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Thorough Mixing at Lower Energy Requirements
New Energy Revolution in Massachusetts City

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Massachusetts City Becoming an Important Part of Today's "New Energy" Revolution

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Abstract

The City of Pittsfield, Mass., and Kleinfelder/S E A explored the feasibility of combusting digester gas produced in the anaerobic digestion of sludge at the city's wastewater treatment facility in a combined heat and power (CHP) system to produce recoverable waste heat and electricity. It is estimated the city could reduce its electricity bill by 30 percent annually, generating an annual net savings of over $200,000. The study concluded that the CHP system would have a payback period from 5 to 8 years, depending on which federal, state, regional and third-party financial incentives and credits are leveraged. Based on the findings of both the feasibility study and a preliminary design, the final design was completed, and construction began in April 2010.

Keywords
combined heat and power, CHP, anaerobic digestion, digester gas, wastewater treatment, electricity generation, microturbines

Microturbines play an important role in the country's "new energy" revolution. "Green," cost effective, and adaptable to a wide array of applications, they are used to provide on-site and self-contained electricity and heat at many locations in the country.

Pittsfield is becoming an important part of this new energy revolution. The construction phase for an upgrade to the city's wastewater treatment facility, an upgrade that addresses the issues of renewable energy and energy efficiencies, began in April 2010.

The wastewater treatment facility features an anaerobic digester in which some of the digester gas being produced is flared. A combined heat and power (CHP) system will be installed, comprising three 65-kW-rated, skid-mounted microturbines for a total rating of 195 kW. The microturbines will be fueled by the digester gas.

Figure 1 presents a simplified process schematic of how the CHP system will be integrated into the plant's infrastructure.

Pittsfield will reap many benefits from this project. Along with reduced environmental impact, the city will benefit from a reduced utility bill, since the digester gas will be used to generate both electricity and heat for on-site use. In addition, the plant will generate approximately $45,000 a year in revenue through the Renewable Energy Credit market.

Another vital aspect of the project is the example Pittsfield is setting for other cities and towns by demonstrating how municipalities can be both economically savvy and environmental stewards at the same time.

The Design

Design for the upgrade to Pittsfield's wastewater treatment facility includes:

- Installing a brick-and-block building to house the entire CHP system
- Allowing space for a fourth microturbine should the city decide to expand
- Furnishing and installing three double-disc digested sludge transfer pumps to replace the progressive cavity pumps
- Replacing the existing shell and tube sludge heat exchanger with one 1.2 MMBTU/hr spiral heat exchanger
- Installing sufficient instrumentation to

monitor sludge and hot water temperatures, pressure drops across the sludge heat exchanger in the sludge and water lines, and instrumentation to automate sludge mixing through using a timer and interlocking mixing operations with sludge pumping

How the CHP system will work

The solids processing infrastructure at the wastewater treatment facility includes: primary and waste-activated sludge pumping; gravity belt thickeners; thickened waste activated sludge pumps; secondary and primary anaerobic sludge digesters; belt filter presses; and dewatered sludge pumps. The purpose of this infrastructure is to reduce the overall mass and volume of sludge for disposal.

Anaerobic digestion at the facility is a two-stage process. The first stage facilitates the destruction of volatile solids through active heating and mixing. Heating of the primary digester is accomplished by re-circulating sludge from the primary digester through a heat exchanger located within the digester building, while mixing is accomplished by re-circulating compressed digester gas from the headspace of the primary digester to the bottom of the vessel through lances. In the second stage of the anaerobic digestion there is no active mixing or heating of the sludge; instead, there is solids-liquid separation through quiescent settling of the sludge.

A byproduct of this anaerobic sludge digestion process is digester gas, which primarily comprises methane (approximately 62 percent by volume) and carbon dioxide. Under the current system this digester gas (which has a heating value of approximately 620 BTU/SCF) is used as fuel for boilers located in the plant's pump and power building. The boilers are then used to heat a water loop, which heats the sludge in the digesters and maintains it at the optimal temperature for anaerobic digestion.

Any excess digester gas is used to heat the pump and power building in the winter or is flared through a waste gas burner located on the top of the digester building. The amount of digester gas flared would be minimized significantly under the proposed CHP system.

