Savings Everywhere

MICROTURBINE COGENERATION AND OTHER ENERGY-EFFICIENCY MEASURES HELP A WISCONSIN TREATMENT PLANT TOWARD THE GOAL OF BEING ENERGY NEUTRAL

By Doug Day

The new Capstone microturbines at the Sheboygan Wastewater Treatment Plant produce 60,000 therms of energy per year, reducing the plant's natural gas usage by 40 percent. (Photos by Jim Kneiszel)

What's Your Story?

***TPO* welcomes news about environmental improvements at your facility for future articles in the Greening the Plant column. Send your ideas to editor@tpomag.com or call 877/953-3301.**

Clean water may not be the only thing coming out of the Sheboygan (Wis.) Regional Wastewater Treatment Facility in a few years. If all goes as planned, the plant may be sending electricity to the grid at times rather than just using power from outside sources.

Plant superintendent Dale Doerr.

Energy-efficiency projects have already sliced the plant's utility costs by about 40 percent while earning revenue from renewable energy and emission credits.

"This is a business," says plant superintendent Dale Doerr. "We try to save money for the ratepayers. When we do projects, the first thing we look at is energy efficiency. We can't control what energy costs, but we surely can control how much we use."

The installation of 10 digester-gas-fueled microturbines for cogeneration has greatly reduced the plant's use of natural gas and has ended the practice of flaring methane — good for the environment and good for ratepayers, who pay among the lowest rates in the state. Other recent projects include:

- New and more efficient sludge boilers.
- Variable-frequency drives and premium-efficiency motors for lift pumps.
- High-efficiency single-stage, centrifugal air compressors and airflow control valves.
- A pump overload monitoring system.
- An automated chlorination control system.

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ENERGY NEUTRAL?

Since 2006, the plant has cut its carbon dioxide emissions by about 3 million pounds, equivalent to planting 8,400 trees. Doerr says the plant could become "energy neutral" in the next three to five years.

The new blowers and airflow control valves have also improved the plant's nutrient removal process and have made it more stable, resulting in less phosphorous and nitrogen going into Lake Michigan. Doerr credits an excellent staff and forward-thinking decision-makers for the plant's success.

The 18.4 mgd secondary treatment plant serves 68,000 people in the Lake Michigan cities of Sheboygan and Sheboygan Falls, the village of Kohler, and four townships. Doerr came on board in 2000 and immediately added half a million dollars to the budget, about a 10 percent increase, to cover a maintenance backlog.

"It had a minimal impact on rates that first year, and it's been in there ever since," he says. "After six years, we got caught up on maintenance and started concentrating on energy efficiency."

COGEN ON HIS MIND

Despite using biogas to fuel boilers for digester heat and a 500 hp engine for an influent pump, about 25 percent of the plant's biogas used to be flared off — about 50,000 cubic feet per day. To Doerr, that was a waste of fuel.

A 2003 study pointed toward cogeneration, but it took two years before the plant found a workable strategy and a partner: Alliant Energy-Wisconsin Power & Light, the local utility and a distributor of Capstone microturbines.

"They said they would pay for the electrical generation part of the project if we paid for the heat recovery and building modifications," says Doerr. The utility also agreed to pay for gas compression and filtration and, after some negotiation, agreed to pay for the Cain heat exchangers, as well. Unison Solutions managed the construction project and designed and built the gas treatment and compression system.

Two newer, more efficient sludge boilers from Hurst Boiler & Welding replaced three less-efficient boilers. The boilers heat water used in a hot-water loop that heats the Sheboygan plant. BELOW: Dale Doerr checks readouts on the new gas conditioning skid (Unison Solutions), which removes moisture, compresses gas and removes siloxanes, cleaning the fuel to drive the microturbines.

The total project cost was $1.2 million, of which Sheboygan paid only $205,000, funded in part through a $20,000 grant from Wisconsin Focus on Energy. The payoff was big once the 300 kW project went online in February 2006. "We recovered nearly all our money in the first two years," says Doerr.

The plant still pays the utility for the annual 1,660 MWh net output of electricity from the microturbines. But the plant gets monthly payments from Alliant Energy for monitoring the system, keeps the revenue from selling renewable energy credits, and realizes all the savings from reduced use of natural gas enabled by heat recovery.

Capstone heat recovery modules capture heat at about 1 million Btu/hr (about 65,000 therms per year) to keep the digesters at their proper operating temperature of 95 degrees and to heat plant buildings.

MICROTURBINE SAVINGS AND REVENUE

YEAR	NATURAL GAS SAVINGS	PAYMENT FROM UTILITY	RENEWABLE ENERGY CREDITS (REC)	FOCUS ON ENERGY GRANT	ANNUAL SAVINGS	TOTAL SAVINGS
2006	$56,519	$23,372	$3,000	$20,000	$102,891	
2007	$56,911	$27,118	$6,000		$90,029	$192,920
2008	$61,686	$25,730	$5,100		$92,516	$285,436
2009	$44,294*	$27,230	$1,492**		$73,016	$358,452

*Savings reduced by cut in natural gas rates,
** Revenue dropped from $3.15 per REC to $0.95.

