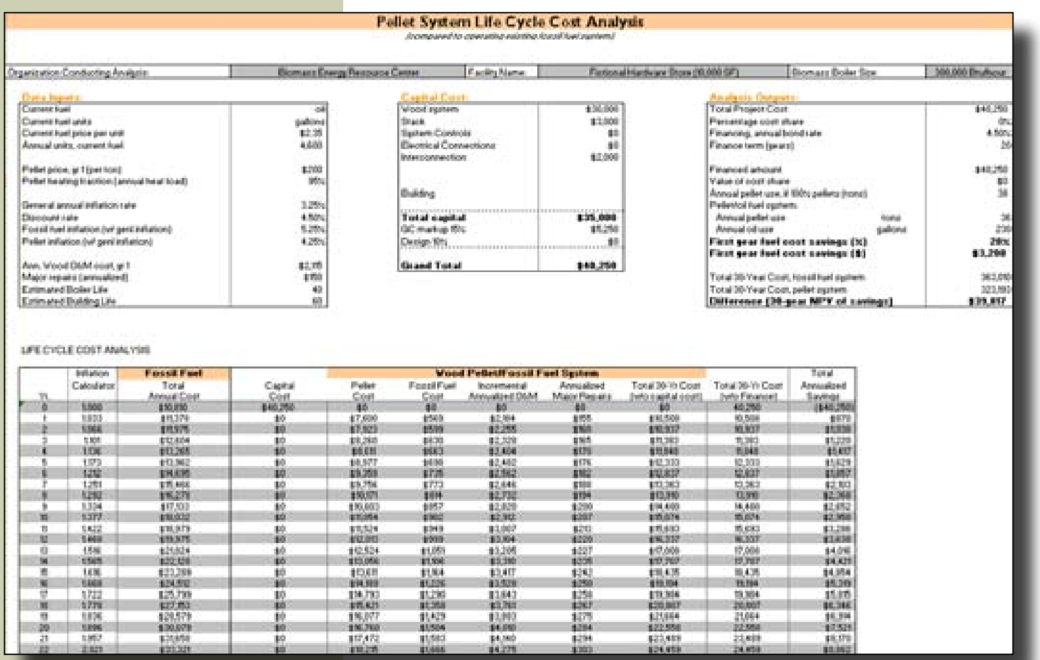


FIGURE 4.

LIFE CYCLE COST ANALYSIS TOOL

A life cycle cost analysis tool takes a number of economic parameters into consideration when calculating the cost effectiveness of installing a wood pellet heating system (see pages 24 and 25 for full-sized screens).

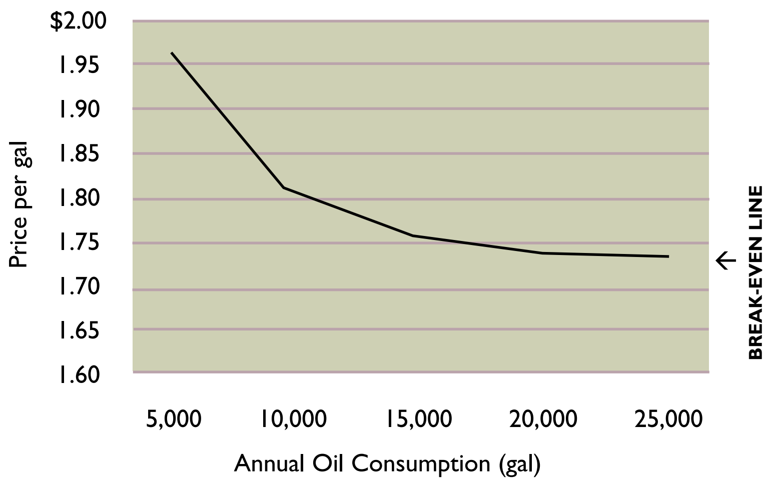
GENERAL INDICATORS OF COST EFFECTIVENESS

The best candidates for heating with wood pellets are buildings between 10,000 and 50,000 square feet (SF) that use heating oil, propane, or electricity for space heat and/or for serving large domestic hot water loads. Electric heat is the most expensive, therefore fuel cost savings generated by switching from electric heating to wood pellets could potentially be substantial, although the costs of converting the electric heaters to hot water heat distribution must be part of the analysis. Propane is typically the next most expensive heating fuel, followed by heating oil. LCC analysis assumes conservative inflation rates for fossil fuels as well as the general inflation rate, and does not take into consideration any additional financial incentives for wood energy, such as possible future taxes on carbon emissions.

