U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

CHP Case Studies in the Pacific Northwest

Lewis & Clark College: 30 kW Microturbine CHP

Figure 1: Zehntbauer Swimming Pavilion gets heat and electricity from Capstone Turbine

Site Description

Lewis & Clark College, founded in 1867, is an independent college located in Portland, Oregon. Its core is an undergraduate liberal arts college of approximately 1,700 students. Its Graduate School of Education and School of Law offer professional programs to another 1,300 students.

Lewis & Clark has installed a 30-kiloWatt microturbine combined heat and power (CHP) system that provides electricity for a new campus building and heat for the school's swimming pool facility. (**Figure 1**.) The electrical output is utilized 8760 hours per year, as is the available waste heat from the natural gas microturbine. The heat from the turbine exhaust is reclaimed through an air to water heat exchanger. The hot water generated from waste heat reclaim is used to maintain the swimming pool water temperature. Additional heat is available to support facility domestic hot water needs.

A decade earlier when making a much needed replacement decision on its 50 year old steam boilers, Lewis & Clark considered installing a much larger CHP system to meet the needs of the entire campus. However, there wasn't enough year-round thermal load to support such a system. Instead, the college installed a modern, efficient boiler plant.

Though a large CHP project did not make economic sense at the time, the environmental benefits of a CHP project were still of great interest to the college. After completion of the North campus central heating plant in 1994, discussions continued concerning the financial feasibility of a smaller CHP project that would generate electricity for the campus and heat the Olympic-size indoor swimming pool – Zehntbauer Swimming Pavilion.

The resulting microturbine system was installed and commissioned in December of 2003. An official dedication ceremony to showcase the new facility was held on Earth Day (April 22) 2004.

Plant Configuration

Figure 2: The Generator and heat recovery installation

The project consists of a natural gas-fueled microturbine driving an electrical power generator. Electricity from the power generator is utilized within the campus boundaries. Heat from the turbine exhaust is captured in an air-to-liquid heat exchanger, the heat from which is then used to heat the indoor swimming pool. Because the CHP project provides all heat necessary to maintain the pool temperature at 82 degrees Fahrenheit, steam from the large North Central Heating Plant boilers is not needed to heat the pool. In addition, electricity generated by the CHP project will supply more than 40% of the electrical requirements of Howard Hall. Howard Hall is a 52,000 square foot classroom and office building, scheduled for occupancy during January 2005.

The Lewis & Clark CHP plant consists of the following equipment:

- Capstone C30 low-emission natural gas fueled Microturbine with a nameplate rating of 30 kW – net 28 kW to the facility.
- Integral natural gas compressor to bring the campus gas supply pressure from 10psig to 55 psig.
- Unifin MicoGen heat exchanger that extracts 180,000 Btu/hour for pool heating
- Interconnection hardware and software that had been pre-certified by Portland General Electric
- Remote controls and diagnostic package.

Energy/Financial Analysis

Installation of the project equipment began in November 2003 and was completed in December 2003. . Electricity has been generated and the indoor pool has been heated by the Capstone microturbine since December 29, 2003.

Though total project cost was $114,023, total cost to the College was $39,607. The difference, $74,316 was funded by a combination of incentives and tax credits from the Oregon Energy Trust, the CHP Consortium, and the Oregon Office of Energy. Christopher F. Galati, P.E., Director Technology & Conservation for NW Natural was the College's primary contact for developing and funding the project.

Using present electricity costs of $0.068 per kWh, natural gas costs of $0.507 per therm, and $2,000 per year maintenance costs, the project, with incentives, has a payback period to the College of less than 4 years.

Figure 3. The Unit is open for inspection at the Earth Day Dedication

Richard Bettega, Associate Vice President for Facilities said, “The College actively seeks to minimize its impact upon the environment by following sustainable building practices that incorporate energy-efficient design when constructing or renovating buildings. Operation of the recently installed microturbine illustrates how energy, both electrical and thermal, may be generated more efficiently to supply the College’s needs. Direct observation and analysis of the processes involved in this conservation project contribute to the education of our community.”

Electricity from the microturbine is available 24 hours a day at the Pavilion, while “waste heat” from the generating turbine is reclaimed through an air-to-water heat exchanger and provides heat to maintain the temperature of the swimming pool.

