Sheboygan Wastewater Treatment Plant

BACKGROUND

State and local governments are constantly looking for ways to reduce operating costs for public services. Although some investments can have a large upfront capital cost, they can end up saving taxpayers money over time. The Sheboygan Regional Wastewater Treatment Plant (WWTP), located in Sheboygan, Wisconsin along Lake Michigan, provides wastewater collection and treatment to approximately 68,000 people in the surrounding area and provides a useful example of how local governments can make common sense investments to improve the energy efficiency of public services.

In 2002, the city of Sheboygan carried out a plant-wide assessment to identify opportunities to reduce the WWTP's energy consumption and power costs. After a thorough evaluation and implementation of other energy efficiency measures, the city decided to install a combined heat and power (CHP) system.[1]

The new CHP system, composed of ten 30 kW Capstone microturbines using about 160 MCF of digester gas per day, came on line in 2006.[2] Two additional microturbines began operating in December 2010, increasing the total capacity of the CHP system to 700 kW (equivalent to the plant's daytime electrical load).

The plant is expected to attain a 90 percent cumulative energy saving and will be able to sell energy back to the grid.[1, 2, 3] These energy savings mean less taxpayer dollars will be needed to treat the city's wastewater and biosolids.

PROJECT ECONOMICS

The city of Sheboygan teamed with the local power utility, Alliant Energy, to secure the required funds for the original CHP project. Alliant provided and owns the ten 30 kW microturbines and the digester gas treatment equipment. Sheboygan Regional WWTP owns the heat recovery system and has the option to purchase the microturbines and digester gas treatment equipment after 6 years of operation for $100,000.[3]

Figure 1. 10-30 kW Capstone Microturbines. (Source: Day, 2010)

The total cost to develop and construct the original ten 30 kW microturbine CHP system was $1.2 million, of which Sheboygan paid $200,000 for the heat recovery equipment. The project was funded in part through a $20,000 grant from Wisconsin Focus on Energy. The estimated payback for the original CHP system is about six years. Since the installation of the original CHP system in 2006, the city of Sheboygan has saved over $150,000 per year as a result of CHP operation and other energy efficiency gains achieved at the WWTP.[3] By replacing old non-CHP equipment with new, more energy-efficient equipment, the Sheboygan Regional WWTP has been able to reduce energy consumption by about 20 percent.

Figure 2. 2-200 kW Microturbines. (Source: Zahreddine, Phil and Dale Doerr, 2012)

Funding to install the two additional 200 kW microturbines in 2010 was obtained through a $1.2 million loan, which Sheboygan anticipates to have paid back in five years thanks to energy cost savings. Additionally, Focus on Energy provided a $205,000 grant to help fund the expanded CHP system. Sheboygan covered the remaining $100,000 project cost.[3]

Sheboygan's investment in CHP and energy efficiency has been proven to significantly increase in value over time, and cost savings at the plant are expected to continue to grow as natural gas and electricity rates continue to increase.

SYSTEM COMPONENTS[3]

Each of Sheboygan's CHP systems has a dedicated digester gas treatment system. The methane gas used to fuel the microturbines is collected from the wastewater and biosolids the city was already treating. By capturing this resource Sheboygan is able to provide electricity and thermal energy to run the plant. Sheboygan's four anaerobic digesters produce around 490 MCF of digester gas per day. A compression system increases digester gas pressure to about 90 psig, which is then used by the microturbines. Digester gas fuels the two microturbine-based CHP systems, both firetube boilers, and the engine-driven influent wastewater pump.

Microturbine exhaust is diverted to two heat exchangers that convert the exhaust heat to useable heat for the anaerobic digesters. The original CHP system recovers approximately 877,000 BTUh of heat for use in anaerobic digestion. The plant's two 3.8 MMBTUh fire-tube boilers provide any remaining heat that is required for digester operation and facility heating. Overall, the microturbine heat recovery system and the fire-tube boilers have reduced the WWTP's natural gas consumption by almost 80 percent.

ENERGY EFFICIENCY EFFORTS

Sheboygan WWTP has invested close to $1.3 million in energy efficiency projects, which have reduced the plant's utility costs by around 40 percent while earning revenue from renewable energy and emission credits. Through 2013, the total savings and revenue from that work are estimated at $1.5 million — representing a payback period of seven years. Examples of the plant's energy efficiency projects include:

- Efficient sludge boilers that cut natural gas consumption by 78 percent and saved an average of $155,000 annually.
- Variable-frequency drives and premium-efficiency motors for lift pumps, cutting electricity usage by about 30 percent annually.
- High-efficiency single-stage, centrifugal air compressors and airflow control valves, cutting electricity use for aeration by 20 percent annually.
- A pump overload monitoring system.
- An automated chlorination control system. (Source: Day, 2010.)

Sources:

[1] Day, Doug. "Savings Everywhere: Microturbine Cogeneration and Other Energy-Efficiency Measures Help a Wisconsin Treatment Plant Toward the Goal of Being Energy Neutral." Treatment Plant Operator Magazine, 2010.

[2] Willis, John, et al. "Barriers to Biogas Use for Renewable Energy." Water Environment Research Foundation and nyserda, 2012.

[3] Wiser, Jason, et al. "Evaluation of Combined Heat and Power Technologies for Wastewater Facilities." Columbus Water Works, 2012.