The graphs on the following page show the potential for wood pellets to be a cost-effective alternative heating fuel when compared to oil, propane, natural gas, and electric heat. The LCC of a wood pellet heating system was compared to that of each of the fossil fuel heating systems across a range of heat load sizes and fuel prices. On each graph there is a line that represents the "break-even" point, at which the wood pellet system costs just as much as it saves over the life of the system (30 years). At conventional energy prices and consumption rates above the break even line, wood pellets would be a cost-effective alternative heating fuel. At the prices and consumption rates below the break even line, wood pellets are not likely to be cost effective. The farther above or below the break-even line, the clearer the message of the graph. While these graphs give a general idea of cost effectiveness for a range of situations, a site-specific LCC analysis will give more definitive answers.

The best candidates for heating with wood pellets are buildings between 10,000 and 50,000 square feet that use heating oil, propane, or electricity for space heat and/or for serving large domestic hot water loads.

OIL



PROPANE

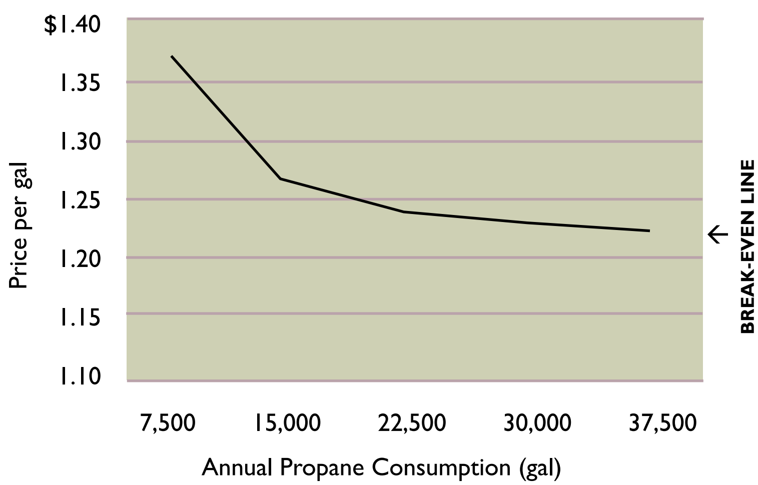


FIGURE 5.

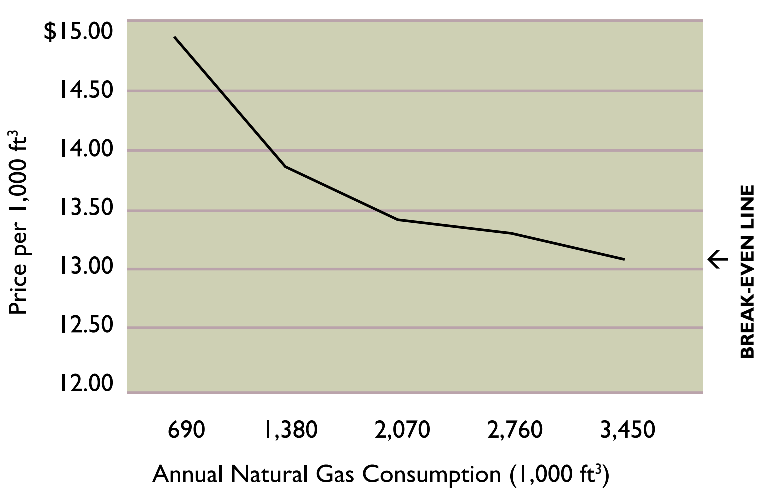
BREAK-EVEN ENERGY PRICES: WOOD PELLETS COMPARED TO OIL, PROPANE, NATURAL GAS & ELECTRIC HEAT

The graphs on this page demonstrate the price points and annual consumption rates above which wood pellet heating is likely to be cost effective. The break-even line illustrates the point for each price and consumption rate where wood pellets would cost the same as heating with the existing fuel. Above the break-even line, wood pellets are likely to be a cost-effective alternative; below the line, they are likely not to be.

