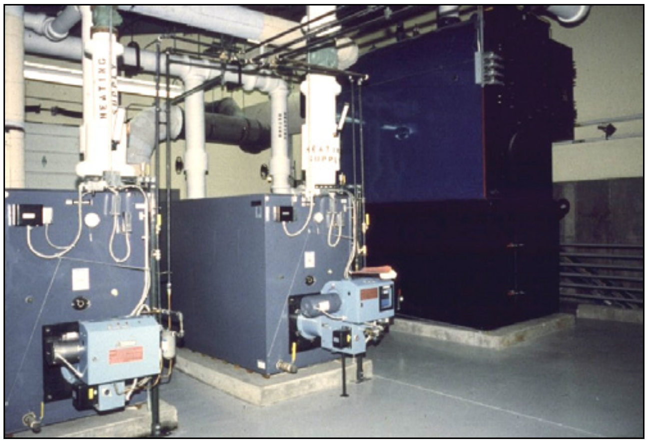
TechLine

Forest Products Laboratory

Wood Biomass for Energy



Wood fuel has several environmental advantages over fossil fuel. The main advantage is that wood is a renewable resource, offering a sustainable, dependable supply. Other advantages include the fact that the amount of carbon dioxide (CO_2) emitted during the burning process is typically 90% less than when burning fossil fuel. Wood fuel contains minimal amounts of sulfur and heavy metals. It is not a threat to acid rain pollution, and particulate emissions are controllable.

The principle economic advantage of wood biomass energy is that wood is usually significantly less expensive than competing fossil fuels. Public institutions, such as schools, hospitals, prisons, and municipality-owned district heating projects, are prime targets for using wood biomass energy.

Before building or remodeling a facility to utilize wood biomass for energy, potential users should evaluate the local market for the available supply of wood. Transportation costs may limit the benefits of burning wood fuel—hauling wood biomass from outside a 50-mile radius is usually not economical. This should be followed by a rigorous life-cycle analysis for the energy system. Initial costs of a wood biomass energy system are generally 50% greater than that of a fossil fuel system due to the fuel handling and storage system requirements.

Today, the installed cost of a 1 to 5 million Btu/h (0.3 to 1.5 MW) wood fuel burner/boiler system is estimated at $50,000 to $75,000 per million Btu/h (0.3 MW) of heat input. New and existing technology for using wood fuel effectively can be a combination of wood combustion, wood gasification, cogeneration, and cofiring, depending on the fuel application.

Wood Combustion

Instead of paying disposal costs, wood combustion for electricity and heat is one way in which forest products companies can utilize their wood residues. Typically, wood in a variety of forms, particularly green chips (45% to 50% moisture content on a wet basis), is shipped and maintained at a holding site by the energy plant. Augers or belt conveyors transport the wood chips to the combustor, where they are burned, and the heat of combustion is transferred to a steam or hot water boiler. Steam is converted to electrical power by steam turbines. Excess steam can be used in other plant processes—for example, in a dry kiln. Hot water boilers can provide heat to a building through a piping distribution network.

Wood Gasification

Wood gasification is the process of heating wood in an oxygen-starved environment until volatile pyrolysis gases (carbon monoxide and hydrogen) are released from the wood. Depending on the final use of the typically low-energy wood (producer) gas (~150 Btu/ft^3 (5.6 MJ/m^3)), the gases can be mixed with air or pure oxygen for complete combustion and the heat produced transferred to a boiler for energy distribution. Otherwise, the gases can be cooled, filtered, and purified to remove tars (a major concern for any wood gasification process) and particulates and used as fuel for internal combustion engines, microturbines, and gas turbines.

Cogeneration

Cogeneration is the simultaneous production of heat and electricity, commonly called combined heat and power (CHP), from a single fuel. Traditionally, a steam turbine is used to produce electricity, although a wood gasification/internal combustion unit can also be a cogeneration unit. Several factors affect the economic feasibility of a CHP unit including wood waste disposal problems, high electricity costs, and year-round steam use.

Two common mistakes when installing a CHP system are buying a steam boiler that is designed for less than 100 lbf/in^2 (689 kPa) or oversizing the system. Buying a steam boiler that is designed for less than 100 lbf/in^2 results in a quality of steam that is not adequate for turbine operation. Oversizing the system results in additional capital costs, not better quality steam.

More electricity and heat are generated for a lesser amount of fuel by a CHP unit than by a separate heat and power (SHP) unit. Common challenges for all wood-fired systems are ensuring adequate fuel procurement and solving the complex fuel handling and storage issues.

Cofiring

Cofiring refers to the practice of introducing biomass as a supplementary energy source in coal plants. It is a near-term, low-cost option for using woody residue, costing approximately $0.02 per kWh while reducing pollutants. According to the U.S. Department of Energy, 20 electric utilities are cofiring biomass with coal. Extensive demonstrations and trials have shown that effective substitutions of biomass energy can be made from 10% to 15% of the total energy input. Investments are expected to be $100 to $700 per kW of biomass capacity, with the average ranging from $180 to $200 per kW. Cofiring results in a net reduction in greenhouse gases and lower emissions of sulfur dioxide and nitrogen oxides.

