



**MIDWEST  
CHP  
APPLICATION  
CENTER**

In Partnership with  
the US DOE

**combined heat & power in universities**

# University of Iowa 24.9 MW CHP Application

## Project Profile

### Quick Facts

**Location:**

Iowa City, Iowa

**Size:**

1,900 acres

119 buildings

14.5 million ft<sup>2</sup>

**Prime Mover:**

3 - Steam Turbines

**Fuel Utilized:**

Coal, Natural Gas and Biomass

**Distance from Biomass Fuel Source:**

20 miles

**Generating Capacity:**

24.9 MW

**Annual Energy Savings:**

\$735,000/yr

**Retrofit Cost Cost:**

\$500,000

**Simple Payback:**

Less than 1 year

### Background

Combined Heat & Power (CHP) is not a new concept at the University of Iowa, located in Iowa City, Iowa. As early as 1947, the University introduced cogeneration or 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. Today, the campus spans 1,900 acres and has 119 buildings with a total footprint of 14.5 million ft<sup>2</sup>. In 2001, the CHP plant supplied 100% of the campus heat and 30% of the campus electrical demand. Approximately 85% of the required steam was produced utilizing a coal fired stoker boiler and a coal fired circulating fluidized bed (CFB) boiler. Natural gas is utilized for peaking and backup steam production needs.

### Project Overview

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 a biomass based product called "resifil" in the coal fired CFB boiler. Resifil is a dense powdery substance that is a byproduct produced when raw oat hulls are utilized to produce a chemical that Quaker Oats sold into the petroleum industry. The initial project was a 90 day test burn of resifil in the University's CFB boiler. Many lessons were learned regarding the combustion process, the fuel handling process, and the effect on emissions. With the positive results from this test and the reduction in the market for the chemical sold into the Petroleum industry, Quaker decided to test the direct use of raw oat hulls as the co-fired fuel. These results were very encouraging allowing the co-firing of up to 50% of the fuel input into the CFB boiler being raw oat hulls. 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 are produced daily at the mill. 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.

The result was a "win, win, win" situation. In 2004, the University entered into a four year contract with Quaker Oats to provide the biomass fuel at about one half the cost of the coal it is replacing. Quaker had an economic and reliable outlet for the waste product from the mill. Finally, the citizens of Iowa gained from significantly reduced air emissions.



*University of Iowa Cogeneration Plant*

## Project Benefits

Utilizing the biomass fuel co-firing in the CHP plant has resulted in overall fuel savings of between \$500,000 and \$735,000 annually, depending on the percent co-firing. With the price of coal in the US rising, this annual savings number is expected to be even greater. The initial cost of converting the CHP plant and boiler to accept and efficiently burn the oat hulls was approximately \$500,000. The power plant had to design, procure, and install 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<sub>2</sub>, and an annual reduction of 55,000 tons of global CO<sub>2</sub>.

## CHP System Configuration:

- **Four Water Tube Boilers – 540,000 lbs/hr total capacity**
  - 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) – 100,000 lbs/hr capacity each
- **Steam Turbine Generators – 24.9 MW capacity**
  - 17.4 MW Worthington
  - 4.0 MW Worthington
  - 3.5 MW Elliott

## 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<sup>3</sup>, much less than that of coal at 55 lbs/ft<sup>3</sup>. 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 major 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 one half the cost of coal and therefore provides economic savings to the University of Iowa for their on-site steam and electric production.

## Project Awards:

The Coal/Biomass CHP plant has received several awards since its installation in 2003:

- Iowa Governor's Environmental Excellence Awards for "Air Quality" and "Energy Efficiency / Renewable Energy" issued in 2003
- The "Effective and Innovative Practices Award" issued in 2003 by the Association of Higher Education Facilities Officers

## For further information, contact:

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**Co-firing in a CHP system saved the university \$735,000 in 2005**

**WIN**  
for the University of Iowa

**WIN**  
for Quaker Oats

**WIN**  
for the environment and local community