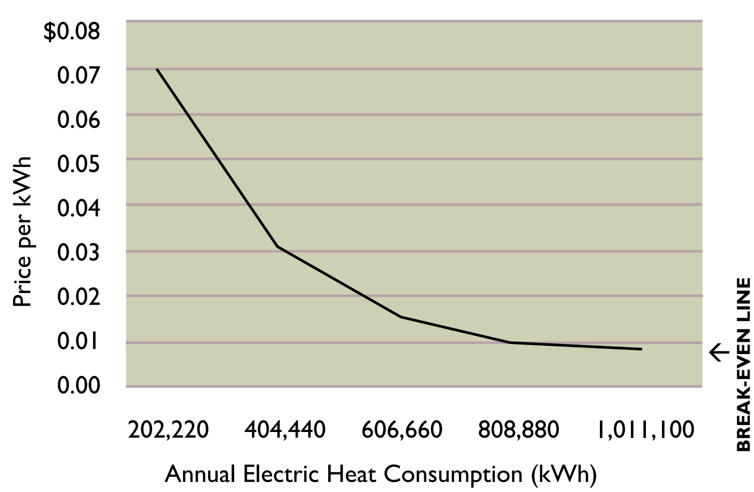
Building owners can input their consumption rate and current fuel price into the appropriate graph to determine whether or not wood pellets would make good financial sense at their site.

For example, a building that uses 15,000 gallons of oil per year for heating where the price is lower than $1.70/gal would be below the break-even point for cost effectiveness, thus it would not be a good candidate for heating with wood pellets. Alternatively, the building might be a good candidate if the oil price was $1.70/gal.

NATURAL GAS



ELECTRIC



How-To Do a Detailed Life Cycle Cost Analysis

DEFINE THE PROJECT & ITS COSTS

Wood pellet boiler systems are one of the least expensive biomass heating options to purchase and install and often do not require any newly constructed space. The full cost of the wood pellet boiler system is dependent on the capacity of the boiler, plus the cost of the equipment associated with it (such as the storage silo). There is also a cost for installing the system, including connecting the plumbing and controls to the existing heat distribution system. Complete wood pellet systems typically cost in the range of $75,000 to $100,000 per MMBtu (measured as heat output). A qualified professional or a wood pellet system vendor can provide site-specific project cost estimates.

Whether contemplating wood pellets for a heating system conversion project or for new construction, a full analysis of the cost effectiveness of any project requires that all costs of purchasing and installing the system, as well as purchasing fuel and operating the system, are considered. Cost components of a wood pellet heating system may include the following:

- System equipment and installation
- Complete fuel storage and handling system, including installation and any optional system components
- Construction (such as building additional boiler room space or a new boiler house, if required)
- Site costs (possibly including driveways for fuel deliveries)
- Chimney equipment and installation, if required
- Emissions permit or control equipment, if required
- Professional fees (such as those for engineering)
- Connection of controls and piping to the existing system

In addition to the cost of purchasing and installing a wood pellet boiler, ongoing costs for operating and maintaining the system need to be included in the LCC analysis. In the same way that a fossil fuel heating system requires general maintenance, a wood pellet boiler will require, on average, 15-30 minutes per day for an operator to keep the system running smoothly. The cost associated with the operator's time, as well as routine parts or service, should be included.

ASSUMPTIONS & DATA REQUIREMENTS

When comparing two heating system options, for example, wood pellet and oil heat, the cost of owning and operating each must be characterized in the same way. The option with the lower LCC will be the better financial investment.

In general, the important parameters for doing a life cycle cost analysis of a wood pellet heating system are:

- Initial system equipment and installation costs, including any construction or site-specific work
- Costs for system design and project management
- The expected life of the wood pellet boiler system
- Estimated costs for any equipment replacements or repairs over the anticipated life of the system
- Costs associated with maintaining and operating the back-up fuel system, including fuel purchases
- The projected volume of wood pellets required each year;
- The projected volume of back-up fuel required annually
- The current price of wood pellets, back-up fuel, and electricity
- The rates of escalation for wood pellet, back-up fuel, and electricity
- Annual general inflation rate, to model the future costs of operation and maintenance
- The projected first-year costs of running the wood pellet system, including costs for electricity, staff time, and routine maintenance
- The projected cost of major repairs on an annual basis
- Financing costs
- Amount of any financial incentives, such as grants or tax breaks, that will offset any portion of the project cost

Fictional Case Studies of Life Cycle Cost Savings

GENERIC HARDWARE STORE

A fictional hardware store is located within 50 miles of a wood pellet distribution center in Massachusetts. The store, including its associated storage space, is roughly 10,000 SF and uses 4,600 gallons of heating oil at a current price of $2.35 per gallon. The annual heating fuel bill at this price is $10,810. Because the store is within 50 miles of the wood pellet depot, the cost of wood pellets is kept relatively low, at $200 per ton, including delivery charges.

