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University of Iowa

FLUIDIZED BED BOILER BIOMASS RETROFIT

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PROJECT PROFILE

MARKET SECTOR
HIGHER EDUCATION

QUICK FACTS

LOCATION:
Iowa City, Iowa

CIRCULATING FLUIDIZED BED BOILER RETROFIT APPLICATION:
- Originally designed to burn 100% coal
- Modified in 2003 to accept up to 80% biomass oat hulls (20% coal) using special fuel injection system

DISPLACED FOSSIL FUEL:
27,424 tons of coal (CY 2006)

BIOMASS CONSUMPTION:
41,514 tons of oat hulls (CY 2006)

ANNUAL SAVINGS:
$1,017,780 (CY 2006)

PROGRAM PARTNERS:
- University of Iowa
- Quaker Oats Company
- Iowa Department of Natural Resources

AWARDS WON:
- Iowa Governor's Environmental Excellence Awards
  - Special Recognition in Air Quality (2003)
  - Special Recognition in Energy Efficiency / Renewable Energy (2003)
- APPA Effective and Innovative Practices Award (2003)

PHOTO COURTESY OF UNIVERSITY OF IOWA

University of Iowa Power Plant

PROJECT OVERVIEW

The University of Iowa (UI), through an innovative partnership with the Quaker Oats Company, utilizes biomass by-products to save hundreds of thousands of dollars on annual energy costs. Biomass oat hulls, a residual material from the cereal making process, are co-fired with coal in a circulating fluidized bed (CFB) boiler to provide heating, cooling, and electricity to the UI campus buildings.

FLUIDIZED BED COMBUSTION

Fluidized bed combustion is a combustion technology used in power plants that suspends solid fuels on upward-blowing jets of air during the combustion process. The result is a turbulent mixing of gas and solids. The tumbling action, much like a bubbling fluid, provides more effective chemical reactions and heat transfer. The benefits of using fluidized bed combustion include:

- Flexibility in the choice of fuel that can be burned (coal, waste, biomass, etc.)
- Burning at lower temperatures than typical combustion processes
- Possibility of achieving low nitrogen oxides (NOx) emissions and removal of sulfur (SO_2) during the combustion process using limestone injection

Fluidized bed boilers incorporate fluidized bed combustion technology to generate steam energy in many facilities today.

INITIAL BIOMASS TESTING

In 2001, the Quaker Oats Company, located 20 miles northwest of the University of Iowa campus, approached the UI Power Plant in search of a market

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Fuel Characteristics	Oat Hulls	Coal
Heat Content (Btu/lb)	7,000	11,000
Density (lbs/ft3)	12	55
Oxygen Content (%)	35.44	7.62
Carbon Content (%)	43.51	65.44
Moisture Content (%)	10.43	14.90
Hydrogen Content (%)	4.71	4.39
Nitrogen Content (%)	0.65	1.47
Ash Content (%)	5.22	5.07
Sulfur Content (%)	0.04	1.11

Lessons Learned for a Successful Biomass Fuel Project
1. Proximity to the source of biomass supply
2. Reasonable transportation costs from the supply
3. An adequate supply of biomass
4. A mutual desire between the supplier and the University to make the project successful
5. A circulating fluidized bed boiler

for Resifil, a processed oat hull product. When the UI Power Plant agreed to test the biomass product in its CFB boiler, both parties began researching the special needs of biomass combustion. Although most of the technical experience was identified in Europe, where bio-energy had been utilized for decades, specific information relating to burning oat hulls in a fluidized bed boiler was not readily accessible. Therefore, combustion testing of the blended fuel (coal and oat hulls) would be most valuable to determine the feasibility of this new opportunity.

The first biomass test burn was coordinated with the Iowa Department of Natural Resources yielding mixed test results. The major obstacle in the test burn was to overcome the premature burning of Resifil after it was introduced into the boiler. Realizing that a fuel blending approach would not yield long-term satisfactory results, UI concluded it would be necessary to transition to a pneumatic injection system for feeding the biomass fuel into the boiler. This would be required before proceeding with additional biomass test burn experiments.

Although, Quaker Oats had been producing furfural and Resifil from oat hulls for nearly 80 years, the traditional method to dispose of Resifil was changing and the furfural chemical market was collapsing. These conditions led Quaker Oats to make the business decision to abandon the production of furfural and Resifil and seek alternative markets for the oat hulls remaining after manufacturing food products. The focus of the UI biomass test burning then turned to the unprocessed oat hulls.

Source: http://www.facilities.uiowa.edu/

PLANT MODIFICATIONS

The lightweight unprocessed oat hulls required special material handling solutions, boiler control modifications, and new procedures to ensure the biomass fuel could be a viable long-term energy source for UI.

A component of the pneumatic injection system included a separate, more compatible fuel silo in order to avoid having the hulls “bridge”, a condition that was observed when oat hulls were placed in the existing coal silos and would not flow out into the fuel handling system. It was also necessary to design, procure, and install pneumatic blowers, fuel injection nozzles, transport piping and fittings, safety interlocks, and new boiler control logic specifically designed for the biomass fuel.

These modifications needed to be done in a manner that would not have a negative impact on the existing coal systems. After installation of a pneumatic fuel injection system, oat hull testing resumed. Smoke stack testing was performed at various blend ratios of biomass and coal to quantify the changes in pollutant emission levels. This testing demonstrated and validated additional positive environmental impacts of oat hull combustion due to decreasing criteria pollutant emissions.

The testing of unprocessed oat hulls proved successful for the University of Iowa Power Plant and Quaker Oats Company. Concerns of fouling, corrosion, and temperature control were proven void and regulated pollutant emissions decreased when oat hulls were burned. Today, the UI Power Plant continues to burn the biomass oat hulls consuming approximately 40% of the Quaker Oats total oat hull production. In 2006, the consumed oat hulls accounted for 13.8% of the University's total purchased energy (fuel and electric), displaced 27, 424 tons of annual purchased coal, and provided $1,017,780 in annual savings to the university.

CARBON EXCHANGE

In August 2004, UI became the first Iowa-based commercial entity to join the Chicago Power Plant Climate Exchange (CCX), a greenhouse gas emission (GHG) registry where members make a voluntary but legally binding commitment to reduce emissions.

The CCX required facilities to reduce direct GHG emissions 4% below a determined baseline (average of 1998-2001 emissions) by the end of 2006 and a total reduction of 6% by the end of 2010. Since joining the CCX, UI has exceeded its GHG reduction target each year because it reduces its coal consumption using biomass oat hulls.

FOR MORE INFORMATION

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