CENTRAL

CHP TECHNICAL ASSISTANCE PARTNERSHIPS

Iowa State University
46 MW CHP System and Microgrid

Project Overview

Iowa State University (ISU) is located in Ames, Iowa, about 30 miles north of the capital city of Des Moines. ISU is Iowa's largest university with an enrollment of more than 34,000 students. ISU started producing energy using CHP in 1891. Today's system provides district heating and cooling and a microgrid with 46 MW of electrical capacity. The CHP system serves approximately 12 million square feet of facilities including research laboratories, academic buildings, residence halls, dining facilities, athletic facilities, computing center, and administrative buildings.

Quick Facts

LOCATION: Ames, Iowa
MARKET SECTOR: Colleges/Universities
STUDENT ENROLLMENT: 34,000
CHP POWER GENERATION CAPACITY: 46 MW
CHP MAXIMUM STEAM OUTPUT: 790,000 lb/hr at 400 psig and 750°F
PRIME MOVERS: Four Extraction/Condensing Steam Turbines
PRIMARY FUELS: Natural gas and coal
USE OF RECOVERED THERMAL ENERGY: Heating & Cooling Needs of Building Space and Process Research
AREA SERVED: 12 million sq. ft.
ENVIRONMENTAL BENEFITS: Reduction of over 35,000 tons/year of greenhouse gas emissions
INITIAL CHP OPERATION YEAR: 1891
SYSTEM UPGRADE YEAR: 2016

The CHP system at ISU has been upgraded many times over the years to increase capacity and to use new technology. It now incorporates five boilers and four extraction/condensing steam turbines. Two of the boilers are coal-fired and the other three boilers operate on natural gas, and fuel oil if needed. The five boilers can produce up to 790,000 lbs./hr of steam for power generation, campus thermal needs, such as heating, domestic hot water, sterilization, and chilled water production. The campus energy distribution systems consists of 25 miles of 13.8 kV and 4,160 volt electric lines, 6.3 miles of steam and condensate return piping, and 8.5 miles of chilled water piping. The CHP system is capable of meeting 100% of the electric and thermal loads. However, the economics of on-site generation versus cost of purchasing electricity determines how much is actually generated on-site.

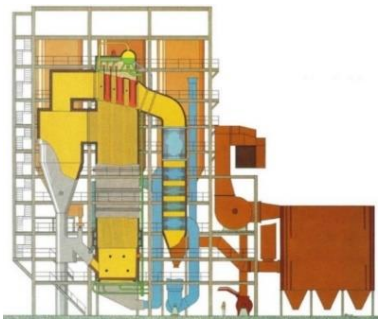
Heating, Cooling and Power

The two coal-fired boilers are state-of-the art circulating fluidized bed boilers that were installed in 1988. These boilers (Ahlstrom's Pyropower) were some of the first such type of boilers installed in the US. The production capacity of these two boilers is 340,000 lb/hr of steam at 400 psig pressure and 750°F temperature. The three natural gas-fired boilers, which can also run on fuel oil, were installed in 2016. The combined capacity of these three boilers is 450,000 lb/hr of steam at 400 psig pressure and 750°F temperature. The three gas/fuel oil-fired boilers replaced the old coal boilers (the pre-fluidized bed boilers) and helped ISU to be in environmental compliance with EPA Boiler MACT regulations by the January 31, 2016 deadline.

An Aerial View of the ISU CHP System
Photo Courtesy of ISU

The high-pressure steam from the boilers is used for operating the four extraction/condensing steam turbines. The capacities of these steam turbines range from 6 MW to 15 MW. The extraction steam turbines provide steam at 90 psig for the campus heating needs. The CHP plant not only provides power and heating needs for the ISU campus, in 1968 it also began providing chilled water to campus. Chilled water provides cooling for campus buildings and process cooling for research. The system incorporates seven chillers with a total cooling capacity of 28,000 tons. Two of the seven chillers are driven by high-pressure steam turbines, two are driven by low-pressure steam, and the remaining three are driven by electric motors. The plant operators run the most efficient chillers first to minimize the energy required to cool the campus.

Circulating Fluidized-Bed Boiler



Circulating Fluidized-Bed Boiler
Figure Courtesy of Ahlstrom

The circulating fluidized-bed coal boiler burns crushed coal in a turbulent air atmosphere in a combustion chamber that is fed air and limestone. Combustion of coal in this chamber produces heat and sulfur-containing gases. The limestone reacts with the gases to form calcium sulfate. This product is removed along with ash as a dry material. This type of boiler significantly reduces emissions of sulfur-containing gas in the exhaust. Fine particles of partly burned coal, ash and limestone bed material are carried along with the flue gases to the upper areas of the furnace and into a cyclone. There the heavier particles separate from the gas and fall to the hopper. This returns to the furnace for recirculation. Hence the name Circulating Fluidized Bed combustion. The hot gases from the cyclone pass to the heat transfer surfaces and out of the boiler.

Energy Efficiency, Environmental and Economic Benefits

The overall energy efficiency of ISU's CHP system averages around 60%, which is nearly twice as efficient as a typical electric-only power plant. The system could achieve higher efficiencies, but the system is operated at times to reduce electric load, when the available thermal energy is more than the campus needs. The utilities team takes pride in operating the plant as efficiently and sustainably as it can while still maintaining reliable utility services to the campus. As the plant developed and grew over the years, the utilities team selected equipment to enhance the overall operation and improve efficiency for the future. Campus building utility consumption is metered and billed to the building occupants so they are incentivized to reduce their energy usage.

Compared to the conventional system of buying all electric power from the grid and burning fuel on site for meeting the thermal needs, the CHP system helps reduce greenhouse gas emissions by over 35,000 tons per year. Because of the higher efficiency of the CHP system compared to a conventional system that buys or produces electricity and thermal energy separately, it helps ISU save over $1.25 million per year in utility cost.

System Resiliency

"ISU is very happy to continue to benefit from its CHP systems for more than 125 years. The CHP system has proven to be reliable, efficient and environmentally sound. Today's utility staff is proud to be part of this legacy." Jeff Witt, Director, Utility Services, ISU

The CHP plant is designed with N+1 redundancy. It allows the system to meet the campus load even with one of the largest production equipment out of service. The CHP system has significant flexibility of using coal, natural gas, and fuel oil. In addition to the 46 MW available from the CHP system, ISU has two 30 MW transmission connects to the the Midcontinent Independent System Operator (MISO) grid connecting through the transmission systems operated by the City of Ames Electric System.

For More Information

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