In addition to calculating the fuel requirements of this wood pellet heating system and a total project cost of $39,817, the LCC analysis shows that the owners of the hardware store could save about $3,208—or 28 percent—in the first year of operation. These savings are realized after the cost of purchasing fuel and the costs of operation and maintenance have been subtracted from the fuel cost savings. This translates to a net savings of approximately $45,000 (in 2007 dollars) over 30 years after accounting for the rise in costs of operation and maintenance due to general inflation. This building would be a good candidate for heating with wood pellets.

GENERIC TOWN HALL

This fictional Town Hall represents a municipally owned building located within 50 miles of a wood pellet distribution center. It houses a variety of town offices within its 30,000 SF. The entire space is heated by one centralized oil boiler. The price of oil is currently $2.35 per gallon and wood pellets would be available in bulk at $200 per ton.

The LCC analysis shows that the Town Hall would require about 110 tons of pellets per year and estimates the system would cost about $124,200. Fuel cost savings in the first year of operation would be 28 percent. Over the 30-year expected life of the wood pellet boiler, the Town Hall would save a net of more than $211,722 (in 2007 dollars). The Town Hall is a good candidate for a wood pellet heating system.

Sensitivity Analysis

In cases where an LCC analysis shows that a wood pellet boiler system installed at a certain site at current fuel prices would not be cost effective, the tool can be used to determine the point(s) at which the wood pellet boiler system might become cost effective. For example, a wood pellet boiler system may not be cost effective at the current fuel price being used in the analysis; however, if the price were to go up over the next couple of years, the system may become a good candidate for conversion.

In those cases where an LCC analysis shows that a wood pellet boiler system installed at a certain site at current fuel prices would not be cost effective, the tool can then be used to determine the point(s) at which the site would be a good candidate for conversion.

Financial Incentives for Wood Pellet Boiler Systems

MASSACHUSETTS TAX INCENTIVES

The Massachusetts Department of Energy Resources (DOER) website lists several tax incentive programs for renewable energy projects. A professional tax consultant can assist with determining eligibility for and claiming these incentives.

- State Income Tax Credit
- State Sales Tax Exemption
- Local Property Tax Exemption
- Corporate Income Tax Deduction

OTHER COMMONWEALTH INCENTIVES

In addition to the tax incentives listed on the DOER website, there are two other primary sources of financial incentives for wood pellet heating projects in Massachusetts. These can be in the form of reimbursements or financing assistance.

1. Massachusetts School Building Authority offers reimbursement money on a demonstrated need basis to communities that are improving existing schools or constructing new school buildings. An additional two percent is awarded for projects that meet the Massachusetts High Performance Schools criteria (http://www.massschoolbuildings.org/Documents/PDF/MA-CHPS_Green_School_Guidelines_10_20_06.pdf), including the installation of biomass heating systems. (http://www.massschoolbuildings.org/index.htm).

2. MassDevelopment
This finance agency offers loans, guarantees, and bond financing programs to Massachusetts businesses that are looking to grow their operation while supporting local economic development. (http://www.massdevelopment.com/)

FEDERAL INCENTIVES

In addition to Massachusetts-based financial incentives, there are numerous federal-level incentives available to businesses, municipalities, and nonprofits. They are also listed on the Massachusetts DOER website. A professional tax consultant can assist with determining eligibility for and claiming these incentives.

Business Tax Incentive (http://www.energytaxincentives.org/business/commercial_buildings.php)

A tax credit for up to $1.80 per SF is available to building owners, tenants, or federal building designers, for heating system projects that reduce heating costs by more than 50 percent. This program is scheduled to continue through December 2008.

Modified Accelerated Cost Recovery System (MACRS)
The MACRS provisions of the federal tax code give businesses the opportunity to recover investments in renewable energy systems by taking depreciation deductions over an accelerated five-year period.

Tax Incentives for Grants and Subsidies
Funds awarded to projects as part of federal programs may be exempt from taxation.

Grants, Financing Provisions, Production Incentives & Other Programs
Federal agencies such as the Department of Energy, Environmental Protection Agency, and Department of Agriculture periodically offer programs designed to encourage the research, development, and deployment of renewable energy technologies.

GLOSSARY

ACID RAIN: Cloud or rain droplets containing such pollutants as oxides of sulfur and nitrogen, damaging trees, soils, and aquatic environments.

ASH CONTENT: The amount of ash produced during combustion relative to the amount of fuel fed into the wood pellet boiler. Ash content is one indicator of quality for wood pellet fuel. Ash content for wood pellets should be between 1 and 3 percent.

