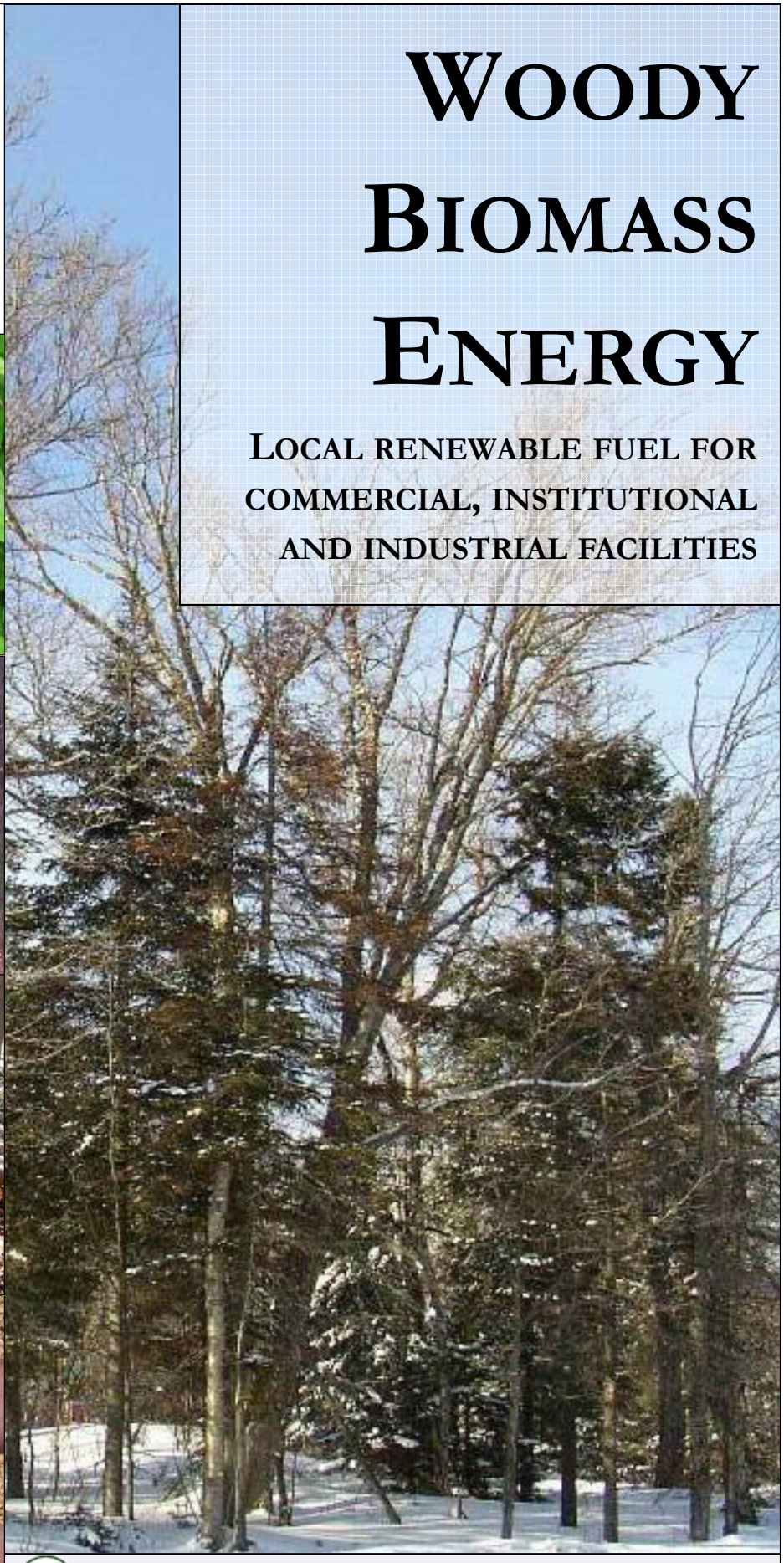
Massachusetts Sustainable Forest Bioenergy Initiative

Division of Energy Resources
Department of Conservation and Recreation

WOODY BIOMASS ENERGY

LOCAL RENEWABLE FUEL FOR COMMERCIAL, INSTITUTIONAL AND INDUSTRIAL FACILITIES



Executive Office of Energy and Environmental Affairs

LOCAL LEADERSHIP

"Massachusetts has become a national leader in the development and implementation of renewable energy technologies. We are moving forward with solar, wind and bioenergy programs that will curb greenhouse gas emissions, reduce energy costs, and tap the economic potential of the rapidly growing clean energy sector."