The design calls for diversion of the digester gas to a fuel gas conditioning system that removes water vapor and siloxanes from the digester gas and boosts the pressure of the gas prior to it being supplied to the microturbines. Siloxanes are silicone-based compounds contained in many health and beauty care products. The pressure of the digester gas as it enters the fuel gas conditioning system is at approximately 10 inches H_2O. A gas blower increases the pressure to approximately 3 psig before the gas is directed through a series of heat exchangers to reduce the temperature prior to further compression. A coalescing filter removes entrained water from the gas stream prior to it entering the siloxane scrubber vessel. This vessel contains activated carbon upon which the siloxanes adsorb as the gas passes through the media bed. After final compression of the gas to approximately 85 psig and subsequent moisture removal following compression, the gas is ready to be supplied as fuel gas to the microturbines.

The conditioned digester gas will fuel the microturbines, generating electricity and heat to meet the plant's baseload demands. The plant's minimum average electrical load is 400 kW with peak monthly average kW usage as high as 700 kW. Based on operating two of the microturbines at full output and the third unit at full output approximately 50 percent of the time, it is estimated that the CHP system will meet approximately 30 percent of the electrical baseload demand.

The waste heat created in the exhaust of the CHP system will be used in a heat exchanger, referred to as a heat recovery module (HRM) in the vendor's literature, to produce hot water, which will then heat the sludge in the primary digester and as building heat in the digester building. Use of the existing boilers in the plant's pump and power building for sludge heating and building heat may still be required, as it is anticipated not enough heat will be generated to meet the peak sludge heating requirements under design winter conditions. However, operation of the microturbine system is expected to reduce the need for operation of the boiler system, so a reduction in the volume of required diesel fuel is anticipated.

Figure 1 provides a detailed process flow schematic of the various process streams discussed above.

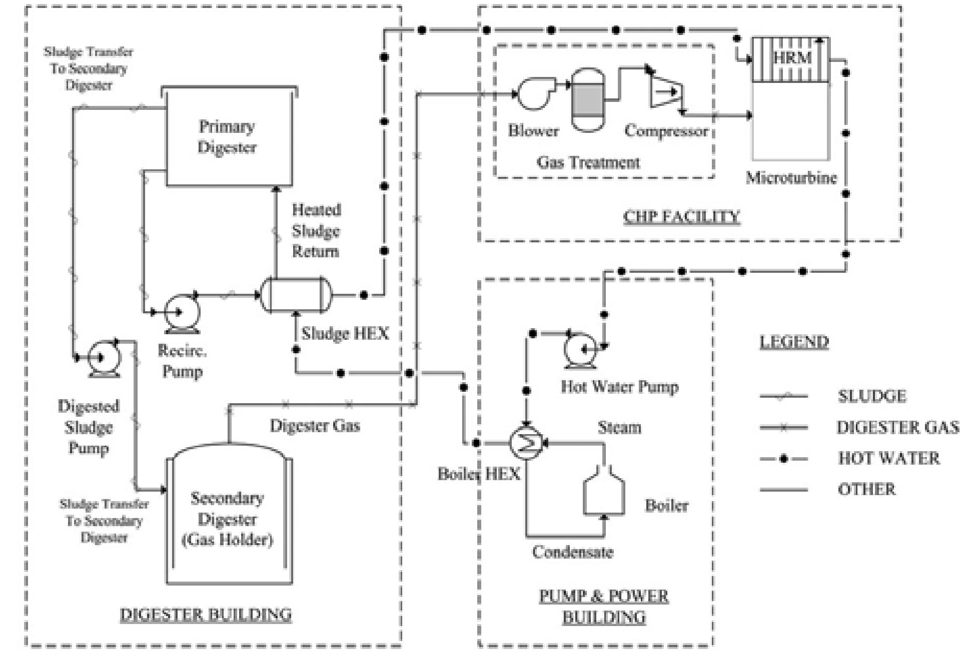

Figure 1. Process Flow Diagram for Energy Recovery from Digester Gas

The "new energy" revolution

The construction cost of this project, which includes both the CHP system and other plant upgrades, is approximately $2 million. Operation of the CHP system at the Pittsfield wastewater treatment facility is expected to reduce the plant's electric bill by 30 percent—saving taxpayers over $200,000 a year—and have a payback period from 5 to 8 years. This payback period was estimated prior to the city receiving ARRA stimulus funding for the entire project. Additionally, the city received a $400,000 grant from the Massachusetts Technology Collaborative under its Large On-Site Renewables Initiative.

Aside from the project's beneficial financial and environmental outcomes, the project could be a template for other municipalities considering microturbine projects for their communities. Currently, only one other known community in New England that uses microturbines and digester gas to produce electricity for a wastewater treatment plant is Essex Junction, Vt., which installed two 30-kW-rated microturbines in 2003.

What Essex Junction and Pittsfield already know, the rest of this area of the country may soon be learning: Microturbines are a vital part of today's "new energy" revolution. ■