BIOMASS: Any biological material, such as wood or grass, that can be used as fuel. Biomass fuel is burned or converted in systems that produce heat, electricity, or both.

BRITISH THERMAL UNIT (BTU): A unit used to measure the quantity of heat, defined as the quantity of energy required to heat 1 lb. of water 1° F. It takes about 1,200 Btu to boil 1 gallon of water.

CRITERIA AIR POLLUTANTS: A group of air pollutants regulated by the US Environmental Protection Agency and state air pollution control agencies to protect human health and the environment.

ENERGY CONTENT: The total Btu per unit of fuel. For biomass fuels, energy content can be considered on a dry or wet basis, since the amount of energy per pound of fuel is reduced with increasing moisture content.

FOSSIL FUELS: A group of combustible fuels, such as oil, propane, coal, or natural gas, formed from the decay of plant that animal matter and can be burned to produce energy. Liquid fossil fuels include oil, gaseous fossil fuels include propane, and solid fossil fuels include coal.

GLOBAL CLIMATE CHANGE: A term that is interchangeable with "global warming" and refers to the warming of the earth caused by the buildup of greenhouse gases (such as carbon dioxide, water vapor, and methane) in the atmosphere. While these gases are naturally occurring, humans are increasing these amounts through burning fossil fuels and other activities.

HEATING DEGREE DAYS: A measure used to estimate energy requirements for heating. It is calculated by subtracting the average daily temperature in a given area from 65 degrees Farenheit. Yearly totals can be used to compare the severity of the winter in different regions.

LIFE CYCLE COST: The total cost to purchase, own, and operate a piece of equipment over its entire life. The life cycle costs of several heating system options can be compared to determine which option will be the least expensive to own and operate over the entire expected life of the heating system.

MILLION BRITISH THERMAL UNITS (MMBTU): The amount of heat energy roughly equivalent to that produced by burning eight gallons of gasoline.

MOISTURE CONTENT: The total amount of water in a biomass fuel given as a percentage of the total weight of the fuel. Wood pellets, for example, typically have 6 percent moisture content, while woodchips have 40 percent and heating oil has 0 percent.

NET PRESENT VALUE (NPV) OF SAVINGS: The difference, in current year dollars, between the value of the cash inflows and the value of the cash outflows associated with operating an energy investment. A positive NPV of savings indicates that, from society's economic perspective, the project is worth doing. A negative NPV of savings indicates that a project is not economically worth doing.

PARTICULATE MATTER (PM): Extremely small pieces of solid matter (or very fine droplets) ranging in size from visible to invisible. Relatively small PM—10 micrometers or less in diameter—is called PM10. Small PM is of greater concern for human health than larger PM, since small particles remain airborn for longer distances and can be inhaled deeply within the lungs.

Next Steps

Building owners wishing to install wood pellet heating should begin by taking the following steps:

- Review the four cost-effectiveness graphs provided in this guidebook (page 18) to get a preliminary sense of whether wood pellet heating will make financial sense.
- Undertake a preliminary feasibility study to determine whether the wood pellet heating project will be cost effective. This study will include the preliminary analysis of site-specific data and estimated project costs.
- Tour facilities with existing wood pellet heating systems. Seeing this technology and talking with current owners is extremely valuable in addressing doubts and concerns.
- Identify any potential funding sources or renewable energy incentives that may be available from the Commonwealth of Massachusetts, the federal government, or other sources (see financial incentives on page 21).
- For municipal or public projects, educate the public about the benefits of biomass prior to any vote.
- Learn about the air quality permitting requirements in the area and work with air quality regulators to determine whether an operating permit will be needed before a wood pellet heating system is purchased and installed.

Pellet System Life Cycle Cost Analysis

(compared to operating existing fossil fuel system)

Organization Conducting Analysis:	Biomass Energy Resource Center	Facility Name:	Fictional Hardware Store (10,000 SF)	Biomass Boiler Size:	300,000 Btu/hour

Data Inputs:

Current fuel	oil
Current fuel units	gallons
Current fuel price per unit	$2.35
Annual units, current fuel	4,600
Pellet price, yr 1 (per ton)	$200
Pellet heating fraction (annual heat load)	95%
General annual inflation rate	3.25%
Discount rate	4.50%
Fossil fuel inflation (w/ genl inflation)	5.25%
Pellet inflation (w/ genl inflation)	4.25%
Ann. Wood O&M cost, yr 1	$2,115
Major repairs (annualized)	$150
Estimated Boiler Life	40
Estimated Building Life	60