Ian Bowles
Secretary, Executive Office of Energy and Environmental Affairs

"Biomass is an important and often over looked renewable energy resource for Massachusetts. We have abundant woody biomass resources that can produce electric power, thermal energy, and biofuels. Utilizing these resources sustainably will help us meet our renewable energy and climate goals and create substantial economic development and job opportunities, particularly in our rural communities."

Philip Giudice
Commissioner, Division of Energy Resources

"Massachusetts forests are a precious resource for the Commonwealth and must be carefully managed for ecological, economic and social values. Biomass energy creates markets for low value wood that can be managed using our nation-leading sustainable forestry practices to promote forest health and growth."

Richard K. Sullivan Jr.
Commissioner, Department of Conservation and Recreation

"There is a growing interest in the use of biomass energy in Massachusetts for power plants and institutional applications. With advanced conversion technologies and appropriate environmental controls, biomass can offer clean renewable energy and substantial climate benefits compared with fossil fuels."

Laurie Burt
Commissioner, Department of Environmental Protection

ACKNOWLEDGMENTS

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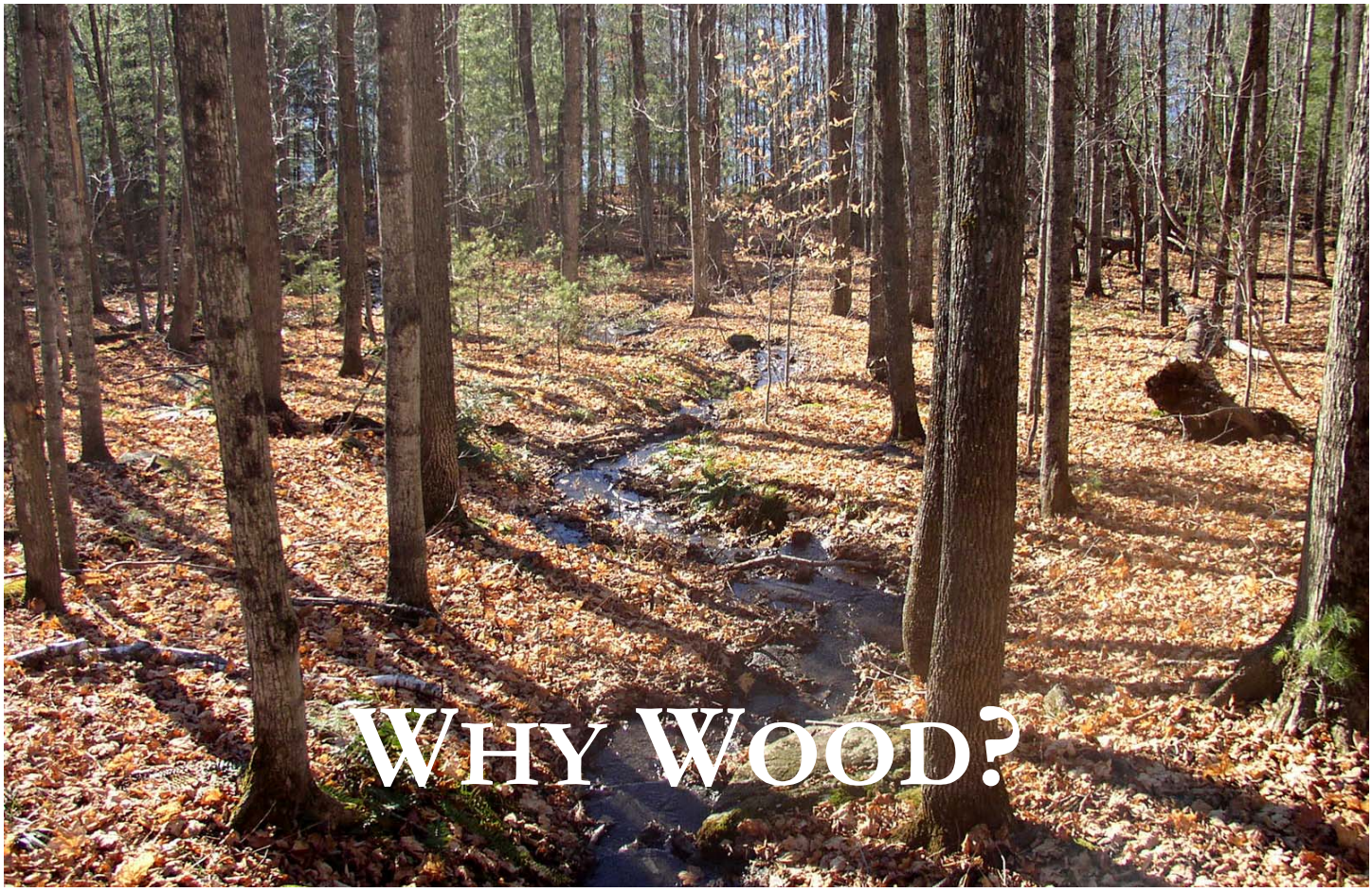


