Feature Story

Biomass District Energy Update:
Current trends and issues in the U.S.

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Across the United States, the number of biomass-based district energy plants is growing, incorporating a variety of renewable fuels, technologies and business strategies. The motivations behind this increase include offsetting greenhouse gas emissions by utilizing carbon-neutral fuels, promoting renewable energy and reducing dependency on fossil fuels. With crude oil frequently topping $100 a barrel, the momentum to go green is compelling. But biomass systems are not without risks or significant financial investment that can make or break them. A look at recent trends and issues in biomass district energy can provide an overview of this segment of the industry and how various systems have found success.

Small-Scale Modular Boilers in Institutions

Among the district energy plants utilizing biomass are those at several higher education and health care institutions, which have capitalized on the availability of cost-effective modular biomass boilers. Several manufacturers of biomass combustion equipment have successfully packaged systems that can be offered at a competitive price and installed with minimal field fabrication and customized assembly. The pre-engineered, shop-manufactured equipment in the 10,000- to 50,000-lb/hr steam production range enables plants to incorporate a renewable energy source in their portfolio with limited capital investment.

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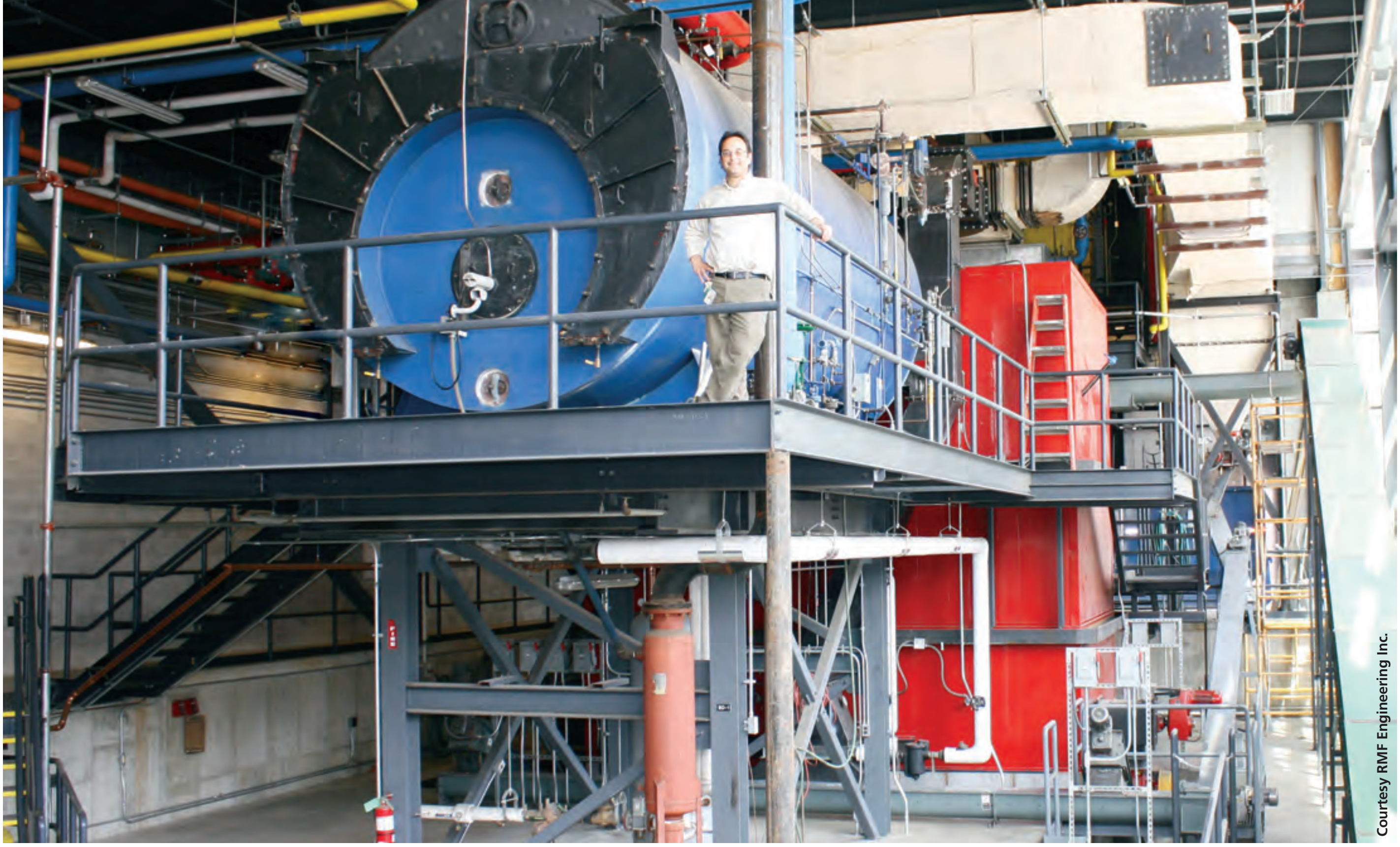
Small-scale biomass boilers are now in use, for example, at Middlebury College, Bennington College and Green Mountain College in Vermont; Colby College, Maine; Colgate University, New York; Longwood University, Virginia; Northwest Missouri State University; Central Michigan University; and Cooley Dickinson Hospital in Massachusetts. Throughout the country, biomass-fired combined heat and power projects have also been funded at U.S. Department of Veterans Affairs (VA) medical centers. These systems have broken ground in Ohio, New York and Maine. More biomass CHP plants are proposed at Wyoming, Michigan, Tennessee and California VA medical facilities.

