MIDWEST

CHP Technical Assistance Partnerships

PROJECT PROFILE

University of Michigan
Decarbonization / Central Power Plant Expansion
16.5 MW CHP Addition

Background

The University of Michigan (U-M) is a public research university. Founded in 1817, U-M is the oldest and largest university in Michigan. It was established 20 years before the territory became a state. Since 1871, U-M has been a coeducational institution. Today, it enrolls approximately 32,000 undergraduate and 16,000 graduate students.

The Central Power Plant (CPP), located on campus, is a highly efficient and reliable source of steam, electricity, compressed air, and domestic hot water for the university's central and medical campuses. U-M completed an expansion of the CPP in January 2022 to enhance electric service reliability while advancing the university's decarbonization goals. The expansion project added a 16.5 MW (rated capacity) natural gas-fueled combined heat and power (CHP) unit (combustion turbine/generator with heat recovery), replaced and upgraded the 13.2 kV on campus electrical switchgear, and installed two natural gas compressors capable of providing the high-pressure natural gas required to operate the onsite combustion gas turbines.

Quick Facts

Location: Ann Arbor, Michigan
Market Sector: Universities and Colleges
CHP Generation Capacity: Rated Capacity 50.5 MW
Prime Movers:
- Two 12.5 MW Backpressure Steam Turbines
- Two 4.5 MW Natural Gas Combustion Turbines
- One 16.5 MW Natural Gas Combustion Turbine

CHP Heat Recovery:
- Two HRSGs with duct firing (each capable of 65,000 lb/hr steam at 400 psi)
- One HRSG with duct firing (capable of 125,000 lb/hr steam at both 400 psi and 60 psi)

Fuel Type: Natural Gas (backup fuel: low sulfur diesel)
Expansion Project Cost (completed in 2022):
- Approximately $100M ($20M for switchgear update; $80M for CHP, gas compressors, and building extension

Key Drivers & Benefits of the CPP Expansion Project

16.5 MW Turbine Generator Set
Source: University of Michigan

U-M initiated the CPP expansion in 2015, completing the project in January 2022. The roughly $100-M project, totally financed by the university, was first recommended in a 2015 report published by the university President's Greenhouse Gas (GHG) Reduction Committee. The report stated that the project "would be the single largest contributor to meeting the 2025 GHG reduction target", which at the time was to reduce emissions on the Ann Arbor campus by 25% by 2025. The addition of the 16.5 MW turbine is estimated to remove 400,000 metric tons of CO_2 over the first ten years of operation. Thanks in large part to this expansion project, the campus's original GHG reduction target was met in 2022, three years ahead of schedule. Today, U-M is committed to procuring 100% of its purchased electricity from renewable sources by 2025 and to eliminate greenhouse gas emissions from direct, campus sources by 2040.

The expansion project also improved the reliability of heat and electricity supplied to the university, for its mission-critical applications. With the addition of the 16.5 MW combustion turbine CHP unit, both the onsite electric generation and steam production capacities increased significantly. The CHP units can operate in an island mode should the local electric grid become inoperative. The local grid and the university's natural gas boilers now function more as backup units, providing the greater utilities reliability required by the university.

The CPP expansion project also included the replacement and upgrade of the 13.2 kV on-campus electrical switchgear. The university has three independent electrical feeds that bring electricity onto campus from the local grid. Each electrical feed is protected by an independent and isolated buss. Should a problem occur on any of the electrical feeds, the transformer shuts down that feed and all campus buildings (circuits) on that feed lose power. The upgrade redesigned the system into a "ring" design, in which all three busses are connected so that if one feed becomes inoperative, the others can pick up the electric load and the university buildings do not lose power. Since the CPP expansion project was completed, U-M has experienced five significant events and, with the new switchgear, has never lost power.

CPP Utilities Operation

The CPP generates steam at 400 psi and 750 ^{0}F from two sources: three heat recovery steam generators (HRSGs) that utilize the waste heat from the CHP units to produce high pressure steam and four traditional water tube boilers that range in capacity from 80K to 200K lbs/hr steam and are fueled by natural gas. From March 2022 to March 2023, the total steam load for the campus was 1,885,327 Klbs. The CHP driven HRSGs provided 64% (1,215,716 Klbs) of the steam, reducing the operating requirements of the natural gas-fueled steam boilers.

Central Power Plant, Univ. of Michigan

Although the CPP generates steam at 400 psi, it is distributed through a series of steam tunnels at 12.5 psi to heat campus buildings and provide domestic hot water throughout the campus. Steam is also distributed to the hospital campus at 60 psi for sterilization purposes. The CPP utilizes two backpressure steam turbine/generator sets to reduce the steam pressure from 400 psi to the required pressure for use on campus. By utilizing backpressure steam turbines, rather than pressure reducing valves, to reduce the steam pressure, the CPP can utilize the energy contained in the pressure drop to generate up to 25 MW of electricity (12.5 MW per turbine/generator set). These units normally operate at 50% to 75% of their rated capacity, depending on the daily steam load of the campus.

The CPP includes two 4.5 MW (rated capacity) natural gas-fueled combustion turbine/generator sets. These CHP units operate 24/7 and can each generate up to 34,944,000 kWhr annually as well as produce up to 65,000 lbs/hr steam through their duct-fired HRSGs. These two HRSGs are equipped with fresh air intake, which allows continued operation should the turbines be inoperative. The CPP expansion project, completed in January 2022, added a 16.5 MW (rated capacity) natural gas-fueled combustion turbine/generator set, capable of generating 144,144,000 kWhr annually. The duct-fired HRSG connected to this CHP unit can produce 125,000 lbs/hr steam at both 400 psi and 60 psi.

The onsite electric generation CHP assets (25 MW steam turbines and 25.5 MW combustion turbines) displace electricity that otherwise would be purchased from the local utility, DTE Energy. From March 2022 to March 2023, campus total electric consumption was 276,968 MkWhr. The onsite CHP units provided 242,292 MkWhrs., or 87% of the annual electric load. For roughly five months of the year, the CHP assets produce 100% of the campus's electric demand.

"The plant's CHP system produces half the emissions as the conventional method of delivering the same energy: utility generated electricity plus boiler produced steam for heat. By recovering the heat from the CHP engine/generators, the CPP produces both electricity and heat at a system efficiency between 75% and 80%."

Melissa Seedorf Utility Results Engineer,
Central Power Plant, University of Michigan

Lessons Learned

- The initial design phase of the project was important for ensuring the inclusion of operational flexibility, system redundancy, and equipment standardization. Commitment to providing the needed technical expertise and continuity during the design phase is critical.
- Involvement of plant personnel during all phases of the project planning, implementation, and commissioning was essential to ensure the efficient transfer and integration of the expansion into the existing system.
- The university benefited from the implementation of a focused training program for plant personnel including the development of standard operating procedures, classroom training, on-line videos, and extended commissioning support.

For More Information

U.S DOE Midwest CHP Technical Assistance Partnership
www.mwchptap.org

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