Why Wood?

Biomass refers to any biological material that can be used for energy, which includes corn, manure, algae, and other feedstocks that can be burned as solids or converted to liquid fuels. Here in New England, the most abundant and sustainable source of biomass is wood. Over the past thirty years, interest in woody biomass energy has waxed and waned with the price of fossil fuels and changing government incentives. Today, the rising price of oil coupled with growing recognition of the environmental and social consequences of fossil fuels has generated fresh enthusiasm for woody biomass energy.

This is in part because wood is often much less expensive per unit of energy than fossil fuels. As a local energy resource, the price and availability of wood is determined more by local conditions than international forces. Equally important is that money spent on wood directly supports the local economy, maintaining local jobs and increasing the energy independence of the United States.

Sustainably produced local biomass can also be much better for the environment than fossil fuels. With proper forest management, wood can be sustainably produced and climate friendly. For as long as the land producing the wood remains forested and is allowed the opportunity to grow, the net greenhouse gas emissions of wood-burning systems are much less than those generated by burning fossil fuels. The carbon dioxide produced by burning wood is roughly equal to the amount absorbed during the growth of the tree. When compared to coal and oil, wood fuel contains low amounts of heavy metals and sulfur. Emission control devices add to the cost, but with careful planning, design and operation, biomass can be a viable, cost effective source of renewable energy for commercial, institutional and industrial sites.

Much has been written about the benefits of burning wood for heat and electricity over the past thirty years; this booklet is a brief introduction to the economic, environmental, and social advantages of using woody biomass as fuel. If you are considering alternative energy systems to reduce the cost of heat and power at your facility, wood can work for you! Determining if a biomass combustion system would benefit your company will require careful consideration of many factors, including the current cost of fuel, the age and condition of the current boiler, the availability and cost of wood fuel, state air quality regulations, and type and cost of potential combustion and control equipment.

Wood Energy

Simply speaking, energy is the ability to do work. Wood is the oldest and most common source of energy, but in comparison to fossil fuels, wood has much less energy per unit of weight. Coal can contain as much as 13,000 BTU per pound and heating oil contains 19,000 BTU per pound (138,800 per gallon). Dry wood contains about 8,000 BTU per pound, and recently cut "green" wood can contain as much as 50 percent water. When burning green wood much of the energy in the fuel will be used to evaporate moisture, which reduces the overall efficiency of the system. This low energy density is one reason why woody biomass fuel is rarely transported more than fifty miles.

Green wood residues are generally available from logging operations, land clearing companies, and urban wood waste. Clean wood residues can be obtained from sawmills, pallet manufacturers, and other forest product manufacturers, but most of this material is already utilized for fuel, pulpwood, mulch, or other markets. Other potential sources of wood fuel such as municipal waste, construction and demolition debris can be contaminated with chemicals, plastics and metals, which produce toxic emissions when burned.

Forest derived woody biomass includes small diameter trees, tops, and branches that would not be included in a conventional timber harvest. Throughout most of New England, forest growth exceeds harvest and mortality and some of this growth is potentially available for biomass energy. With proper management and harvesting techniques this traditionally unmerchantable woody material can be removed without compromising the health of the forest ecosystem, wildlife habitat, or soil nutrient cycles. With new markets for low grade forest products, foresters will be able to use a greater array of management techniques to produce higher quality timber, improve forest health, create early successional habitat, and design management plans for long term forest owners.