Middlebury College

One of the institutions tapping small-scale biomass boilers, Middlebury College used to consume approximately 2 million gal per year of residual (No. 6) fuel oil. Natural gas was not within geographic reach in the Northeast. A "carbon reduction resolution" initiated by Middlebury's student body was approved by the college's trustees. The college invested $12 million in a campus heating plant in 2008, complete with a glass front to increase visibility and showcase its mission. The project included a receiving facility for wood chip trucks, wood chip conveyors, a close-coupled gasifier with four-pass firetube boiler, and emission controls including cyclone separators and a baghouse.

"We considered every imaginable option," says Michael Moser, Middlebury's assistant director of facilities services. "The final solution was to retain our oil-fired infrastructure for backup and utilize biomass at the main plant for day-to-day steam production."



Michael Moser, assistant director of facilities services at Middlebury College, demonstrates the close-coupled gasifier boiler installed in the new campus heating plant.

This plant operates year-round with a steady load, consuming 75 tons of green wood chips daily. The boiler produces 22,000 lb/hr of 250 psig steam. "We cogenerate using as many as three backpressure steam turbine generators, which exhaust at 20 psig to heat the campus," Moser explains. "When we are not heating, the steam is used for generating up to 2,000 tons of absorption cooling."

The biomass system is very cost-effective: Twenty thousand tons of regional wood chips (primarily 'whole-tree') displace one-half of the previous oil consumption. Hardwood chips delivered for $40-$50/ton beat the oil alternative ($2.75/gal) by a ratio of more than 4-to-1. Although the chips are purchased through a broker, the college now wants to learn more about what state, town and wood lot the fuel is coming from and what is being done to restore it.

Bennington College

Bennington College built its biomass plant in 2007. "We used to burn about 370,000 gallons of No. 4 oil per year to heat 22 campus buildings. This year, that number will be less than 10,000 gallons," says boiler operator Todd Siclari.

Bennington invested $4 million in the new facility, which houses a 400 HP wood chip-fueled underfed stoker boiler and earned an architectural design award in 2009. The plant receives 30-ton trailer loads of whole-tree green wood chips, which fall onto a 'walking floor' and vibrating belt conveyors, and then pass through a magnet and shredder to ensure a clean, uniform grade of fuel. "The key is getting a good, reliable wood chip supplier," says Siclari. "No long sticks, dirt or contaminants: We find what works best is mostly hardwoods within a certain range of moisture content (less than 50 percent)."

