Energy Savings for WWTFs

Combined heat and power (CHP), also known as cogeneration, can be an excellent solution for controlling energy costs while improving the reliability of power and thermal energy supplies for your wastewater treatment facility (WWTF). With a well-designed CHP system, your facility can:

- Produce power at a cost below retail electricity.
- Reduce operating costs by displacing purchased fuels for thermal needs.
- Ensure the availability of reliable heat and electricity supply.
- Increase energy efficiency, reduce greenhouse gas emissions, and generate renewable power.

CHP is the production of both power and heat from a single fuel source. CHP is a reliable, cost-effective option for WWTFs that have, or are planning to install, anaerobic digesters. The biogas flow from the digester can be used as "free" fuel to generate electricity and power in a CHP system using a turbine, microturbine, fuel cell, or reciprocating engine. The thermal energy produced by the CHP system is then typically used to meet digester heat loads and for space heating. By making use of the waste heat from onsite electricity production, CHP increases fuel efficiency and decreases energy costs.

CHP has the greatest technical and economic potential at WWTFs that have anaerobic digesters and influent flow rates greater than five mgd. Anaerobic digestion continuously produces biogas that contains about 60 percent methane. The biogas generated from each 4.5 mgd of influent flow generates approximately 100 kW of electricity and 12.5 million Btu of thermal energy in a CHP system. The electricity and heat can be used for a variety of purposes:

- To sell back to the grid as green power.
- To operate pumps and blowers used throughout the treatment process.
- To maintain optimal digester temperatures, dry the biosolids, and provide space heating for the WWTF.

A variety of CHP technologies can be used at WWTFs. Reciprocating engines are the most widely used CHP systems and can be employed at facilities with any influent flow rate. Microturbine and fuel cell CHP systems up to approximately one MW can be employed at facilities with influent flow rates less than 50 mgd. Combustion turbine CHP systems greater than one MW are an option for facilities with influent flow rates greater than 50 mgd.

Engineering Rules of Thumb for Considering CHP at a WWTF

- A typical WWTF processes 100 gpd of wastewater for every person served.
- Approximately 1.0 cu ft of digester gas can be produced by an anaerobic digester per person per day. This volume of gas can provide approximately 2.2 watts of power generation.
- The heating value of the biogas produced by anaerobic digesters is approximately 600 British thermal units per cu ft.
- For each 4.5 mgd processed by a WWTF with anaerobic digestion, the generated biogas can produce approxi mately 100 kilowatts of electricity and 12.5 million Btu of thermal energy.

What Can CHP Do for You?

Reduce Energy Costs. A well-designed CHP system can be an attractive investment for your WWTF. A CHP system allows your facility to generate both electric and thermal energy on site, offsetting the costs of grid power and purchased fuel.

A market analysis developed by EPA's CHP Partnership (available at www.epa.gov/chp/markets/wastewater.html) estimates the net cost to generate power for three representative CHP systems at a WWTF. Depending on the WWTF, costs can range from:

- 3 cents per kilowatt-hour (kWh) to 6.5 cents/kWh for a 126-kW microturbine.
- 9.1 cents/kWh to 10.2 cents/kWh for a 300-kW fuel cell.
- 0.1 cents/kWh to 3.8 cents/kWh for a one-MW reciprocating engine.

Although the economics of CHP at WWTFs are often attractive, in states where electricity prices are low, burning biogas directly in boilers for onsite heating needs might be more economical.

Ensure the Availability of Heat and Electricity Supply. CHP systems provide critical power and thermal reliability for WWTFs by producing power and heat 24 hours per day, seven days per week. CHP integrates seamlessly into existing heating and electrical systems and provides a steady supply of hot water or steam. A CHP system can also be configured to provide backup power in the event of a utility outage so operations can continue during a blackout or catastrophic event.

Increase Energy Efficiency, Reduce Greenhouse Gas Emissions, and Generate Renewable Power. With CHP, improved efficiency means that your facility uses less fuel; therefore, operating and maintenance costs are reduced, while environmental performance is improved. The power and heat produced on site by the CHP system displaces purchases of electricity and fuel for boilers. The same reductions in purchased electricity that result in energy cost savings also reduce the environmental impact of WWTF operations by reducing air pollution.

On a national scale, if all WWTFs that operate anaerobic digesters and have influent flow rates greater than five mgd were to install CHP, about 340 MW of clean electricity could be generated, offsetting 2.3 million metric tons of carbon dioxide emissions annually. These emission reductions are equivalent to removing approximately 430,000 cars from the road.

Additionally, because the biogas produced by WWTFs is considered renewable by most state renewable portfolio standards and third-party green power certification programs, the environmental attributes of electricity generated by CHP systems at WWTFs can be sold as renewable energy certificates (RECs). The monetary value of the REC sale may be used to defray the capital costs of the CHP system to further improve project economics.