Recent estimates from the MA Sustainable Forest Bioenergy Initiative (SFBI) suggest that 1.7 million tons of residue and forest-derived biomass fuel are available every year in western Massachusetts on a sustainable basis. In anticipation of the increased demand for this material, the SFBI has researched the economic and ecological effects of increased biomass utilization.

There are several types of wood fuel and conversion technologies available to facilities considering woody biomass energy systems.

Types of Wood Fuel

CORDWOOD is the most common form of woody biomass energy in New England today although residential use has decreased over the past three decades. By definition, a cord of wood measures 128 cubic feet of stacked wood, weighing about two and a half tons. Some consumers are able to obtain this fuel from their own land, while others pay between $150 and $300 per cord. Over the past ten years, there have been great improvements in the efficiency and management of emissions of some new cordwood burning systems.

WOOD CHIPS are generally inexpensive and are well suited for large buildings and district heating systems. Successful projects often obtain their fuel from sawmill residues, manufacturers, and forest harvesting operations within 50 miles. There can be great variety in the quality, composition, price, and moisture content of wood chips depending upon the source. Chip handling systems are complicated and expensive to build and operate, but this expense can be offset by the low cost of the fuel.

WOOD PELLETS are densified woody biomass that can work very well for small residential systems and in some larger buildings. Pellets are more expensive than wood chips, but they are almost completely dry, uniform in shape and size, and contain nearly twice the energy per pound. This uniformity allows pellet combustion systems to be highly tuned, clean and efficient. Pellets can be delivered in individual bags or conveyed in bulk for silo storage units.

BIOMASS CONVERSION TECHNOLOGIES

ADVANCED DIRECT-COMBUSTION is the burning of biomass in a modern boiler or furnace system. Unlike the common residential wood stove, burning wood fuel in an enclosed, oxygen regulated firebox heats an exchange device, which distributes heat through an air or water system. The net efficiency of modern biomass heating systems varies between 60 and 80% depending in part upon the moisture content of the wood fuel.

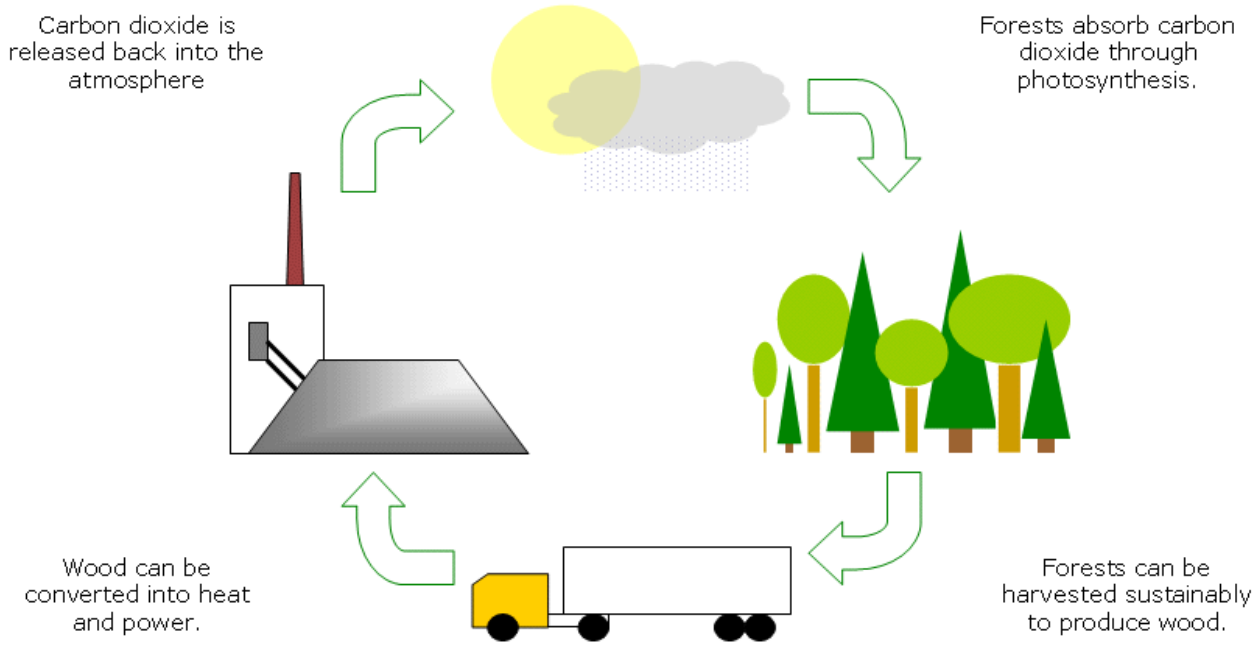
COGENERATION is the production of both thermal and electrical energy by a combustion system. In most scenarios, steam produced in a boiler heats an exchange device and spins a turbine to generate electricity. The conversion efficiency of electricity generation alone is only about 35%, meaning that a majority of the energy is lost as heat during combustion. When there is a use for this "waste heat", a combined heat and power system (CHP) can exceed 80% efficiency.