Capital Cost:

Wood system	$30,000
Stack	$3,000
System Controls	$0
Electrical Connections	$0
Interconnection	$2,000
Building	
Total capital	**$35,000**
GC markup 15%	$5,250
Design 10%	$0
Grand Total	**$40,250**

Analysis Outputs:

Total Project Cost		$40,250
Percentage cost share		0%
Financing, annual bond rate		4.50%
Finance term (years)		20
Financed amount		$40,250
Value of cost share		$0
Annual pellet use, if 100% pellets (tons)		38
Pellet/oil fuel system:		
Annual pellet use	tons	36
Annual oil use	gallons	230
First year fuel cost savings (%)		**28%**
First year fuel cost savings ($)		**$3,208**
Total 30-Year Cost, fossil fuel system		363,010
Total 30-Year Cost, pellet system		323,193
Difference (30-year NPV of savings)		**$39,817**

LIFE CYCLE COST ANALYSIS

		Fossil Fuel		Wood Pellet/Fossil Fuel System						
Yr.	Inflation Calculator	Total Annual Cost	Capital Cost	Pellet Cost	Fossil Fuel Cost	Incremental Annualized O&M	Annualized Major Repairs	Total 30-Yr Cost (w/o capital cost)	Total 30-Yr Cost (w/o Finance)	Total Annualized Savings
0	1.000	$10,810	$40,250	$0	$0	$0	$0	$0	40,250	($40,250)
1	1.033	$11,378	$0	$7,600	$569	$2,184	$155	$10,508	10,508	$870
2	1.066	$11,975	$0	$7,923	$599	$2,255	$160	$10,937	10,937	$1,038
3	1.101	$12,604	$0	$8,260	$630	$2,328	$165	$11,383	11,383	$1,220
4	1.136	$13,265	$0	$8,611	$663	$2,404	$170	$11,848	11,848	$1,417
5	1.173	$13,962	$0	$8,977	$698	$2,482	$176	$12,333	12,333	$1,629
6	1.212	$14,695	$0	$9,359	$735	$2,562	$182	$12,837	12,837	$1,857
7	1.251	$15,466	$0	$9,756	$773	$2,646	$188	$13,363	13,363	$2,103
8	1.292	$16,278	$0	$10,171	$814	$2,732	$194	$13,910	13,910	$2,368
9	1.334	$17,133	$0	$10,603	$857	$2,820	$200	$14,480	14,480	$2,652
10	1.377	$18,032	$0	$11,054	$902	$2,912	$207	$15,074	15,074	$2,958
11	1.422	$18,979	$0	$11,524	$949	$3,007	$213	$15,693	15,693	$3,286
12	1.468	$19,975	$0	$12,013	$999	$3,104	$220	$16,337	16,337	$3,638
13	1.516	$21,024	$0	$12,524	$1,051	$3,205	$227	$17,008	17,008	$4,016
14	1.565	$22,128	$0	$13,056	$1,106	$3,310	$235	$17,707	17,707	$4,421
15	1.616	$23,289	$0	$13,611	$1,164	$3,417	$242	$18,435	18,435	$4,854
16	1.668	$24,512	$0	$14,189	$1,226	$3,528	$250	$19,194	19,194	$5,319
17	1.722	$25,799	$0	$14,793	$1,290	$3,643	$258	$19,984	19,984	$5,815
18	1.778	$27,153	$0	$15,421	$1,358	$3,761	$267	$20,807	20,807	$6,346
19	1.836	$28,579	$0	$16,077	$1,429	$3,883	$275	$21,664	21,664	$6,914
20	1.896	$30,079	$0	$16,760	$1,504	$4,010	$284	$22,558	22,558	$7,521
21	1.957	$31,658	$0	$17,472	$1,583	$4,140	$294	$23,489	23,489	$8,170
22	2.021	$33,321	$0	$18,215	$1,666	$4,275	$303	$24,459	24,459	$8,862
23	2.087	$35,070	$0	$18,989	$1,753	$4,413	$313	$25,469	25,469	$9,601
24	2.155	$36,911	$0	$19,796	$1,846	$4,557	$323	$26,522	26,522	$10,389
25	2.225	$38,849	$0	$20,637	$1,942	$4,705	$334	$27,618	27,618	$11,230
26	2.297	$40,888	$0	$21,514	$2,044	$4,858	$345	$28,761	28,761	$12,127
27	2.372	$43,035	$0	$22,429	$2,152	$5,016	$356	$29,952	29,952	$13,083
28	2.449	$45,294	$0	$23,382	$2,265	$5,179	$367	$31,193	31,193	$14,102
29	2.528	$47,672	$0	$24,376	$2,384	$5,347	$379	$32,486	32,486	$15,187
30	2.610	$50,175	($10,063)	$25,412	$2,509	$5,521	$392	$33,833	23,770	$26,405
Totals		**$789,178**		**$444,503**	**$39,459**	**$108,204**	**$7,674**	**$599,839**	**$589,777**	**$199,401**
30 YR NPV:		**$363,010**	**$37,563**	**$210,786**	**$18,151**	**$52,939**	**$3,755**	**$285,630**	**$323,193**	**$39,817**

