**U.S. Department of Energy - Energy Efficiency and Renewable Energy**

## EERE State Partnerships and Activities: State Energy Alternatives

# Biomass Energy

Wood residues such as chips left from pulp and paper manufacturing and lumber mills, are economic sources of biomass fuel.

Biomass is plant matter such as trees, grasses, agricultural crops, and other living plant material. Biomass can be used in its solid form for heating applications or electricity generation, or it can be converted into liquid or gaseous fuels. Biomass fuels are converted to heat and electricity with technologies similar to those used when converting fossil fuels, like coal, to heat and electricity. The mechanical device turns a generator that produces electricity. There are four primary types of biomass power systems: direct-fired, cofired, gasification, and modular systems.

The focus of this discussion is on biomass-fueled electricity generation systems. This discussion does not include landfill gas electricity generation. For more information on landfill gas, visit the U.S. Environmental Protection Agency (EPA) Landfill Methane Outreach Program.

Biomass used for energy purposes includes:

- Leftover materials from the wood products industry
- Wood residues from municipalities and industry
- Forest debris and thinnings
- Agricultural residues
- Fast-growing trees and crops
- Animal manures.

These materials can be renewable and sustainable sources for fueling many of today's energy needs.

Next to hydropower, more electricity is generated from biomass than any other renewable energy resource in the United States. A key attribute of biomass is its availability on demand: much like fossil fuels, the energy is stored by nature in the biomass until it is needed. Technologies have now been developed that can generate electricity from the energy in biomass fuels at scales small enough to be used on a farm or in remote villages, or large enough to provide power for a small city.

Biomass is plentiful in various forms across the country. Certain forms of biomass are more plentiful in specific regions where climate conditions are more favorable for their growth. The most economical forms of biomass for generating electricity are residues. Residues are the organic by-products of food, fiber, and forest production such as sawdust, rice husks, wheat straw, corn stalks, and bagasse (the residue remaining after juice has been extracted from sugar cane).

Wood is the most commonly used biomass fuel for heat and power. The most economic sources of wood fuels are usually wood residues from manufacturers, discarded wood products diverted from landfills, and nonhazardous wood debris from construction and demolition activities. Generating energy with these materials can recoup the energy value in the material and avoid the environmental and monetary costs of disposal or open burning.

In the future, fast-growing energy crops may become the biomass fuels of choice. These energy crops

will be carefully selected plants that are fast growing, drought resistant, and readily harvested to allow competitive prices when used as fuel.

Economic sources of biomass are also common near population and manufacturing centers where residues in the form of clean wood waste materials are available in large quantities. Examples are woody yard trimmings and discarded pallets and crates.

## Biomass Power Systems

Most of today's biopower plants are direct-fired systems that are similar to most fossil fuel-fired power plants. The biomass fuel is burned in a furnace or boiler. The heat is used to produce high-pressure steam. This steam is introduced into a steam turbine where it flows over a series of aerodynamic turbine blades, causing the turbine to rotate. The turbine shares a common shaft with an electric generator, so as the steam flow causes the turbine to rotate, the electric generator is also turned and electricity is produced. The efficiency of direct-fired biopower facilities is typically 20%-24%.

Cofiring involves substituting biomass for a portion of coal in a power plant furnace. It is the most economic option for the near future to introduce new biomass power generation. Because much power plant equipment can be used without major modifications, cofiring is far less expensive than building a new biopower facility. Since the larger coal-fired facilities are usually more efficient than direct-fired biopower facilities, the biomass used in a cofiring application is converted to electricity with 33%-37% efficiency.

Biomass gasifiers operate by heating biomass in an environment where the solid biomass breaks down to form a flammable gas. This offers advantages over directly burning the biomass. The biogas can be cleaned and filtered to remove problem chemical compounds before it is burned. This will allow use of a wider range of biomass fuels. Also, the gas can be used in more efficient power generation systems called combined cycles, which combine gas turbines and steam turbines to produce electricity. The efficiency of gasification-based biopower systems can reach 60%.

Modular systems employ some of the same technologies mentioned above, but do so on a smaller scale that is more applicable to villages, farms, and small industry. These distributed energy systems are now under development and could be most useful in remote areas where biomass is abundant and electricity is scarce.

## Biomass Benefits and Costs

As a renewable energy source, biopower offers an attractive alternative to conventional energy sources in the form of rural economic growth, national energy security, and environmental benefits. Although biopower is also generated through a combustion process, in most cases, it produces fewer emissions than conventional, fossil-fuel sources. It can actually improve environmental quality by offsetting fossil fuel use and related emissions and by using wastes that are creating land use problems.

Biopower growth can also create new markets and employment for farmers and foresters, many of whom currently face economic hardship. It can establish new processing, distribution, and service industries in rural communities.

The cost to generate electricity from biomass varies depending on the type of technology used, the size of the power plant, and the cost of the biomass fuel supply. Currently, the most economically attractive technology for biomass is cofiring. These projects require small capital investments per unit of power generation capacity. Cofiring systems range in size from 1 MW to 30 MW of biopower capacity. When low-cost biomass fuels are used, cofiring systems can result in payback periods as low

as 2 years.

A typical coal-fueled power plant produces power for about $0.023/kilowatt-hour (kWh). Cofiring inexpensive biomass fuels can reduce this cost to $0.021/kWh, while the cost of generation would be increased if biomass fuels were obtained at prices at or above the power plant's coal prices. In today's direct-fired biomass power plants, generation costs are about $0.09/kWh. In the future, advanced technologies such as gasification-based systems could generate power for as little as $0.05/kWh. For comparison, a new combined-cycle power plant using natural gas can generate electricity for about $0.04-$0.05/kWh at fall 2000 gas prices.

For biomass to be economical as a fuel for electricity, the source of biomass must be located near to where it is used for power generation. This reduces transportation costs — the preferred system has transportation distances less than 100 miles. The most economical conditions are when the energy use is located at the site where biomass residues are generated, such as at a paper mill, sawmill, or sugar mill.

For more information, visit the DOE Biomass Program Web site.

The Biomass Research and Development Initiative, a multi-agency effort to coordinate and accelerate all federal biobased products and bioenergy research and development, is a good source of biomass news and information.