COFIRING is the combustion of multiple fuels in the same energy system. This usually means mixing a small percentage of wood with coal to fuel a large power plant. Burning wood in a coal plant can increase equipment performance and reduce pollution. In most scenarios the wood must be low cost to justify modifying the power plant. The volume of supplemental wood fuel required for a large coal-fired power plant is often comparable to the volume required by a small wood-only plant.

GASIFICATION involves heating biomass or other materials in an oxygen-limited environment. The resulting volatile gases (known as synthesis gas) can be used to fire a boiler, drive an engine or generator, or power a fuel cell. For many of these uses, the gas must be cleaned of tar and particulates before serving as fuel. Gasification is generally more efficient than direct combustion and can provide significantly reduced emissions depending upon the type of pollution control measures installed.

LIQUID BIOFUELS such as ethanol, methanol, bio-oil, and biodiesel can be produced from biomass through pyrolysis, fermentation, and other methods for transportation and bio-refining. Current feedstocks for these fuels include corn, soy, and other agricultural crops. Advanced conversion technologies for cellulosic feedstocks such as wood and other plant fibers may become commercially viable within a few years.

When a forest is sustainably managed, harvested trees provide income to the landowner and resources to the local economy without sacrificing the health or biodiversity of the ecosystem.



EMISSIONS

Older wood stoves and outdoor boilers are notorious for producing a haze of smoke and odors. However, with proper design, operation, maintenance and emission control devices, modern biomass energy systems can produce little or no visible smoke and low emissions.

Burning fuel of any kind produces pollutants. In general, modern biomass combustion systems produce only a fraction of the particulate matter per unit of energy input as compared to a residential wood stove. Wood contains low levels of sulfur and heavy metals, but nitrogen oxides, volatile organic compounds, and carbon monoxide can be higher for wood in comparison to oil fired systems. Particulate matter is also an important concern. Many biomass energy systems will require pollution control devices and a permit from the local or state pollution control agency.

It is also important to recognize the environmental consequences of not removing biomass material in some fire-prone ecosystems. Markets for woody biomass can offset the costs of wildfire mitigation treatments and provide an alternative to pile burning and prescribed fires while reducing the probability of rampant wildfire.

Carbon dioxide (CO_2) is a gas that captures energy from the sun in the form of heat in the atmosphere. This is known as the greenhouse effect. Human activity over the past two hundred years has increased atmospheric concentrations of CO_2 and the concern is that this increase will raise global temperatures, change weather patterns, raise sea levels and disrupt human society and the economy. Some countries and states have instituted political mechanisms to encourage carbon reductions in the hope that this will mitigate the future consequences of global climate change.

Burning fossil fuels releases "new" carbon into the atmosphere that has been stored underground for millions of years. Burning biomass releases carbon that was recently absorbed from the atmosphere by a growing plant. In other words, the net greenhouse gas emissions of wood-burning systems are much less than those generated by burning fossil fuels because the carbon dioxide produced by burning wood is roughly equal to the amount absorbed during the growth of the tree. There are some fossil fuels used in the harvest and production of woody biomass fuels, but for as long as the land producing the wood remains forested and is sustainably harvested, the system produces significantly less greenhouse gas emissions.

Will Wood Work For You?

