Biopower FactSheet

A Biopower Triumph—The Gasification Story

Biomass is this country's second leading source of renewable energy, exceeded only by hydroelectric dams. More than 500 U.S. electric power plants with a combined capacity of 7,000 megawatts (MW) use biomass fuels from a variety of sources. Most consist of residues from bioprocessing industries—forestry and wood products, agriculture and food processing, and other industries such as construction and transportation that must dispose of large quantities of unused biomass. Most of the plants use combustion boilers to create steam for generating electricity. But new and improved processes are being introduced, thanks to the U.S. Department of Energy's (DOE) Biopower Program. New processes will increase the efficiency of producing power from biomass while reducing pollution emissions.

What Is Gasification?

One of these "new" processes is called gasification. The gasification process makes a fuel gas from organic materials such as biomass by heating them under carefully controlled temperature, pressure, and atmospheric conditions. A key to gasification is using less air or oxygen than is usually found in the firebox of a boiler. The fuel product of gasification is called biogas or fuel gas, which (like natural gas) can be burned in high-efficiency gas turbines.

Gasification was used as long ago as the early 1800s. The process was rather crude and the fuel was most often coal. The gas product, called town gas, was used for heating and lighting. For example, in 1807 (or perhaps even earlier), town gas was used as the heat source to make glassware at the Sowerby glassworks in northeast England. Town gas was piped to street lights as early as 1846 in Fakenham, Norfolk, England. In 1860, a company called Citizen Gas Light began to provide the town of Wakefield, Massachusetts with town gas. Undoubtedly there are earlier examples; some may reach to the late 1700s.

Modern processes use many fuels, including waste rice hulls, wood waste, grass, coal, and dedicated energy crops. Gasification is a clean process with few air emissions and little or no ash. It is very economical and is not highly sensitive to size.

What Is a Gasifier?

The gasifier is the heart of the gasification process. Gasifiers today are carefully engineered steel tanks that are designed to process the fuel in a variety of ways consistent with the type of fuel, the end use of the gas, the size of the process, and the source of oxygen. The oxygen may be introduced as a pure gas or may come from air or steam. Some gasifiers operate under pressure; others do not. Names of these types of modern gasifiers include:

Warren Gretz, NREL/PIX06292

A high-throughput biomass gasifier converts biomass into gas for electric power generation.

- fixed bed, downdraft; fixed bed, updraft
- concurrent flow; countercurrent flow
- circulating fluidized bed; bubbling fluidized bed
- direct fired; indirect fired

DOE's Biopower Leadership

Since the Biopower Program's inception in 1991, its leaders recognized that gasification could be a major process contributor to converting biomass into energy. Acceptable fuels for gasifiers include waste wood, forest cuttings and thinnings, agricultural wastes, crop wastes, landscaping wastes, manufacturing wastes from industries such as paper and furniture, and dedicated energy crops such as switchgrass and fast-growing trees. DOE researchers knew that biomass gasification was a clean energy producer. Gasification's emissions of acid gases, ash residues, and other pollutants are far less than from either oil or coal combustion. The recent interest in carbon dioxide (CO_2) as a major contributor to the global warming risk has reinforced support for biomass gasification because this process has no net CO_2 emissions. The actual emissions are low and biomass consumes the CO_2 produced from thermal treatment during its growth cycle.

When biogas is made, its energy content is concentrated and converted to a substance that's broadly usable in a variety of applications. And this is being done with greater and greater efficiency—more of the energy is being captured—all the time, thanks to the success of DOE's Biopower Program. Biomass gasifiers can potentially generate electricity twice as efficiently as conventional boilers. For even greater efficiency, heat from the gas turbine exhaust can be used to generate additional electricity with steam. These improvements can make environmentally clean biomass energy cost competitive with fossil fuels.

A Major Success Story

Special Award

In 1998 an innovative partnership between government and industry received the prestigious R&D 100 Award for developing a new biomass gasification technology. Based on research sponsored by DOE, the technology demonstrates how biomass can be converted into a clean-burning gas for fueling advanced power systems with high efficiency and low emissions. The award is given yearly by *R&D Magazine* to the 100 most significant technical achievements of the year.

The Winning Team

The 1998 R&D 100 Award is shared by Battelle (Columbus, Ohio), for inventing the process and licensing the technology; the National Renewable Energy Laboratory (Golden, Colorado), for supporting the gasifier design, engineering, and operation; the Burlington Electric Department (Burlington, Vermont), for hosting the demonstration and integrating the gasifier into its McNeil Generating Station; and Future Energy Resources Company (Atlanta, Georgia), for licensing the technology from Battelle for commercial production and leading the commercialization effort. These partners continue their research and development of biomass gasifiers for fueling other advanced power systems.

The Winning Facility

The award-winning gasifier is located at the McNeil Generating Station in Burlington, Vermont, which uses wood from nearby forestry operations—forest thinnings and discarded wood pallets—to generate electric power for the city's residents. The gasifier can convert 200 tons of wood chips each day into a gaseous fuel that is fed directly into the McNeil Station boiler to generate 8 MW of electricity.

Wood fuel in the gasifier is surrounded by sand heated to 1800–1900°F, which breaks down the biomass into gas and residual char in a fluidized-bed reactor at 1500–1600°F. Sand is used to carry the biomass and the char and to distribute the heat. Using sand as a heat carrier keeps out air, which results in a better quality fuel gas. The biomass gasifier enables the use of advanced power systems based on gas turbines and combined cycles that will nearly double the efficiency of today's biopower industry.

Dave Parsons, NREL/PIX06886

The McNeil Generating Station at night

The Promise of Gasification

Research continues to improve gasification technologies. Scientists are refining hot gas cleanup and particulate emissions control. They are studying use of power conversion technologies such as turbines and fuel cells in connection with biomass power generation. Finally, progress continues to be made in lowering costs and boosting efficiencies to make biomass gasification and power generation competitive in the marketplace.

For More Information

Visit the Biopower Web Site:

http://www.eren.doe.gov/biopower

For copies of print documents on renewable energy, call DOE's Energy Efficiency and Renewable Energy Clearinghouse (EREC) 1-800-DOE-EREC (1-800-363-3732)

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