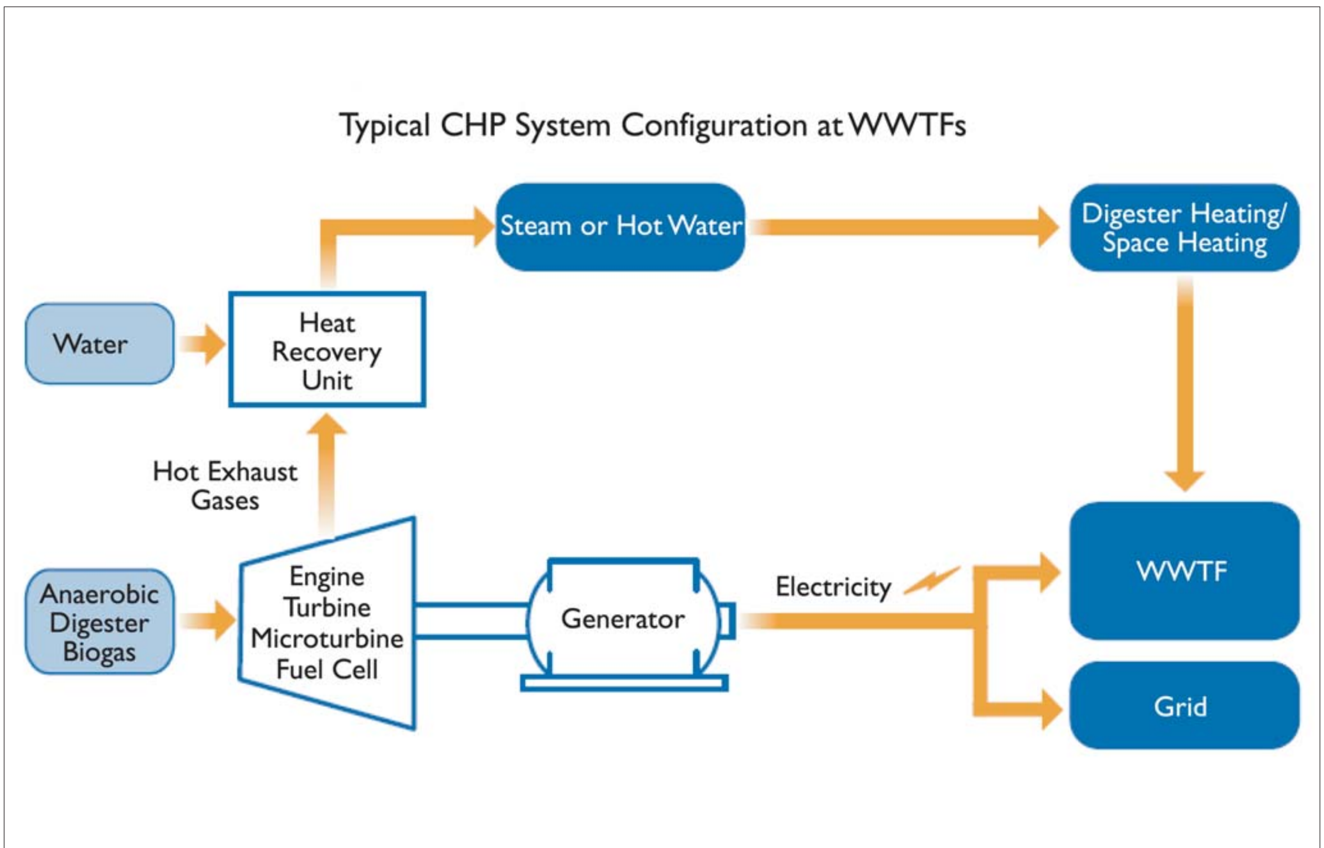
Case History

The Columbia Boulevard Wastewater Treatment Plant (CBWTP) in Portland, OR, is the largest water treatment facility in the state. Operated by the Bureau of Environmental Services (BES) of the City of Portland, the plant treats an average of 80 to 90 mgd. The plant is the collection point for hundreds of miles of sewer pipe throughout the city powered by dozens of pumping stations. The plant takes the wastewater through several processing steps before returning clean water to the Columbia River. Left behind are tons of biosolids that are themselves treated extensively before being dried and removed for use as a fertilizer on dry pasture land outside the city.

A key part of the biosolids processing are anaerobic digesters that produce a combustible gas composed primarily of methane and carbon dioxide (600 Btu/standard cu ft). The city sells some gas to a nearby industry, heats plant buildings and digesters with some, and flares the rest.

In 1993, Portland adopted a strategy to reduce climate change through reduction in the production of carbon dioxide from combustion of fossil fuels. One of the recommendations contained in that strategy was to find ways to effectively utilize the anaerobic digester gas (ADG) produced at the Columbia Boulevard Wastewater Treatment Plant. Several options for cleaning up, compressing, and transporting the fuel were explored.

During the consideration of options the CBWTP experienced extended power outages, in December 1995 and again in February 1996. These outages caused the shutdown of the control center that provides essential communication with over 100 pump stations throughout the community. To avoid this problem in the future, it was decided that the critical process control center needed to have back-up power so that the BES could maintain communication and control of remote facilities during power outages. The facility was faced with installing back-up diesel gen-



erators and an uninterruptible power system.