Bennington College's emissions are controlled by a multiclone collector that removes particulate matter from the stack gases. The material-handling, combustion boiler and ash-removal systems were provided by AFS Energy.

Lessons Learned

Among the lessons Middlebury and Bennington have learned from their experience are the following:

- Fly ash byproduct has been a valuable resource to the agricultural community as fertilizer.
- Allow plenty of time to shake down the system and gain confidence. Moser reports: "It took us about a year of trial and error to get there."
- Secure a good, reliable, consistent fuel source. Wood fuel moisture levels and composition (percentage of hardwood, softwood, etc.) have very noticeable effects on combustion characteristics.
- Install a central vacuum system, as dust is an everyday challenge.
- Schedule outages every eight weeks for ash cleanouts and inspections.

Fewer Large-Scale Applications

Besides the small-scale biomass boilers, larger-scale systems have also been implemented, though they are fewer in number by an estimated 3-to-1, generally require customization and are many times more expensive. Two of the most visible biomass pioneers have been District Energy St. Paul, with the nation's largest wood-fired CHP plant (310,000 lb/hr) serving a district energy system, and the University of Iowa, which burns oat hulls to fuel its district

Bennington College's Todd Siclari inspects the delivery of whole-tree chips.

energy system and has displaced more than 150,000 tons of coal consumption to date. Both systems have operated successfully since 2003.

A more recent example is Seattle Steam Co.'s $25 million urban wood waste-fired boiler project at its Western Avenue Plant, completed in 2009. (See the cover story on this project in First Quarter 2011 *District Energy*). The company's new 85,000-lb/hr bubbling fluidized-bed boiler accommodates a wide variety of wood materials including storm damage, pallets and construction debris. Because of its size and location, Seattle Steam added a semidry absorption scrubber system to remove acid gases and urea injection to remove nitrogen oxide emissions.

Similar-scale gasification plants using various wood fuels such as hogged fuel, chips, etc., have also recently been developed by Nexterra Systems Corp. for the University of South Carolina and Oak Ridge National Laboratory (plants at both locations have 60,000-lb/hr capacity). Gasification plants of this size in a greenfield environment can require significant investments ($15 million to $25 million) but report some of the lowest-achievable emission levels and are able to accommodate a variety of fuels and moisture compositions.

Larger stoker-type wood-fired boilers have long been in common use in the pulp and paper industry to produce process steam and electricity. Established manufacturer Indeck Power Equipment Co., for example, has been providing units as large as 600,000 lb/hr for nearly 40 years.

One of the most ambitious and largest district energy system biomass projects is currently under way at the University of Missouri (MU, or 'Mizzou') in Columbia, Mo. This $76 million investment includes the removal of an older coal-fired boiler and installation of a 150,000-lb/hr, 950-psig, 850 degrees F, utility-grade bubbling fluidized-bed boiler; fuel-storage silos; and fuel-handling conveyors. Expected to be operational in mid-2012, the new boiler is estimated to burn more than 100,000 tons per year of regionally supplied biomass.

MU Power Plant Superintendent Gregg Coffin reports that "the bubbling fluidized-bed boiler system will offer flexibility to use a wide variety of sustainably sourced biomass feedstocks such as milling residues, clean wood waste, urban development clearing, logging residues, managed forestry thinning, corn stover, crop residues, waste papers and biomass crops that have been grown specifically for this purpose." Emission controls for the boiler are extensive, including a fabric-filter baghouse, selective catalytic reduction ammonia injection system, dust collection, and continuous emissions monitoring and continuous opacity monitoring systems.

Pellets: Still an Immature Market

There are an estimated 1 million residences or businesses in the United States currently heated with wood pellets, which are now produced at approximately 200 pellet mills throughout the country. The wood biomass used in pellet production comes largely from previously discarded forestry resources like tree tops, branches and stumps. Chips, bark and sawdust are also commonly processed into pellets.

