PROJECT PROFILE

SOUTHEAST CHP Technical Assistance Partnerships

Vanderbilt University

13.5 MW CHP System

Project Overview

Vanderbilt University is a private research university of about 7,000 undergraduate and 6,500 graduate and professional students located in Nashville, Tennessee. The campus has 179 buildings across 341 acres and includes both university and medical facilities. To support this large campus, electric, heating and cooling utilities are provided and maintained by the plant operations department of Vanderbilt.

Aerial Photo of Vanderbilt University *photo from vanderbilt.edu*

The plant operations department serves 12 million square feet of conditioned space on campus providing steam and chilled water for heating and cooling. The Vanderbilt CHP power plant, located in the center of the university campus, produces 90 percent of campus heating and 40 percent of campus cooling while providing 23 percent of campus electricity. The power plant has undergone many renovations over the years, and in the summer of 2015, another major renovation was completed. This included the elimination of coal-fired equipment in favor of natural gas-fired equipment, including a new combined heat and power (CHP) unit. The 2015 project increased the efficiency of Vanderbilt's energy system and saves the university $3 million annually while reducing campus greenhouse gas emissions by 30%.

Quick Facts

LOCATION: Nashville, TN
MARKET SECTOR: University, Hospital
GENERATING CAPACITY: 13.5 MW
THERMAL OUTPUT: 460,000 lb/hr @125 psig
FUEL: Natural Gas
IN OPERATION: 1925
LATEST MAJOR RENOVATION: 2015
EQUIPMENT:
- (1) 7 MW Combustion Turbine with HRSG
- (1) 6.5 MW Combustion Turbine with HRSG
- (2) Packaged Boilers
- (2) Steam Turbine Chillers
- (1) Absorption Chiller

USE OF ELECTRIC ENERGY: On-site
USE OF THERMAL ENERGY: Heating and Cooling
EXPANSION INSTALLED COSTS: $29 million
ESTIMATED ANNUAL SAVINGS: $3 million
SIMPLE PAYBACK: ~10 years
ENVIRONMENTAL BENEFITS:
- 75% reduction in NOx
- 99% reduction of SO2
- 50% reduction of Particulate Matter
- 30% reduction of campus greenhouse gas emissions

Reasons for Installing Combined Heat & Power

Several factors led to the decision to upgrade Vanderbilt University's power plant in 2015:

- The coal boilers were near the end of their expected useful life;
- The more stringent emissions standards of the Boiler MACT rule would have required Vanderbilt to install additional air emission controls, resulting in a large capital expenditure and increasing operational and maintenance costs;
- The new CHP system and natural gas boilers translates to increased operational and fuel efficiency; and
- The new CHP system and natural gas boilers reduce greenhouse gas emissions and significantly reduce other air pollutants such as nitrogen oxides, particulate matter and sulfur dioxide.

Prior to the 2015 upgrade, the plant consisted of two 5 MW natural gas-fired combustion turbines, multiple boilers, two steam turbine generators and a dual pressure steam system. Three of the boilers were fueled from both coal and natural gas, operating at a high pressure, which allowed electricity production through the steam turbines. The 2015 upgrades included the installation of a 7 MW natural gas combustion turbine with a heat recovery steam generator (HRSG) and two packaged natural gas boilers. This project also included the decommissioning of the high pressure steam system and coal equipment including the coal boilers, a coal storage silo, the tall coal boiler stack, and the two steam turbine generators. The new system is a single pressure delivery steam system. Additional changes occurred following the major 2015 upgrade, including the 2017 removal from service of one of two older 5 MW combustion turbines, which was replaced with a new 6.5 MW combustion turbine. In 2019, the remaining 5 MW combustion turbine was also removed from service.

CHP Equipment & Operation

Current Equipment and Configuration:

- One 7 MW Combustion Turbine – Solar Turbines Taurus 70
  - Rentech 100,000 lb/hr HRSG
- One 6.5 MW Combustion Turbine – Solar Turbines Taurus 65
  - ERI 100,000 lb/hr HRSG
- Two 1,800 ton Steam Turbine Chillers
- One 1,500 ton Absorption Chiller
- Two Babcock and Wilcox Packaged Boilers

7 MW CHP Gas Combustion Turbine at Vanderbilt

Operation

The combustion turbines are fueled by natural gas and operate 24/7 base loaded. The exhaust gas from these turbines is ducted to two heat recovery steam generators to produce 125 psig saturated steam for the campus district steam system. During the summer, the steam is used to drive two steam turbine chillers and an absorption chiller to provide cooling for the campus. This reduces the electrical demand for cooling and increases the overall efficiency of the CHP system by utilizing as much of the thermal energy as practical. Packaged boilers provide steam for peak demand during heating season.

Construction

The biggest challenge for the project was to maintain the ability to produce steam for the campus with no interruptions while major construction was completed on and around the steam system. Temporary boilers were brought in to provide steam during construction.

Campus Sustainability

Vanderbilt operated coal boilers from 1888 to 2014. Through decommissioning of the coal boiler system and the installation of a natural gas-fired CHP system, campus greenhouse gas emissions were reduced by 30%, sulfur dioxide emissions have been virtually eliminated, nitrogen oxides were reduced by 75% and particulate emissions were reduced by more than 50%.

For More Information

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Issued 04/2022