PROJECT PROFILE

University of Iowa

25.5 MW CHP Application

Background

Combined Heat & Power (CHP) is not a new concept at the University of Iowa, located in Iowa City. As early as 1947, the University introduced CHP into its central plant utilizing coal to produce high pressure steam. The steam was utilized to generate electricity and provide for thermal loads at the University through the use of extraction steam turbines. The campus spans 1,900 acres and has 119 buildings with a total footprint of 14.5 million ft^2. Today the CHP plant supplies 100% of the campus heat and 30% of the campus electrical demand. Approximately 85% of the required steam is produced from coal and the co-firing of coal and biomass, with the remaining 15% of the steam met with natural gas, utilized typically during peaking and backup steam production needs.

Quick Facts

LOCATION: Iowa City, Iowa
SIZE: 1,900 acres, 119 building, 14.5 million ft^2
GENERATING CAPACITY: 24.9 MW
PRIME MOVER: (3) Steam Turbines
- 18 MW Worthington Steam Turbine
- 4.0 MW Worthington Steam Turbine
- 3.5 MW Elliott Steam Turbine

BOILERS:
- 1 – Pyroflow© Circulating Fluidized Bed (CFB) – 170,000 lbs/hr capacity
- 1 – Riley Stoker – 170,000 lbs/hr capacity
- 2 – Riley (back-up and peak) – 145,000 lbs/hr capacity each

FUEL UTILIZED: Coal, Oat Hulls, Wood Chips, Giant Miscanthus.
CONVERSION COST IN 2001 TO ACCEPT AND CO-FIRE OAT HULLS:
$500,000 (<1 year simple payback)

Beginning to Co-Fire with Biomass

In 2001, the University and the Quaker Oats Cereal Mill, located 20 miles away in Cedar Rapids, Iowa, identified a potential opportunity to co-fire raw oat hulls in the coal fired CFB boiler. Quaker tested the direct use of raw oat hulls as the co-fired fuel and found the results very encouraging. The raw oat hulls, the plant casings that house oats, are the byproduct of the commercial cereal products that are the main product at the Quaker Oats mill. A volume of twelve rail cars of oat hulls were produced daily at the mill. The initial cost of converting the boiler and CHP plant to accept and efficiently burn the oat hulls was approximately $500,000, this included the design, procurement, and installation of a new storage, handling, and pneumatic injection system. The payback on the investment was less than 1 year. The co-fired CHP plant has resulted in much lower air pollutants, including an annual reduction of 60 tons of SO_2, and an annual reduction of 55,000 tons of CO_2.

Today, the 170,000 lb/hr circulating fluidized bed boiler has been modified to burn 50% coal and 50% raw oat hulls. This results in 23,000 tons of coal annually being replaced with approximately 35,000 tons of less expensive and more environmentally friendly oat hulls.

Biomass Fuel Characteristics

Oat hulls are produced as a residual from the oat milling process. The raw oat grain is milled and the protein containing center removed. The remaining hull has little protein, but does have a heat content of about 7,000 Btu/lb. This compares to coal that is used in the power plant with a heat content of about 11,000 Btu/lb. The lower heat rate content of the oat hulls is due to a 34% reduction in carbon content of the oat hulls as compared to coal. The density of oat hulls is 7 lbs/ft^3, much less than that of coal at 55 lbs/ft^3. Also the sulfur content of oat hulls is nearly zero compared to coal and the nitrogen level in oat hulls is approx 50% lower than in coal. However, the oxygen level in oat hulls is approx 500% higher

than in coal, resulting in the need for modifications in the boiler combustion controls to properly adjust the amount of combustion air supplied as the co-firing rate is increased. The cost of the biomass fuel is approximately half the cost of coal and therefore provides economic savings to the University of Iowa for their on-site steam and electric production.

Moving Towards Cleaner Generation

Truck Delivering Coal and Woodchip Mixture

Since the adoption of oat hulls in 2001 the University of Iowa has been looking to increase the amount of biomass used to provide energy to the campus. Their experience with co-firing oat hulls has demonstrated that biomass is a cleaner, more environment friendly fuel source and one that can be obtained at a price comparable with coal.

In 2013 the University of Iowa began exploring how woodchips could further supplement the coal used in their boilers. This idea started as a collaboration between the University and the Johnson County Conservation Department when the Conservation Department needed to root out invasive conifer trees in parks throughout the county. This opportunity fuel was tested by the University in the CFB boilers and proved to work quite well. Today the University now purchases woodchips from the Odessa Wood and Pallet Company in Wapello through a fuel aggregator which mixes the chips with the coal to be delivered to the university. Woodchips comprise 40% of the delivered fuel volume the university receives for its CFB boilers. Because of the success co-firing oat hulls and woodchips, the CFB boiler currently generates 70-80% of its heating load through biomass.

Not content to stop there, the University of Iowa wanted to explore how to further reduce their coal needs. In 2014, the University began planting Giant Miscanthus as an energy fuel to replace coal in the Riley Stoker boilers. Currently used in Europe as an energy crop, Giant Miscanthus is a woody grass native to Eastern Asia and is texturally similar to bamboo. The grass has an estimated energy content of 6,500-7,000 Btu/lb which is similar to the oat hulls already co-fired on site. In 2015, the University had 200 acres of Miscanthus planted with a goal of planting a total of 2,000 acres over the coming years. The grass is currently being tested co-firing with coal in the Riley Stoker boilers so that the University can gauge the most beneficial ratio.

Future Expansion

In 2015 the Iowa Board of Regents approved a new $75 million power plant to serve the west campus of the University of Iowa. The new plant is to be built as a CHP. The West Campus Energy Plant will provide critical steam for heating, cooling, and sterilization to buildings on the west side of campus and provide energy security for all UI campus facilities in the event of flood, grid failure, or other adverse event. The new plant will likely take two years to construct and will be operational in four years. According to Glen Mowery, director of Utilities and Energy Management, "The University of Iowa Hospital and Clinics' research and residential services require continuous, uninterrupted supplies of steam. The new plant will not only ensure continuity of services to our most critical health and research facilities, but also provide back-up service to both sides of campus while providing the most flexibility in fuel sources."

For More Information

U.S. DOE MIDWEST CHP TECHNICAL ASSISTANCE PARTNERSHIP

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