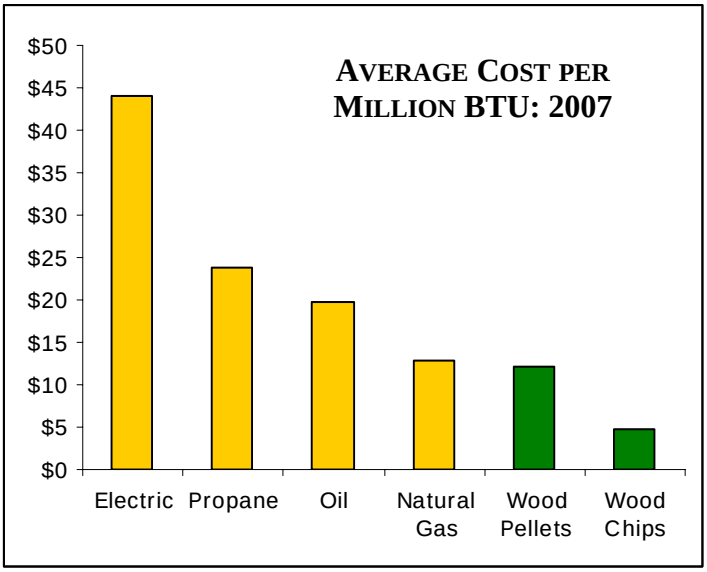
Using local, sustainably harvested wood can be better for the environment and local economy than using fossil fuels, but every potential wood burning facility must carefully evaluate the particular variables of their situation.

The first thing to consider if you are contemplating woody biomass energy is economics. Wood is less expensive per unit of energy than oil, propane or electric heat, but if your facility is fueled by natural gas or coal, wood may not be cost competitive. Wood is also not a traditional commodity fuel and there will be variation in price, quality and availability of material depending upon the source, type and distance of each supplier.

It is important to recognize that the initial cost of engineering, construction, and equipment is higher for biomass energy systems. Wood systems are often designed at or below peak heating load with a redundant backup oil or gas system for use during the shoulder heating season. There may also be increases in annual operating costs for labor, maintenance, and fuel handling. However, there are situations where the annual fuel savings outweigh these other costs. Some wood burning facilities have been able to recoup their initial investment within only a few years. Specifically, installations with on-site maintenance capabilities that have year-round demand for steam or heat are excellent candidates for woody biomass energy.

Location is also critical. Uncontrolled or improperly operated wood burning systems can emit large amounts of particulate matter, which can negatively affect respiratory health. In many areas of Massachusetts, this means that biomass energy systems must have the best available pollution control devices to be permitted by the regional offices of the Department of Environmental Protection. Proper installation and operation of the boiler and pollution control devices can effectively reduce particulate emissions.

To determine whether your facility is a suitable candidate for wood energy, assess your current energy use, fuel cost, and existing boiler system. The following brief worksheet will help you evaluate your current energy consumption.



Current Energy Use

Fuel Type: _____

Annual Consumption: _____

Cost of Fuel: _____

Energy Density: _____

Boiler Efficiency: _____

Information about fuel energy density and average boiler efficiencies can be obtained from the US Forest Service "Fuel Value Calculator" available online at http://www.fpl.fs.fed.us/documents/techline/fuel-value-calculator.pdf

For example, consider a company that uses 200,000 gallons of #6 fuel oil per year at $2.50 per gallon to run a boiler with an efficiency of 83%.

$500,000 worth of fuel will provide about 25,000 MMBTU at a cost of $20 per MMBTU. At current prices, woody biomass is available for between $3 and $5 per MMBTU. This may mean that wood fuel will generate tremendous savings.

Success Stories

Mount Wachusett Community College

Rob Rizzo, Director of Renewable Energy Studies at Mount Wachusett Community College stands next to the 8 MMBTU wood fired boiler that replaced an expensive electric heating and cooling system.

Over the past five years, the Mount Wachusett Community College (MWCC) in Gardner, Massachusetts has become a global leader in promoting and demonstrating renewable energy technologies. Scientists, foresters, and politicians from many countries have visited the woodchip system that was installed in 2002 to replace an expensive all-electric heating and cooling system. With an automatic feed 8 MMBTU boiler unit, equipped with a cyclone and baghouse for emissions control, the college has met Massachusetts standards for emission controls with a clean and dependable biomass system. This system was funded in part by the US Department of Energy and the Massachusetts Technology Collaborative, and was facilitated by technical assistance from the Marketing and Utilization Program of the Department of Conservation and Recreation, the Department of Environmental Protection and other state agencies.

