Finding non-fossil fuel power

Ethanol facility operators search for cheaper solutions for electricity, steam needs

by Susan Reidy

With energy ranking second in terms of ethanol production costs, facility operators are searching for cheaper solutions to power up.

Many of these alternative technologies use non-fossil fuel, opting to use items already produced at the plant, such as thin stillage or inexpensive biomass wastes found within close proximity to the facility.

Two U.S. ethanol facilities, Chippewa Valley Ethanol Co. (CVEC) in Benson, Minnesota, U.S. and Renova Energy in Heyburn, Idaho, U.S., have installed systems that cut down or completely eliminate the usage of natural gas. Details of these unique systems were explained during the International Fuel Ethanol Workshop and Expo this June in Nashville, Tennessee, U.S.

BIOMASS POWERED

Biomass, an organic material of recent origin such as maize stover, wheat straw and switchgrass, is an abundant resource that can be used to power ethanol facilities, said Jerod Smeenk with Frontline BioEnergy, LLC, Ames, Iowa, U.S.

But there are some rules that must be followed when using biomass, he said. For one, biomass is sourced locally, usually within a 30- to-50 mile radius. The equipment used to combust the biomass must be fuel flexible so it can use whatever is available in the area.

Biomass is variable in particle size, shape, density, moisture and composition. It also contains inorganic compounds (ash). The composition of the ash drives the process equipment design. Fuel bound nitrogen, alkali and chlorides may present air emission and equipment corrosion concerns. Par-

Combined heat and power benefits

Combined heat and power (CHP) is the generation of heat and power from the same fuel source. It uses a wide variety of technologies and fuels.

CHP is more efficient than separate generation of electricity and thermal energy. This higher efficiency means lower operating costs. It also reduces the emissions of all pollutants including carbon dioxide, NoX and sulfur dioxide.

CHP can increase power reliability and enhance power quality. On-site electric generation reduces grid congestion and avoids distribution costs.

Ted Bronson with the U.S. Environmental Protection Agency's CHP partnership said CHP is an excellent fit for the dry mill ethanol production process. Energy is the second largest cost of production for a dry mill plant. Electric and steam demands are large and coincident. For a 50-million-gallon-per-year facility (189 million liters), typical power demand is 4 to 6 megawatts and typical steam use is 100,000 to 150,000 pounds per hour.

CHP can offer ethanol facilities increased energy efficiency of ethanol production; energy costs savings from 10% to 25%; reliable electricity and steam generated on site; a hedge against unstable energy costs; improved competitiveness; and a reduced carbon footprint.

Several CHP options were evaluated for use by ethanol facilities including: natural gas — gas turbine/supplemental fired CHP; natural gas — gas turbine with power export; natural gas — gas turbine/steam turbine with power export; and coal/biomass — high pressure boiler/steam turbine.

The best option is the gas turbine with power export, Bronson said. With this system, the plant's fuel use is cut by half.

Overall, the energy use and carbon footprint of the system is driven by the fuel choice and the process configuration. Natural gas used with CHP reduces net energy from 13% to 50% and lowers carbon emissions by 25% to 97%. Using coal reduces net energy by 9% and carbon emissions by 6% while using biomass reduces net energy by 7% and carbon emissions by 90%.

ticular control is required somewhere in the process.

Logistics and conditioning are important considerations, Smeenk said. Storage and transportation of low density biomass is a challenge, and grinding biomass is energy intensive. Another factor to consider is the seasonality of biomass. A facility must create a strategy for year-round delivery of the biomass.

Two methods for converting biomass into power are combustion and gasification. Combustion converts the fuel into heat by complete oxidation. Gasification, on the other hand, converts fuel into combustible gases and heat by partial oxidation. The combustible gases include carbon monoxide, hydrogen, methane and other hydrocarbons.

CVEC decided in 2005 to start exploring alternatives to natural gas. Operators were concerned about the rising cost of natural gas and wanted to improve the fossil energy balance of the plant, Smeenk said. They also saw it as a forerunner to participating in cellulosic ethanol production.

The 47-million-gallon-per-year facility (178 million liters) opted for a gasifier system, which was installed in 2007. The preliminary firing took place in mid-March, and the system is currently logging hours.

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The biomass comes into the facility, goes through the material handling system and onto the gasifier along with air. It is turned into producer gas, which then goes through a gas filtering unit. The unit cleans the gas to make it suitable for distribution throughout the facility.

Smeenk said CVEC needed a system that would displace 90% of the plant's natural gas, and use about 254 tonnes of biomass per day. The system needed to be feedstock flexible with the ability to use wood, cobs, stover, grass, oil, fiber/bran and distillers grains. The plant also wanted to utilize its existing energy assets including its thermal oxidizer, dryers and boilers. A natural gas and propane back-up were also needed.

The gasification system, unlike combustion, allowed for the piping of combustible gas to multiple locations for integration with existing appliances. If the biomass system goes down, the gasifier's burners are able to pick up natural gas without interrupting plant operations.

Gasification allows for gas conditioning and cleanup before firing the gas appliances, Smeenk said. Gas conditioning is done at one location instead of at each individual appliance.

"Gasification is a bridge to cellulose ethanol. It helps build the biomass market," he said.

ENERGY SELF-SUFFICIENCY

Renova, a 27-million-gallon-per-year facility (102 million liters) opted to use co-digestion of thin stillage and whey permeate to achieve energy self-sufficiency. The plant asked ADI Systems, Inc., to conduct an anaerobic pilot study and design/build a full-scale digestion system. In general, biogas from the system is treated and used to make steam and electrical power for the ethanol plant.

Energy is available in the thin stillage that is created during ethanol production and in a cheese whey waste stream from a facility near Renova, said Ian Page of ADI. Key parameters in designing the digestion system are the high nitrogen and high solids content of the thin stillage.

After completing the pilot work, ADI found that combining 75% thin stillage with 25% cheese whey was the ideal mix for satisfying the plant's complete energy needs. During the six-month pilot study, several reactor configurations and loading rates were studied.

A two-reactor, mesophilic system with an optimum design load of 3.5 kg per cubic meter per day was found to be the ideal system. The mesophilic system operates at 100 degrees F (37 degrees C), which meant the very cold waste stream wouldn't have to be heated prior to going into the digester.

In the pilot study, discharge from the digester had a high enough quality that it was able to be discharged into the city's treatment system. The overall sludge yield, a combination of waste biomass, undigested solids, and reactor scale was 0.14 kg per TSS/kg. The digester created 60% methane, which had to be scrubbed prior to reuse in the boiler. Total raw TSS digestion was greater than 80%, Page said.

In the full-scale system installed at Renova, the first reactor is vigorously mixed to ensure good contact between the anaerobic organisms and the waste and maximize the energy recovery. The second reactor reduces the amount of solids and promotes the production of struvite, which helps remove nitrogen and phosphorous.

Two products are produced: the biogas which is scrubbed in an iron sponge scrubbing system and a liquid/solid stream from the digester. Energy generated from the digestion system, about 1.7 billion btu, is enough to satisfy the entire energy needs for the plant, Page said. In the event the biogas isn't needed, it can be burned in an enclosed flare.

The liquid/solid stream goes through a chemical process to force struvite formation, which is then removed in a centrifuge. Sludge from the centrifuge is taken to a storage facility and later applied on agriculture land in the area. **BB**

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