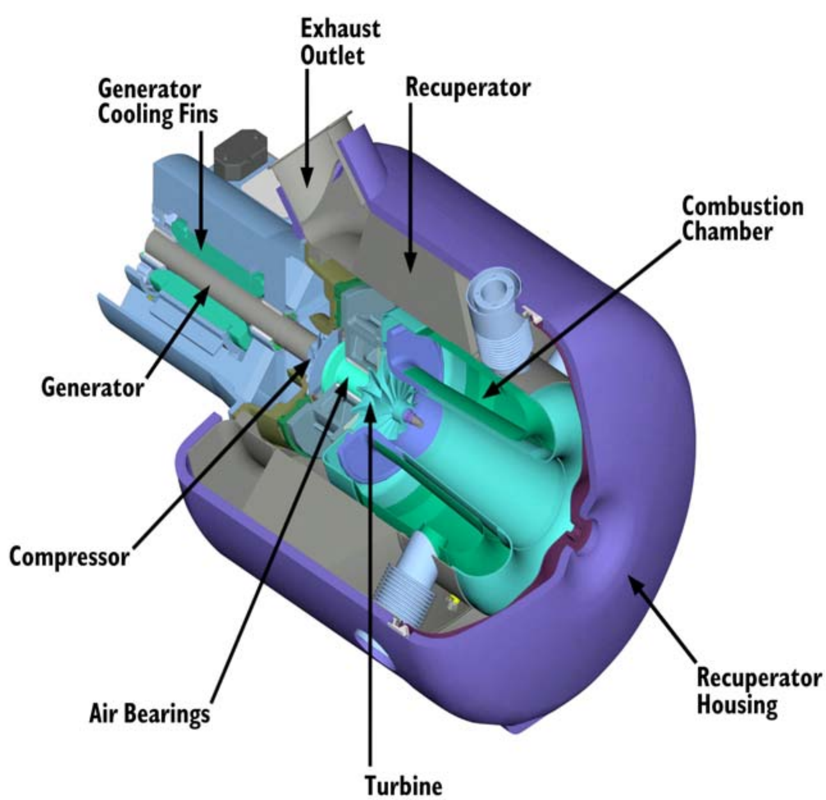
“All the heat recovery – every last bit of energy – is being used,” Galati said. “It has very, very high thermal efficiency.”

Operating Experience and Results

In the nine months since the microturbine went online, the unit has run continuously except for scheduled maintenance.

There has been no need for supplementary heat for the swimming pool; all of the pool heat has come from the thermal energy recovered from the microturbine.

The unit is currently not separately metered for either electrical or thermal output. The rated heat rate (lower heating value) for the unit is 13,100 Btu/kWh or 24.7% electrical efficiency. With heat recovery to produce 165^{o} hot water, the overall efficiency of the fuel input is 80% on a higher heating value basis (88% LHV.)



The Heart of the Capstone Microturbine

The **compressor** increases the pressure of the incoming air-stream by a 3:1 ratio.

Fuel is added to this compressed air in the **combustion chamber**

The additional heat and pressure from the combustion process drives the **turbine** and provides the energy to drive both the compressor and the **high speed generator**.

The compressor and turbine, rotating at nearly 100,000 rpm, ride on **air bearings** so there is no need for an oil based lubrication system.

The **recuperator** extracts heat energy from the turbine exhaust and transfers it to the inccoming air-stream increasing the efficiency and reducing fuel consumption.

These ratings are based on gross output from the unit. A small amount of parasitic electric energy is used to drive the built in natural gas compressor.

On hot summer days, the unit output drops and the heat rate increases. This is a natural characteristic of turbine engines. Contribution to electric load declines somewhat but recoverable thermal energy increases, so the overall efficiencies remain fairly constant.

Environmental Profile

The Capstone C30 microturbine has very low emissions of criteria pollutants. NOx emissions are certified by Capstone Turbine Corporation to be less than 9ppm at 15% oxygen.

The system also reduces the overall production of carbon-dioxide, a contributor to global warming, compared with separate production of hot water in the campus boiler and production of electricity from the most efficient natural gas fired combined cycle power plant.

Lessons Learned

The system shows how a closely-coupled CHP system can be effectively utilized for energy savings within a much larger facility.

Future Plans

According to Richard Bettega, the college would like to put more microturbines in place on the campus. They are considering two 60 kW Capstone units.

Organizational Profile

General Contractor: EC Company
Engineering Design: CBG Consulting Engineers
Mechanical Design: R&W Engineering, Inc.
Local Gas Utility: Northwest Natural Gas Company
Local Electric Utility: Portland General Electric Company

Hoffman Construction of Oregon fabricated and donated the equipment base for the Capstone microturbine and heat exchanger located on the central plant roof.

Chris Galati, NW Natural's Director of Conservation and Technology.Locally, Galati is promoting and assisting the work of the Combined Heat and Power Consortium, an association of private utilities, government agencies and companies that collaborate to install, study and publicize combined heat and power (CHP) projects in commercial applications.

Contacts

Christopher F. Galati – Director, Conservation and Technology, Northwest Natural Gas Company
503-226-4211 x2472

Richard Bettega – Associate Vice President for Facilities, Lewis & Clark College
503-768-7850

For information on other case studies contact:

Ken Darrow
Energy and Environmental Analysis, Inc.
West Coast Office
Bellevue, Washington
425-688-0141