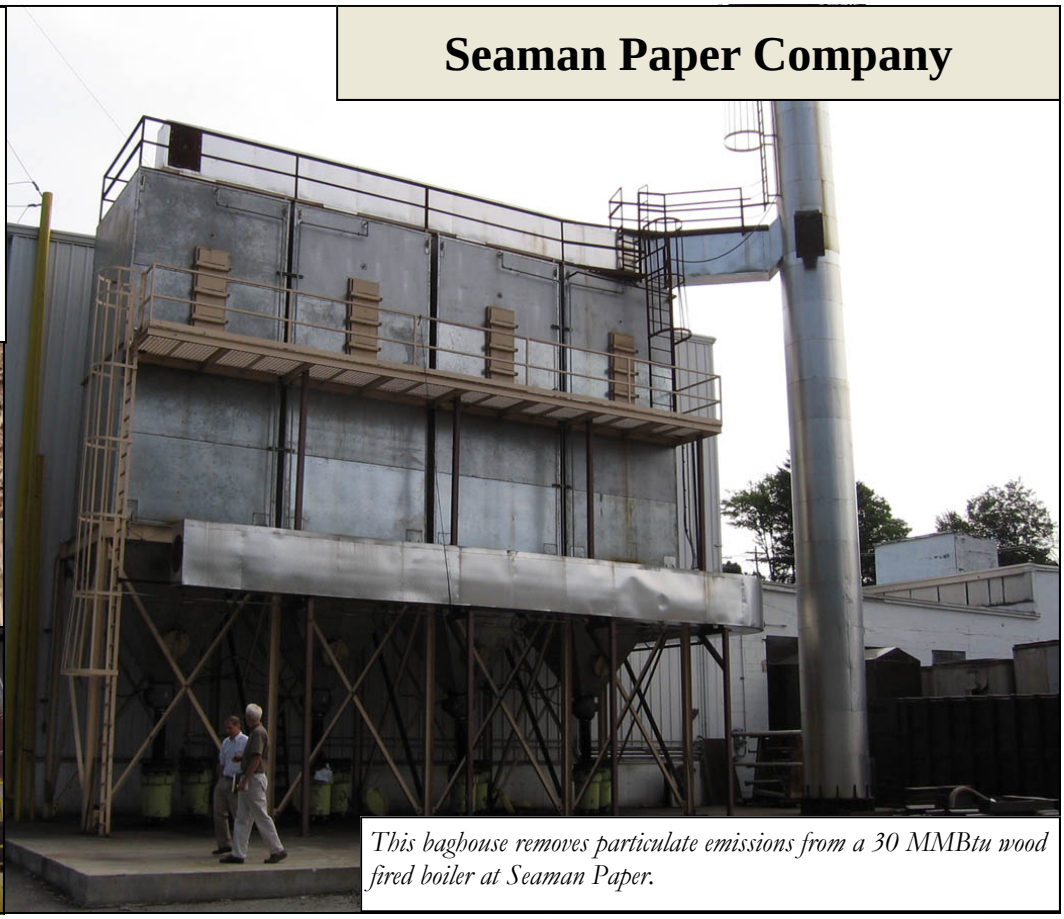
By switching to wood heat, the college has saved more than $270,000 dollars per year and reduced its carbon footprint. These economic and environmental savings are impressive, but the biomass system is only one of the many energy efficient components that have been implemented by MWCC over the past few years. Other technologies include energy-efficient lighting, variable frequency drives for air-handling units, and a domestic hot water heat exchanger. In total, these conservation measures have reduced consumption by 3.3 million kWH, which is enough electricity to power 1000 homes for a year.

MWCC has also installed a 50 kW downdraft gasifier (BioMax 50™) designed by the Community Power Corporation (CPC) of Littleton, Colorado. Using wood chips as the feedstock, this system will provide heat, air conditioning, and electricity for the college's daycare center. This gasifier represents the cutting edge of biomass renewable energy and it is one of only a few such systems operating in the United States today.

In the past three years, MWCC has reduced greenhouse gas emissions by about 19%. The college intends to achieve a 25% reduction by 2012.

Seaman Paper Company

SEAMAN PAPER COMPANY
OF MASSACHUSETTS



This baghouse removes particulate emissions from a 30 MMBtu wood fired boiler at Seaman Paper.

Seaman Paper Company of Massachusetts, Inc. is a privately owned paper manufacturer that produces 100 tons per day of specialty light weight papers. Their product line includes premium tissue paper, crepe streamers and waxed paper for retail, floral and foodservice businesses. The company was established in 1946 and currently employs 100 people in Otter River, Massachusetts.