Typically, wood waste is processed in a hammer mill, significantly reducing particle size. Moisture is then added or removed, and the wood particles are

The largest wood pellet mills in the U.S., like Green Circle Bio Energy Inc., export all of their product to European nations.

pressed through a die, resulting in a dry, consistent fuel product held together by a natural casing formed by lignin melting in the wood as it goes through the die press.

Pelletizing achieves many beneficial results such as densification, uniformity, transportability, storability and ease of cofiring in a combustion process. In this form, wood can be trucked, railed, augured or pneumatically conveyed. Pellets also contain twice the energy content of green wood (8,400 Btu/lb for premium-grade pellets).

A large pellet mill can produce 30,000 to 80,000 tons of pellets per year. Transportation and delivery of the pellets – once distributed only in 40-lb bags for household use – has expanded to a commercial level. Trailers and trucks with up to 25 tons of capacity commonly deliver using pneumatic conveying to a customer's storage silo.

One of the largest wood pellet producers in the world is Florida-based Green Circle Bio Energy Inc. It produces up to 560,000 tons of wood pellets annually using a variety of yellow pine species grown within a 50-mile radius. Plant Manager Greg Martin says that the market for wood pellets in U.S. utility plants has not yet arrived. The company ships all its pellets to Europe for use in district energy and electric utility plants, where they may be cofired with coal or burned exclusively. Martin says, "The difference is that in those countries there are financial incentives supporting biofuel use. The future of wood pellet use in the U.S. is dependent on legislation going forward."

The cost differences between wood chips and pellets have largely confined pellet use to small standalone heating plants.

While large-scale pellet-fired plants are not yet in use in any U.S. district energy systems, institutions such as colleges and secondary schools have installed pellet heating systems for smaller properties. Dartmouth College, for example, installed a 2 million-Btu/hr pellet-fired system for its 125-unit Sachem Village housing complex. But the cost differences between wood chips and pellets have largely confined pellet use to small standalone heating plants. Generally, when combustion equipment capacities get above 3 million or 4 million Btu/hr, the cost differences largely favor chips or bulk wood residues. Commonly reported delivery costs for wood chips range from $30 to $55/ton ($3 million to $5 million/Btu), while pellets are rarely delivered for less than $200/ton ($12 million/Btu).

Expanding Fuel Opportunities

While the most common renewable fuel source used in district energy plants is wood waste, an industry is emerging to cultivate fast-growing grasses for this purpose. The trend is taking root in states such as Virginia, Pennsylvania, New York, Georgia and Kansas, where grasses are grown on farmland or underutilized/abandoned properties. These grasses include native warm-season varieties such as switchgrass and other perennials like Miscanthus and reed canary grass. Perennial grasses can be grown on marginal soils, reach high yields and sequester large amounts of carbon in their root systems and surrounding soils. Perennial grasses are being cofired with coal in electrical power plants and engineered as a feedstock for cellulosic ethanol.

Crops specifically grown for use as biomass fuel, such as giant Miscanthus, can yield as much as 10 tons per acre at maturity. These can be a valuable energy source for biomass firing and create new revenue streams for farmers and land

Perennial energy crops like Miscanthus are proving to be effective at carbon capture and high energy yield.

owners. Grasses can be harvested with conventional farming equipment and grow in closer proximity to plant sites than forests.

The interest in grasses as fuel has created new business enterprises. For example, Ohio-based FDC Enterprises Inc. is responsible for planting and maintaining nearly 150,000 acres of perennial grasses, and its subsidiary First Source Biofuel LLC is now harvesting grasses for use as biofuel feedstock.

Storage can be inefficient, however; and the difficulty of integrating grasses into district energy plants is mainly associated with the low-density material-handling and fuel-feeding systems. Grasses are bulky and nonuniform – generally incompatible with stokers and conventional conveying methods. Perennial grasses can be pressed into briquettes and cubed for densification. In many cases, the nonspecific grasses can be densified to produce pellets with a comparable heating value of approximately 90 percent of that of wood. Commercialized grass combustion has still not been realized, however.