At the same time, Portland made a deal with Portland General Electric (PGE) to consolidate billing for several of its facilities. The resulting change provided a much lower rate. Because of the city's strong commitment to sustainable development and protection of the environment, the decision was made to return part of the rate savings to PGE as a green power premium for PGE to build 500 kW of wind power capacity. Rather than build the green power themselves, PGE later returned the entire amount of the green power premium to BES to install a 200-kW fuel cell running on renewable anaerobic digester gas. The facility would produce continuous renewable power while at the same time solving the plant's need for a second supply source to protect the control center during grid power outages.

The energy office within the city's Department of Sustainable Development spearheaded the plans to demonstrate a clean green power project at one of its own facilities. The office coordinated the development of the project including securing hundreds of thousands of dollars in grants and rebates that reduced the project capital cost by almost half.

The nominally 200-kW system provides continuous power for the facility and waste heat for the maintaining process heating requirements. The fuel cell began operating in 1998.

In 2003, a four-pack of 30-kW Capstone Microturbines (www.capstoneturbine.com) was installed as an additional power supply. The microturbines were run briefly before being shut down for modifications. The microturbines were restarted in November 2004.

The fuel cell plant consists of the ONSI PC 25C fuel cell with integrated fuel reforming. The raw ADG must be treated by the gas processing unit (GPU.) The GPU consists of a dual set of tanks containing activated carbon that absorbs hydrogen sulfide and halogens. An air metering pump provides a small amount of air for proper operation of the carbon beds. A compressor provides pressure boost for the microturbine to raise the pressure of the ADG from seven in. of water to 75 psig.

One of the biggest challenges for operating power generation on digester gas is the design and integration of the fuel clean up system. Digester gas is saturated with moisture. Excessive moisture in the fuel causes problems for turbine and engine operation. In addition, the raw digester gas contains carbon dioxide, hydrogen sulfide, chlorine compounds, and organic silicon compounds called siloxanes. The chlorine and hydrogen sulfide introduce acids that damage the prime movers. The siloxanes cause deposition of silicon dioxide and erosion of the turbine rotor.

The facility experienced a number of problems in integrating the fuel clean-up systems with the power generation systems. The fuel cell proved sensitive to air in the fuel stream, causing an upset in the control system; however, air was needed by the carbon beds to aid in removal of hydrogen sulfide. There were also problems calibrating the hydrogen sulfide monitors to measure the low concentrations in the digester gas.

The original microturbine installation had to be modified because the desiccant bed provided inadequate drying of the gas. A gas dryer was added to supplement the desiccant. In addition, the pressure drop in the carbon beds produced a negative gauge pressure in the fuel line going into the gas compressors. The original compressors were changed out to maintain a positive pressure, thereby eliminating the possibility of a leak creating an explosive air fuel mixture going into the hot compressors.

The fuel cell that has been running now for five years has had to have a new gasket for the cell stack assembly and a new reformer was fitted. The fuel cell is an extremely clean running source of power. There is virtually no NOx produced. The microturbines are guaranteed to operate at less than nine ppm of NOx. Both the fuel cell and the microturbine plants produce less NOx than either the boilers or the flare combustors. Since the fuel is biologically produced, the carbon dioxide produced is more or less in balance with carbon uptake from plants and animals.

Maintenance costs average about two cents/kWh for the fuel cell and about 1.5 cents/kWh for the microturbines. The fuel cell provides about $60,000 per year in net operating savings; the mircoturbines are expected to provide somewhat higher savings at $70,000 to $80,000 per year. GE

Is My Facility a Good Candidate for CHP?

- Do you have an influent flow rate greater than five mgd?
- Do you pay more than $0.06/kWh for electricity?
- Are reliable, high-quality power and thermal energy important to you?
- Is it important to reduce energy costs and increase the overall energy efficiency of your wastewater treatment process?
- Do you want to increase your facility's environmental performance?

If the answer is "yes" to two or more of these questions, CHP can benefit your facility. CHP technologies are flexible, providing a wide range of sizing options. The right CHP system for your WWTF will be determined through consultations and analyses, which will include a site-specific evaluation of your facility's electricity and thermal loads.

The CHP Partnership has developed services and tools to assist those considering implementing CHP at their facilities. Visit the Streamlining Project Development pages of the Partnership's Web site at www.epa.gov/chp/project-development/index.html to learn more about the CHP project development process, whom to involve on your CHP project team, typical options for system financing, and other services EPA provides.

Take advantage of the Partnership's up-to-date lists of state and federal incentives (e.g., rebates, tax credits, environmental revenue streams) for CHP, along with lists of regulatory rules and rates that are advantageous to clean distributed generation. This information is updated monthly at www.epa.gov/chp/funding/index.html.

EPA is available to answer your questions and provide specific technical support for your project. For information on how EPA can support your evaluation and implementation of CHP, contact Tom Frankiewicz at 202-343-9794 or frankiewicz.thomas@epa.gov.