In the early 1980s, faced with rising fuel costs, Seaman Paper decided to explore the option of wood fuel to save money and reduce consumption of foreign oil. After careful consideration, Seaman installed a wood-fired boiler to provide heat and high pressure process steam to the paper mill. A large truck dump was installed to unload trailers of wood chips. When the price of oil fell several years later, Seaman Paper was able to revert back to its oil fired burners.

Now that the cost of oil has risen to new heights, wood energy has again become a green and economical choice. Seaman Paper has installed a brand new 30 MMBtu Hurst water tube boiler that is fueled by chipped wood. This system utilizes the same conveyance equipment as the original wood boiler and consumes about 60 tons of wood per day. To control emissions, the company has installed a large baghouse and flue gas recirculation system. The total cost of this new heating system and the best available emission control measures is substantial, but the anticipated payback will occur within five years.

In fact, this new boiler system has proven to be so effective and reliable that the company will soon be installing a small steam turbine to generate electricity with excess steam, which will earn renewable energy credits from the MA Renewable Portfolio Standard.

The new wood-fired boiler at Seaman Paper is fueled entirely by wood chips and has reduced their consumption of oil by more than one million gallons every year.

Next Steps

Many hospitals, businesses, and colleges in New England have successfully installed and are operating biomass combustion systems that generate tremendous costs savings over fossil fuel energy. However, this does not mean that wood will work for everyone. If you are considering wood energy for your facility or business:

- Determine your current energy consumption and annual fuel expense.
- Review some of the detailed publications listed on the following page to learn more about particular fuels and types of biomass combustion systems.
- Contact a local consulting group, engineering firm, or state agency with experience in woody biomass energy for advice and information.
- Visit sites that have operating biomass combustion systems to learn more about different technologies and the experiences of these operators.
- Evaluate the market for potential vendors of wood fuel within fifty miles of your facility.
- Identify potential sources of funding, grants, or incentives from the state government, federal government, or other sources.
- Learn about the permitting requirements of your community and state. Consult with the local air quality regulatory agency to determine whether your facility will require emissions permits.

Successful biomass combustion systems have reliable local sources of wood fuel, a properly designed system, and a few dedicated personnel who are committed to the success of the project. Determining if wood will work for you may require a professional feasibility study and life-cycle cost analysis.

FOR MORE INFORMATION

This brochure is intended as a brief introduction to the potential of woody biomass energy. The following references provide more detailed information about a variety of subjects, including: environmental benefits, fuel types, equipment vendors, combustion systems, and funding opportunities.

"Primer on Wood Biomass for Energy", R. Bergman and J. Zerbe, (2001), USDA Forest Service: State & Private Forestry Technology Marketing Unit, Forest Products Laboratory.
http://www.fpl.fs.fed.us/tmu/resources/documents/primer_on_wood_biomass_for_energy.pdf

"Forest Service Fuel Value Calculator" (2004), USDA Forest Service: State & Private Forestry Technology Marketing Unit, Forest Products Laboratory.
http://www.fpl.fs.fed.us/documnts/techline/fuel-value-calculator.pdf

"Guidebook to Wood Pellet Heating" (2007), Massachusetts Division of Energy Resources.
http://www.mass.gov/Eoca/docs/doer/pub_info/doer_pellet_guidebook.pdf

"Wood-Chip Heating Systems", Timothy Maker, (2005), Biomass Energy Resource Center,
http://www.biomasscenter.org/pdfs/Wood-Chip-Heating-Guide.pdf

For more information about woody biomass energy, please contact:

Marketing and Utilization Program, Bureau of Forestry
Department of Conservation and Recreation
51 Military Rd.
Amherst, MA 01002
Telephone: (413) 253 1798 x 207
http://www.mass.gov/dcr/stewardship/forestry/utilmark/index.htm

For more information about renewable energy and energy efficiency, please contact:

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

For more information about air pollution and system permitting, please contact:

Massachusetts Department of Environmental Protection
1 Winter Street
Boston, MA 02108
Telephone: 617-292-5500 Fax: 617-556-1049
http://www.mass.gov/dep

For more information about advanced biofuels, please contact:

Massachusetts Executive Office of Energy & Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114
Telephone: (617) 626-1049
http://www.mass.gov/envir/biofuels

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"Creating a Greener Energy Future for the Commonwealth"

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