GETTING MORE VALUABLE

With energy prices increasing, the efficiency investment is growing in value. The plant spends about $380,000 a year for energy, according to Doerr. Natural gas rates have about doubled since 2002 and electricity rates have increased about 70 percent. "Our bill has remained flat during that time," Doerr says. The plant's ENERGY STAR efficiency rating, which was 29 in 2003, is now 89.

It will get even better in 2013, when the plant can buy the microturbines from Alliant Energy. "At that time, we anticipate the microturbines will be generating about $150,000 worth of electricity, and we'll be able to buy them for $100,000," Doerr says. While there will be some maintenance costs, the electricity will essentially be free.

MICROTURBINE ENERGY PRODUCTION

YEAR	ELECTRICAL GENERATION	ELECTRICITY COST	HEAT GENERATION	NATURAL GAS COST AVOIDED
2006	1,591 MWh	$105,788	60,449 Therms	$56,519
2007	1,682 MWh	$121,095	66,369 Therms	$56,911
2008	1,666 MWh	$122,966	65,602 Therms	$61,686
2009	1,621 MWh	$120,897	60,246 Therms	$44,294

That will make the methane even more valuable, as well. The plant has already taken steps to increase methane production. High-strength food processing waste is added directly to the anaerobic digesters. The higher BOD increases methane production by as much as 90 percent, creating even more fuel while reducing processing costs for the industries that provide the waste product. Food pro-cessors such as cheese plants used to pay about $120 per thousand gallons for treatment and now pay about $30.

MORE SAVINGS

The microturbine project came after years of planning. The plant's biggest energy-saving project came from an unplanned maintenance need in 2005 when one of three 2.3-million-Btu sludge boilers failed. With two other boilers the same age, the staff decided to replace all of them with two 3.8-million-Btu boilers.

The new boilers were also tied into the building's heating loop. The reclaimed heat, formerly a waste byproduct, now heats the plant's buildings about 10 months out of the year. That project alone reduced natural gas consumption by 78 percent. The $350,000 project saved around $110,000 over the first two years, and nearly $200,000 in each of the next two years as natural gas rates went up.

Doerr now plans to purchase two more 200 kW Capstone microturbines for the cogeneration system next year, increasing generating capacity to about 700

This ALMiG variable speed air compressor was added early in 2010 to replace two less-efficient models. The unit will pay for itself in energy savings in three years.

kW — equal to the plant's normal daytime electrical load. Nighttime load can drop to about 450 kW. "There will be times at night when we'll be pushing energy back onto the grid," he says.

He also plans to install a hydroturbine in the near future. The plant sits 50 feet above Lake Michigan, and from there the effluent discharge can provide enough energy to add another 20 to 40 kW of generating capacity.

Also on the table are a lighting idea and a solar energy project. "We have 50 outdoor lights that run all night long," Doerr says. "We've been looking at solar lighting, but that can be pretty expensive. Right now we're looking at converting the lights to LEDs that use half the energy of high-pressure sodium bulbs." A 2 MW solar electric project is also under consideration for the 225,000-square-foot plant roof.

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IMPACT ON OPERATORS

Like all technology, upgrades can have negative and positive effects on users. Operators at the Sheboygan plant can tell at any time where the plant's power demand is coming from with the help of nine Allen-Bradley, a division of Rockwell Automation, power monitors.

"Every equipment base has a power meter that reports to our SCADA system so operators can see where power is used," says Doerr. "We've put in equipment that took some of their work away, like airflow control valves. Before that, they'd have to go around when the water temperature changed and make adjustments to the aeration basins. They don't have to do that now."

There are also items they have to watch now that they didn't look for in the past. "We don't want to run equipment when we're at a certain level of electrical power demand," says Doerr. "We want to stay below a peak of 750 kW, unless it's raining. Operators have to be more cognizant of what's running."

Doerr says many wastewater treatment plants could do what Sheboygan has done. "You put a plan together and sell it to the people who make the decisions," he says. "These things weren't done blindly. You have to do the research and do your homework." tpo

ALWAYS GETTING GREENER

The Sheboygan Regional Wastewater Treatment Facility has invested nearly $1.3 million in energy-efficiency projects in the last five years. Through 2013, the total savings and revenue from that work is estimated at $1.5 million — an overall payback of about seven years. Among the projects, the plant:

- Installed variable-frequency drives and premium-efficiency motors at lift pump stations and on influent pumps, cutting electricity usage by about 30 percent.
- Replaced two 250 hp variable-frequency drive positive displacement blowers in 2005 with Turblex Inc., a Division of Siemens Water Technologies, high-efficiency 350 hp single-stage centrifugal air compressors and airflow control valves, cutting electricity use for aeration by 20 percent.

The plant also tested a Strantrol 960 dual oxidation control system from U.S. Filter Corporation (now Siemens Water Technologies) for the control of the chlorination system. Since the plant is unstaffed at night, it was common to have excess chlorine and bisulfite when flows went down at night.

Since the installation, the total cost of disinfection has dropped nearly 50 percent, from $173,000 in 2000 to just under $95,000 in 2009. All told, the plant has saved more than $1 million on chemicals while reducing the environmental impacts of overuse.

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