TechLine

Forest Products Laboratory

Biomass for Small-Scale Heat and Power

Biomass energy technology for small-scale systems holds tremendous opportunities for offsetting local energy needs. The State and Private Forestry Technology Marketing Unit (TMU), located at the Forest Products Laboratory, provides assistance to rural communities and businesses to diversify and expand their economic opportunities by developing value-added uses for thinned material from the forest. In one of TMU's latest projects, they teamed with the U.S. Department of Energy, through the National Renewable Energy Laboratory (NREL), to demonstrate nationwide the use of a small-scale biomass system that produces 15 kW of electricity by gasifying wood chips. When this technology is commercially available, it will provide a reliable and efficient source of heat and power, using both agricultural and forest residues (also see TechLine *Wood Biomass for Energy*).

Today's low-Btu gasifiers have better systems for reducing emissions. Not only are these new gasifiers more reliable for conventional applications, such as driving internal combustion engines, but they may also find suitability for use with Stirling engines, microturbines, and fuel cells.

BioMax 15

The BioMax 15 is a prototype combined heat and power system developed by Community Power Corporation (CPC), an NREL subcontractor. This state-of-the-art, transportable, fully automated, and environmentally friendly downdraft gasifier is suitable for small businesses, rural homes, and schools.

The BioMax 15 operates by feeding wood chips (moisture content up to 25%) from a hopper to a conveyor belt. The conveyor belt moves the chips through a dryer, which is heated by excess heat from the internal combustion engine. After the chips dry to 15% moisture content, they are fed into the gasification hopper. The chips flow downward through the gasifier (operating at 1,472°F (800°C)). Airflow through the wood chips is limited, so they are combusted under starved-oxygen conditions. Byproducts from the combustion are carbon monoxide, hydrogen, hydrocarbons, tars, particulates, and ash. Tars, particulates, and ash are filtered out, and the gases (called producer gas) are used to power an internal combustion engine. Excess heat from the gasification reaction and engine coolant can also be used.

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Features

- Fully automatic startup, operation, and shutdown
- Closed-loop control of gasifier and engine
- Combined heat and power modules from 5 to 50 kW_e
- Noncondensing system; dry gas cleanup
- No liquid effluents; no toxic wastes
- Uses variety of woody biomass fuels—wood chips, pellets, scraps, and coconut and other nut shells
- Low-cost, high-volume design
- Optional automatic dryer/feeder; potential capture of heat from engine coolant and stack emissions
- Trailer or skid mounted; simple installation

Specifications (Based on Latest Model)

- Electrical power: 5- to 100-kW_e modules
- Thermal: ~70k to 1,500k Btu/h (20 to 400 kW_{th})
- Electrical efficiency: 15% to 18%
- Combined heat and power (CHP) efficiency: 55% (with predrying chips); 75% (without predrying chips)
- Footprint: 5 by 5 m (16 by 16 ft)
- Weight: ~1,500 kg (~3,300 lb)
- Gas composition (~): 0% O_2, 20% H_2, 20% CO, 7% CO_2, 2% CH_4, balance N_2
- Gas: 5 MJ/m^3 (~150 Btu/ft^3), <15 ppm tars/particulates
- Fuel conversion: ~1.5 kg/kWh (1200 lb per 24 h for 15 kW_e)
- Dispatchable power (on backup fuel): Within 30 s
- Full cold startup on wood gas: ~30 min
- Turndown ratio: >10:1 (efficient operation down to 10% of full power)
- Startup/backup fuel: LPG (propane, butane)

Economics (Example Cost Analysis)

- Estimated full-scale capitol production costs: $1,800/kW ($27,000 for BioMax 15)
- Assumed value of electricity: 12¢/kWh
- Payback time (operating 16 h/day, 300 days/year): 3.1 years, excluding cost of chips and labor (minimal)

Renewable Energy—It's the Future

Working together with CPC in a joint public–private sector project, the TMU and NREL are fast-tracking biomass technology for small-scale heat and power to commercialization through four to six field demonstration sites located across the country.

For the next 2 years, these sites will be studied to evaluate this small-scale combined heat and power system. The potential of using wood chips as a fuel source and cost of operation will be evaluated along with suggestions on how to modify and improve these systems.