MIDWEST

CHP Technical Assistance Partnerships

PROJECT PROFILE

University of Cincinnati
Cincinnati, Ohio
47 MW CHP System

Background

The University of Cincinnati Utilities Department is responsible for operating and maintaining two utility plants located on campus. Combined, these plants provide the production and distribution of energy to over 100 campus buildings and 6 area hospitals, totaling over 14,000,000 square feet of occupied space. At the center of the on-campus utility system is a 47 MW natural gas fueled combined heat and power (CHP) system installed in the Central Utility Plant, located in between the East and West campuses. The Central Utility Plant, with its featured CHP system, supplies electricity, low pressure steam, and chilled water to the campus. CHP systems provide much cleaner and more efficient electric power than that generated from large utility generating plants and distributed through the local utility grid. By utilizing the waste heat from the CHP units, the system reaches overall efficiencies between 75% and 85%.

Quick Facts

Location: Cincinnati, Ohio
Market Sector: Universities and Colleges
Campus Size: >14,000,000 sq. ft.; >100 buildings
CHP Generation Capacity: 47 MW
CHP Heat Recovery: Two HRSGs with duct firing: Total capacity (unfired) at 80,000 lbs./hr.; (fully fired) at 240,000 lbs./hr. steam at 600 psig
Prime Movers:

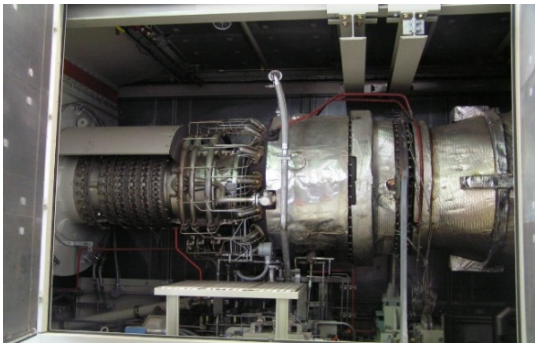
- Two 12.5 MW Solar Turbine Titan combustion turbine generator sets (with low NO_x technology, <5ppm)
- One Dresser Rand 22 MW steam turbine/ generator set

Fuel Type: Natural Gas
CHP Installation: 2004
Thermal Storage Capacity: 6.8 M gallons (chilled water)
Emission Reduction: Annual Avg. 35,000 tons CO_2

Key Decision Drivers & CHP Benefits

One of the key drivers in the University's decision to invest in the natural gas fired CHP system was the **reduction and ultimate removal of coal** from its facilities. In addition, the CHP system with its duct fired heat recovery steam generators (HRSGs) would greatly improve the University's energy reliability by retiring the aged and unreliable coal boilers. The old boilers were experiencing high forced outage rates in excess of 25%. Over the lifetime of the CHP plant, the **forced thermal outages are on an operational trajectory to be less than 1%.** Since startup in 2004, the University's CHP plant has **removed over 700,000 tons of CO_2** from the environment.

The CHP system has been delivering utility grade electricity to the campus and its hospital complex at an availability factor well in excess of 95%. This means that the critical, life-saving function of the hospitals is **no longer as vulnerable to grid outages**. Although the University has not kept record of the number of utility outages avoided by the CHP system over the years, the Director of Utilities relayed a recent incident that occurred in July 2022. Severe storms hit the area, including three confirmed tornadoes. Most of the area surrounding the University lost power, with an estimated 120,000 utility customers affected. **The University's CHP system continued to operate, keeping the University and its hospitals fully operational during the roughly 12 hour electric grid outage.**



Solar Turbine Titan 12.5MW Turbine
Source: University of Cincinnati

In FY2021, the University produced on-site over 80% of its electric load and is expected to produce up to 87% of its electric load in FY2022. The CHP system has fully tested black start capability, allowing the University to start the system without the need of an operating electric grid supporting it. **The electric grid is indeed a backup power supply to the on-site CHP system.**

Capturing the waste heat from the CHP turbines through the HRSGs along with the ability to duct fire the HRSGs provides high quality steam for campus heating, cooling, and/or electric production through an added steam turbine/generator set. This has resulted in an average **$2.5M annual cost reduction** for the University. The flexibility to produce electricity from the excess steam produced through the HRSGs and supplemental natural gas boilers results in the University capable of producing power at $0.0216/kWh with natural gas priced at $3/MCF.

Project Description

In 2004, the University commissioned the CHP system which includes two Solar Turbine Titan 130 natural gas combustion turbine/generator sets each capable of producing 12.5 MW of utility grade electric power. Each turbine/generator set includes a HRSG with duct firing. Fully fired, each HRSG can produce 120,000 lbs. per hr. of 600 psig steam.

The 240,000 lbs./hr. steam from the CHP system is supplemented with large industrial natural gas boilers, which results in a total steam capacity of approximately 721,000 lbs./hr. The steam is distributed throughout the campus at 125 psig for heating. The chilled water and steam are distributed throughout the campus through an underground piping/tunnel system.

New Central Utility Plant (includes the 47 MW CHP system)
Source: University of Cincinnati

The system also includes a Dresser Rand high pressure steam turbine/generator set capable of producing up to 22 MW of additional electric power. Depending on the daily steam load of the campus and the market price for electricity, the University has the option of operating the steam turbine at part or full load along with the two Titan turbine/generator sets to produce up to 47 MW of electric power while satisfying the thermal needs of the campus.

To complete the on campus utility system, the combined natural gas and electric driven chilled water production capacity is 35,100 tons, with two thermal storage units: one located at the East Campus Utility Plant (2.8 million gallons of chilled water) and the second located at the Central Utility Plant (4.0 million gallons of chilled water). The combined 6.8 million gallon thermal storage system provides the University with critical operational flexibility. When electric prices are high, the University can shut down the electric chillers and provide the needed chilled water from the thermal storage system. When electric prices are low, the University recharges the thermal storage system. This flexibility has resulted in the University reducing the cost of producing chilled water for the campus by 60%.

Investing in the Future

The CHP project proceeded with an estimated payback period of approximately 11 years. Since its start up in 2004, the CHP system has averaged just under $6M incremental annual margin, reducing the estimated payback period to less than 10 years. In the last four years, the annual margin has grown to over $10M as a result of the high efficiency and availability of the CHP system, the well below market priced natural gas procured under favorable long term contracts, and the flexibility of utilizing the steam output to both meet the thermal demands of the University and produce additional electric production through the steam turbine generator set.

Lessons Learned

- Utilization of an OEM Maintenance Agreement (including turbine exchanges) has preserved and even enhanced the operability/reliability of the two combustion turbines and allowed the plant to minimize its maintenance staff and overall long term costs.
- Cycling of equipment reduces reliability, and these units were cycled frequently early in their lifespan. Learning how to leverage steam versus electric output of the CHP plant has minimized the cycling, reduced the operational and maintenance costs, and increased system availability and reliability.
- The CHP system provides stable voltage control capability both on campus and to the PJM utility grid. This ensures the reliable and efficient operation of large equipment throughout the campus, while assuring PJM of the quality of the electricity being fed into their grid. PJM will provide the University a monetary incentive for providing the CHP stable voltage control function.
- Monitoring and addressing any issues associated with the University's steam and chilled water system is essential to ensuring maximum operating efficiency of the CHP system, reducing overall operational costs, and preventing system downtime.

"Our CHP system provides us the added reliability we need to provide full energy service to the University, and reduces the overall carbon footprint of the University, while providing the operating flexibility to maximize the economic benefit to the University."
Michael Hofmann
Director, Utilities & Technical Support

For More Information

U.S. DOE Midwest CHP Technical Assistance Partnership

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