Boiler MACT Regulations

With the momentum building for biomass boilers, a new challenge is presented by the U.S. Environmental Protection Agency's new emissions regulations for boilers and process heaters at major sources, i.e., the Boiler Maximum Achievable Control Technology (MACT) rule. The new regulations, signed Feb. 21, 2011, affect 13,800 new and existing boilers across the country, of which an estimated 420 are currently biomass-fired. Any boiler that burns at least 10 percent biomass on an annual heat-input basis is defined as a biomass unit. For new and existing large boilers (greater than or equal to 10 million Btu/hr), there are specific numeric emissions limits for particulate matter, hydrogen chloride, carbon monoxide, mercury, and dioxins and furans. The new regulations will require biomass boilers to add devices to meet the stringent standards in three years.

The emissions regulations for particulate matter are very restrictive. Fabric-filter baghouses and electrostatic precipitators are the most likely addition to cyclones or other mechanical collectors to capture particulate matter. Some sources may require extra measures for acid gases and oxidation catalysts for carbon monoxide. "These devices can add 25 percent to 30 percent to the equipment cost alone," says Richard Bellefleur, general manager of Wellons FEI Corp., manufacturer of packaged biomass boilers. "The emissions levels can be met, but at a cost."

At present, the newest MACT rules have again been temporarily suspended but are likely to return again after a public review period.

What Can Go Wrong?

Though increasing, biomass-fired district energy still faces many challenges. The most common obstacles tend to be a lack of local, reliable, cost-effective fuel supply as well as unanticipated high operating costs. Since fuel price can be the most significant operating cost, it has to be reliable and predictable. Successful plants rely on abundant fuel sources within 50 or 75 miles. Trucking, the most common method of fuel deliveries, is often limited to 25- to 35-ton loads.

Cost and distances are critical. One of the most notable examples of this was the closure of the Northern Nevada Correctional Center biomass plant, constructed in 2007 for $7.7 million. The expectation was that downed trees and other wood debris from the nearby Lake Tahoe Basin would be readily available, but wood proved to be more difficult and costly to obtain. Also, additional air-pollution controls were needed to comply with local requirements. The plant began losing $500,000 per year and was forced to close. Other biomass plants have been forced to seek fuel sources 100 miles or more away, resulting in high transportation costs that have jeopardized their viability.

Using biomass to generate thermal energy is generally more cost-effective than using it to produce electricity alone. In California, 61 biomass electric power plants were reportedly constructed between 1980 and 1992. The economic justification was based on the anticipation that the cost of conventional fossil fuel-produced power would increase significantly. When the power purchase contracts ended in the late 1990s, they were rewritten so low that less than one-half of these biomass plants are in operation today.

Still, large new biomass electric production plants are being developed. Novi Energy has started construction of a 50 MW generating plant in South Boston, Va., which will use ‘slash wood’ from the timber industry; and Dominion Virginia Power also announced that it is planning to convert three coal-fired power stations totaling 150 MW as early as 2013.

Added Bonus: LEED Credit

District energy providers that are incorporating biomass recognize the marketing value of being able to help customer buildings achieve LEED® (Leadership in Energy and Environmental Design) certification. Whether a new or existing facility, buildings seeking LEED certification can earn a tremendous number of points toward that goal if they are connected to a district energy system utilizing biomass that qualifies under LEED guidelines. Tim Griffin’s “LEED + District Energy” column in this issue provides a detailed explanation of the LEED advantages of biomass. LEED points can be achieved under both Energy & Atmosphere Credit 1 and Credit 2.

Additional Resources

The number of operating biomass district energy systems continues to grow, on college and university campuses, at health care facilities and in downtown business districts. Federal agencies, including the Department of Veterans Affairs, have already initiated or plan to initiate in the near term more than 15 biomass-based district energy systems in 10 states. This means the network of seasoned users, manufacturers and consultants is increasing, along with their expertise and eagerness to share advice and lessons learned.

To learn more about who is already successfully using biomass fuels, visit the following online resources:

- Biomass Energy Resource Center – www.biomasscenter.org/database.html
- Wood2Energy – www.wood2energy.org/Database%20Connection.htm

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