Biomass Energy Resource Center

Pellet System Life Cycle Cost Analysis

(compared to operating existing fossil fuel system)

Organization Conducting Analysis:	Biomass Energy Resource Center	Facility Name:	Fictional Town Hall (30,000 SF)	Biomass Boiler Size:	1 MMBtu/hour

Data Inputs:

Current fuel	oil
Current fuel units	gallons
Current fuel price per unit	$2.35
Annual units, current fuel	13,800
Pellet price, yr 1 (per ton)	$200
Pellet heating fraction (annual heat load)	95%
General annual inflation rate	3.25%
Discount rate	4.50%
Fossil Fuel inflation (w/ genl inflation)	5.25%
Pellet inflation (w/ genl inflation)	4.25%
Ann. Wood O&M cost, yr 1	$2,550
Major repairs (annualized)	$430
Estimated Boiler Life	40
Estimated Building Life	60

Capital Cost:

Wood system	$100,000
Stack	$5,000
System Controls	
Electrical Connections	
Interconnection	$3,000
Building	$0
Total capital	**$108,000**
GC markup 15%	$16,200
Design 10%	$0
Grand Total	**$124,200**

Analysis Outputs:

Total Project Cost		$124,200
Percentage cost share		0%
Financing, annual bond rate		4.50%
Finance term (years)		20
Financed amount		$124,200
Value of cost share		$0
Annual pellet use, if 100% pellets (tons)		115
Pellet/oil fuel system:		
Annual pellet use	tons	109
Annual oil use	gallons	690
First year fuel cost savings (%)		**28%**
First year fuel cost savings ($)		**$9,625**
Total 30-Year Cost, fossil fuel system		1,089,030
Total 30-Year Cost, pellet system		877,309
Difference (30-year NPV of savings)		**$211,722**