More on Costs

The necessity of a larger-sized boiler and the need for a waste-handling plant involve 1.5 to 4 times the investment cost of oil-fired package boilers. A combustion efficiency of 65% to 75% may be expected when burning wood waste, compared with 80% obtained from gas- or oil-fired units. The difficulty of automatic firing, slow response to peak demand, and the need for ash removal and disposal are other disadvantages that must be carefully weighed when considering the use of what may at first glance appear to be a cheap fuel.

The cost of electricity from wood-fired power plants ranges from $0.06 to more than $0.11 per kWh. With heat rates of 14,000 to 18,000 Btu per kWh, these plants have an efficiency of 18% to 24%. They are competitive typically when they receive feedstock at very low prices or are located in areas of high electricity costs.

Although it is technically feasible to use wood waste as fuel for power generation, economics invariably proves to be the limiting factor in most cases. Obvious benefits may be gained by burning wood residues to reduce a manufacturer's fuel oil and electricity bill. These benefits may be offset by high capital costs, low plant efficiency, and increased maintenance levels. Of course, the economics of wood waste energy generation becomes more attractive as traditional fuel prices increase. Before comparative studies can be made, the real value of wood waste as a fuel source must take into account its available heat content and the investment and operating costs of the plant needed to handle and convert it to usable energy.

Figure 1 shows the cost of fuel types based on local prices in Wisconsin. No allowance has been made for conversion efficiency. Because market prices for fuels vary, this comparison should be considered as a general guideline only.

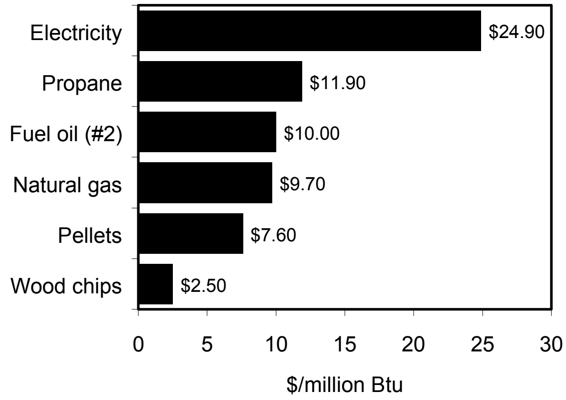


Figure 1. Cost comparisons of fuel types in Wisconsin. (3,413 Btu = 1 kWh) (Source: Mike Metcalf, Madison Gas & Electric, Madison, Wisconsin. February 2003.)

Providing cost estimates for wood energy systems requires flexibility and a technical understanding that, depending on the site requirements and present site capabilities, costs fluctuate widely. The cost estimates shown in Table 1 are meant as a guideline to assist in determining the possibility of installing a wood energy system at a facility.

Summary

The technology to generate energy from wood has entered a new millennium, with virtually limitless possibilities. As public and private sector support increases, the availability of small modular biomass systems ranging from 3 kW$_e$ for homes to 5 MW$_e$ for large sawmills will flourish. Future systems will be capable of utilizing a variety of waste residue (also see TechLine *Biomass for Small-Scale Heat and Power*).

Additional information for wood energy on a residential, commercial, and industrial scale in the United States can be found at www.fpl.fs.fed.us/tmu/small-scale_wood_energy.htm.

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Table 1. Comparisons of electric, thermal, and combined heat and power facilities

	Size (MW)	Fuel use (green ton/yr)	Capital cost (million $)	O&M[a] (million $)	Efficiency (%)
Electrical					
Utility plant	10–75	100,000–800,000	20–150	2–15	18–24
Industrial plant	2–25	10,000–150,000	4–50	0.5–5	20–25
School campus	N/A	N/A	N/A	N/A	N/A
Commercial/institutional	N/A	N/A	N/A	N/A	N/A
Thermal					
Utility plant	14.6–29.3	20,000–40,000	10–20	2–4	50–70
Industrial plant	1.5–22.0	5,000–60,000	1.5–10	1–3	50–70
School campus	1.5–17.6	2,000–20,000	1.5–8	0.15–3	55–75
Commercial/institutional	0.3–5.9	200–20,000	0.25–4	0.02–2	55–75
Combined Heat and Power (CHP)					
Utility plant	25 (73)[b]	275,000	50	5–10	60–80
Industrial plant	0.2–7 (2.9–4.4)	10,000–100,000	5–25	0.5–3	60–80
School campus	0.5–1 (2.9–4.4)	5,000–10,000	5–7.5	0.5–2	65–75
Commercial/institutional	0.5–1 (2.9–7.3)	5,000	5	0.5–2	65–75

[a] Operating and maintenance.

[b] Sizes for the CHP facilities are a combination of electrical and thermal; the first figure is electrical and the figure in parentheses is thermal. 1MW = 3.413 million Btu/h.