100 Years of Service
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Biomass for Small-Scale Heat and Power

Small-diameter and underutilized material must be removed from our forests because this material creates ladder-type fuel that can lead to high-intensity fires up in the crowns of trees. That type of fire can spread very quickly. If economical and value-added uses for this biomass can be identified, the cost of removing the material from the forest can be offset and catastrophic wildfires can be minimized. A wide range of uses for this biomass exists, from a high-value use such as lumber to the lowest value use of burning for energy. Because our energy needs are so great, efforts to encourage using biomass for heat and power will ensure that greater amounts of this material will be utilized.

The State and Private Forestry Technology Marketing Unit, located at the Forest Products Laboratory (FPL), has teamed up with the U.S. Department of Energy (DOE), through the National Renewable Energy Laboratory, to demonstrate nationwide the use of small-scale biomass systems that produce electricity by gasifying wood chips or pellets. Community Power Corporation (CPC) received a grant from DOE to develop and manufacture the BioMax® systems. Although gasification technology is over 100 years old, it is the capabilities of today's computers that have made it more feasible to commercialize these systems.

BioMax units currently range in size from 5 kW to 100 kW. The BioMax 5 unit on display at the Carriage House on the grounds of FPL is one of only three of its kind. These smaller 5-kW units are for demonstration purposes, whereas the larger units (25 kW, 50 kW, 100 kW) are more economically viable and useful for small businesses or schools in rural areas. However, the 5-kW unit could be practical for homes in remote areas that do not have access to an electrical utility. This size unit is actually more complex than the larger size units because it stores power in batteries. The larger units do not have batteries; they are turned on when necessary and shut off at the end of the day.

The BioMax uses about 20 percent of the energy available in the wood to generate electricity, and 80 percent is waste heat. Waste heat is in three forms: (1) from the heat exchanger; (2) from the radiator that is cooling the engine; and (3) exhaust from the engine. To make the BioMax economically viable, every effort should be made to use this waste heat. One possibility is to use the waste heat to heat a cold-climate house in the winter. For example, the waste heat could heat water in a large storage tank (e.g., 1,000 gallons), which could then be pumped to radiators throughout the house. When this water cools, the BioMax would reheat it. Another option is to use the waste heat any time of the year to heat water in an average-size hot water tank; this use requires less energy and the waste heat from the engine exhaust is all that would be needed.

In summer, waste heat not used for heating a house could be used for drying chips that go into the BioMax. The BioMax 5 requires material of a fairly uniform size, so we are using pellets purchased from a local supplier. Larger BioMax units are more able to use chips of varying sizes.

In the future, CPC may decide to manufacture only one or two BioMax sizes, likely in the range of 25 kW to 100 kW. The 5-kW size is not economically attractive right now, but if energy costs go up significantly in the future, this size might be economically viable for homes in remote areas. The 5-kW unit could potentially satisfy the needs of four or five homes at today's usage levels.

How It Works

The computer located inside the BioMax runs everything automatically. After the unit is turned on, the engine is started. In the case of this size unit, gasoline starts the engine, which is connected to a generator that instantly begins generating electricity. This electricity can be used immediately or stored in batteries contained in the BioMax unit. The exhausts from the engine and electrical heaters are used to warm critical parts of the unit.

The gasifier is about 6 inches in diameter and about 3 feet tall. At initial installation of the BioMax and following each gasifier cleaning, the gasifier is filled with charcoal. Thermocouples in various ports inside the unit provide information to the computer so it can appropriately turn on the heating element to light the charcoal and adjust air input to control combustion, as well as control the speed of various cooling blowers. After a few minutes of operation, the gasoline supply that was being used initially is shut off. At that point, the electricity being produced comes from wood.

When the temperature of the gases reaches approximately 1700°F, an auger starts to move pellets from the hopper into the gasifier. At that point, the red hot charcoal (char) is below the wood pellets and heats up the wood pellets to create a partial

combustion zone that is producing smoke and tars. The smoke and tars are converted in the hot zone to something called a producer gas. The computer maintains these critical temperatures at all times until shutdown. During shutdown, all the wood is converted to char.

A grate holds the charcoal. This grate slowly moves back and forth to shake the ash out of the bottom. The ash is vacuumed out when it accumulates

A pair of electric eyes on the gasifier indicates when the pellets drop below a certain line. When this happens, the computer turns on the auger and fills the gasifier with pellets. As soon as the pellets block the view of the electric eyes, the auger shuts down.

The gasifier also has vibrators that go back and forth to level the pellets and maintain a consistent density in the charcoal zone.

The gases coming out of the gasifier are around 1700°F. This is an ideal temperature because carbon monoxide and hydrogen are formed (the combustible constituents of the producer gas). These high-temperature gases then go through a heat exchanger to be cooled below 200°F before entering the filter.

The BioMax contains a high-efficiency particulate air (HEPA) filter. If the gasifier is operating properly, almost no particulates, smoke, or tars are present. The gases go through the filter, then proceed to the engine. If tars and particulates are in the gas, the filter collects them. Tars and particulates can damage the engine if they are not removed

The BioMax 5 has a typical gasoline engine with a spark plug. The producer gas is easily ignited and no other fuel is needed.

Maintenance

The ash that is formed at the bottom of the gasifier is carried into the heat exchanger and is vacuumed out regularly. Occasionally, the gasifier unit is emptied and cleaned (ideally, after more than 100 hours of operation). Clinkers are one of the main reasons for cleaning. When the temperature in the gasifier is extremely hot, noncombustible material (ash) can melt together to form globs, which are called clinkers. The clinkers must be removed. In the cleaning process, all the old charcoal is removed and must be replaced with new charcoal. The computer indicates that a cleaning is needed in various ways. For example, a pressure buildup due to clogging would indicate that the gasifier needs a cleaning.

Economics

The BioMax can be economically attractive, but potential users should perform an analysis with their particular situation. The analysis should take into account such parameters as the intended application, installed capital cost, operating cost (mainly labor and fuel cost), hours of daily operation, peak load, and daily energy requirement.

The best economics occur when (1) the user has high-priced conventional energy (e.g., electricity and natural gas); (2) the user has a biomass supply on-hand; and (3) both heat and power are needed. If the user currently must pay to dispose of biomass, then the economics of installing a BioMax can be extremely favorable.

The goal of the manufacturer is to have the cost be $2,000 per kW, and it appears that CPC may be able to achieve that goal with the largest units. However, with the added complexity of the 5-kW unit, the cost would be much more.

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