LIFE CYCLE COST ANALYSIS

		Fossil Fuel		Wood Pellet/Fossil Fuel System						
Yr.	Inflation Calculator	Total Annual Cost	Capital Cost	Pellet Cost	Fossil Fuel Cost	Incremental Annualized O&M	Annualized Major Repairs	Total 30-Yr Cost (w/o capital cost)	Total 30-Yr Cost (w/o Finance)	Total Annualized Savings
0	1.000	$32,430	$124,200	$0	$0	$0	$0	$0	124,200	($124,200)
1	1.033	$34,133	$0	$22,801	$1,707	$2,633	$444	$27,584	27,584	$6,548
2	1.066	$35,925	$0	$23,770	$1,796	$2,718	$458	$28,743	28,743	$7,182
3	1.101	$37,811	$0	$24,780	$1,891	$2,807	$473	$29,951	29,951	$7,860
4	1.136	$39,796	$0	$25,833	$1,990	$2,898	$489	$31,210	31,210	$8,586
5	1.173	$41,885	$0	$26,931	$2,094	$2,992	$505	$32,522	32,522	$9,363
6	1.212	$44,084	$0	$28,076	$2,204	$3,089	$521	$33,890	33,890	$10,194
7	1.251	$46,398	$0	$29,269	$2,320	$3,190	$538	$35,316	35,316	$11,082
8	1.292	$48,834	$0	$30,513	$2,442	$3,294	$555	$36,803	36,803	$12,031
9	1.334	$51,398	$0	$31,809	$2,570	$3,401	$573	$38,353	38,353	$13,045
10	1.377	$54,096	$0	$33,161	$2,705	$3,511	$592	$39,969	39,969	$14,127
11	1.422	$56,936	$0	$34,571	$2,847	$3,625	$611	$41,654	41,654	$15,282
12	1.468	$59,926	$0	$36,040	$2,996	$3,743	$631	$43,410	43,410	$16,515
13	1.516	$63,072	$0	$37,572	$3,154	$3,865	$652	$45,242	45,242	$17,830
14	1.565	$66,383	$0	$39,168	$3,319	$3,990	$673	$47,151	47,151	$19,232
15	1.616	$69,868	$0	$40,833	$3,493	$4,120	$695	$49,141	49,141	$20,727
16	1.668	$73,536	$0	$42,568	$3,677	$4,254	$717	$51,216	51,216	$22,320
17	1.722	$77,397	$0	$44,378	$3,870	$4,392	$741	$53,380	53,380	$24,017
18	1.778	$81,460	$0	$46,264	$4,073	$4,535	$765	$55,636	55,636	$25,824
19	1.836	$85,737	$0	$48,230	$4,287	$4,682	$790	$57,989	57,989	$27,748
20	1.896	$90,238	$0	$50,280	$4,512	$4,834	$815	$60,441	60,441	$29,797
21	1.957	$94,975	$0	$52,417	$4,749	$4,992	$842	$62,999	62,999	$31,977
22	2.021	$99,962	$0	$54,644	$4,998	$5,154	$869	$65,665	65,665	$34,296
23	2.087	$105,210	$0	$56,967	$5,260	$5,321	$897	$68,446	68,446	$36,764
24	2.155	$110,733	$0	$59,388	$5,537	$5,494	$926	$71,345	71,345	$39,388
25	2.225	$116,547	$0	$61,912	$5,827	$5,673	$957	$74,368	74,368	$42,178
26	2.297	$122,665	$0	$64,543	$6,133	$5,857	$988	$77,521	77,521	$45,144
27	2.372	$129,105	$0	$67,286	$6,455	$6,047	$1,020	$80,809	80,809	$48,297
28	2.449	$135,883	$0	$70,146	$6,794	$6,244	$1,053	$84,237	84,237	$51,646
29	2.528	$143,017	$0	$73,127	$7,151	$6,447	$1,087	$87,812	87,812	$55,205
30	2.610	$150,526	($31,050)	$76,235	$7,526	$6,656	$1,122	$91,540	60,490	$90,036
Totals		**$2,367,534**		**$1,333,508**	**$118,377**	**$130,458**	**$21,999**	**$1,604,342**	**$1,573,292**	**$794,241**
30 YR NPV:		**$1,089,030**	**$115,910**	**$632,357**	**$54,452**	**$63,828**	**$10,763**	**$761,399**	**$877,309**	**$211,722**

Resources

BULK WOOD PELLET SUPPLIERS

Narragansett Pellet Corporation, E. Providence, RI	(401) 434-4800
Natural Living Innovations, E. Providence, RI	(800) 844-2022
New England Wood Pellet, Inc., Jaffrey, NH	(603) 532-9400

WOOD PELLET SYSTEM VENDORS

AFS Energy Systems, Inc.	(717) 763-8689
Alterrus Bioenergy	(503) 235-5234
Biomass Commodities Corporation	(802) 613-1444
Decker	(204) 764-2861
EnergyCabin	(604) 833-0774
Harman Stoves	(717) 362-9080
Pro-Fab Industries, Inc.	(888) 933-4440
Solagen	(503) 366-4210
TARM USA	(800) 782-9927
Trager/Pinnacle	(866) 967-9777

CONTACT INFORMATION

Massachusetts Division of Energy Resources
100 Cambridge Street, Suite 1020, Boston, MA 02114
(617) 727-4732
www.mass.gov/doer

Massachusetts Department of Conservation & Recreation
251 Causeway Street, Suite 600
Boston, MA 02114-2104
(617) 626-1250
www.mass.gov/dcr/stewardship/forestry/utilmark/index.htm

Massachusetts Department of Environmental Protection
Air & Climate Program
Bureau of Waste Prevention – Business Compliance Division
One Winter Street, Boston, MA 02108
(617) 292-5500
www.mass.gov/dep/air

Massachusetts Department of Revenue
PO Box 701, Boston, MA 02204
(800) 392-6089
www.mass.gov/?pageID=dorhomepage&L=1&L0=Home&sid=Ador

Massachusetts School Building Authority
3 Center Plaza, Suite 430, Boston, MA 02108
(617) 720-4466
www.massschoolbuildings.org

Northeast Regional Biomass Prorgam
www.nrbp.org/

Biomass Energy Resource Center
PO Box 1611, 50 State Street, Montpelier, VT 05602
(802) 223-7770
www.biomasscenter.org