

How efficient is my combined heat and power (CHP) system?

Combined Heat and Power System Evaluation Tool (U2R08b)

The Central Issue

The use of combined heat and power (CHP) equipment at a wastewater treatment facility (WWTF) is a big part of the path to becoming energy neutral. To be most effective, a facility needs a means of assessing the efficiency of their CHP system so it can be run in an optimum manner. To support facilities using CHP and to encourage more widespread implementation of CHP at WWTFs, WERF developed the Combined Heat and Power System Evaluation Tool (CHP-SET).

The CHP-SET is a spreadsheet-based calculator designed to evaluate CHP system performance. It is intended for use by utilities already operating CHP systems. The CHP-SET calculates total system efficiencies (inclusive of appurtenant equipment electrical demands) to produce electricity and collect heat. The tool also provides conversion of exhaust emissions (NO_x, CH₄, CO₂, CO, and N₂O) into units of mass per unit of net energy output.

Context and Background

Many wastewater treatment facilities use digester gas to heat their anaerobic digestion process. Recent national and industry emphasis on efficiency and renewable power production has increased the desire to maximize the potential of digester gas and the construction of combined heat and power (CHP) systems to offset a significant portion of the power required for wastewater treatment.

Historically, the most commonly used CHP technologies at WWTFs have been internal combustion engines, although combustion gas turbines have long been used at the largest facilities. In more recent years, fuel cells and microturbines have emerged in the CHP market and are becoming more popular. All of these technologies have the ability to produce electricity from digester gas that would otherwise be flared, while simultaneously providing a portion or all of the heating needs for the digestion process. In some locations, the air emissions from these CHP systems are under scrutiny. The CHP-SET tool can help with this too.

Findings and Conclusions

CHP-SET provides a simple means of evaluating and summarizing basic performance characteristics of individual CHP generators. Based upon user inputs and parasitic loads attributable to ancillary



Microturbines at the Sheboygan Regional Wastewater Treatment Plant.

“Since we were wasting excess biogas produced at the wastewater treatment plant, it became evident that we could use the excess biogas as fuel for the Capstone MicroTurbines and reduce our energy cost.”

***Dale Doerr, Wastewater Superintendent –
City of Sheboygan, WI***

equipment, the CHP-SET calculates prime mover net electrical and thermal efficiencies.

CHP-SET can also convert air emissions, including CH₄, CO, N₂O, and NO_x, to units of mass per fuel input and mass per electric power production so that a more useful comparison of emissions across prime mover technologies can be made. CHP-SET can also be used to calculate a facility’s carbon footprint reduction attributable to each prime mover.

The CHP-SET spreadsheet tool was successfully used to evaluate and document the performance of several existing CHP systems ranging in plant size from 41,600 to 1.14 million m³/d (15-300 mgd) of capacity. The results from a case study in Sheboygan, Wisconsin are included to illustrate the use of and output from the tool.

Management and Policy Implications

In California and some areas of the eastern United States, air emissions regulations are a main driver in the selection and design of CHP systems for the recovery of heat and power from biogas.

Executive Summary



Combined Heat and Power System Evaluation Tool

Related WERF Research	
Project Title	Research Focus
LCAMER: An Assessment Tool for Managing Cost-Effective Energy Recovery from Anaerobically Digested Wastewater Solids: Version 2 (OWSO4R07hT)	The LCAMER (Life Cycle Assessment Manager for Energy Recovery) tool compares the relative life-long merits of one energy recovery system to another for wastewater treatment plant application. It was updated in 2012 with new technical and economic information. LCAMER includes estimates of air emissions from CHP systems.
Carbon Heat Energy Plant Evaluation Tool – CHEApet (OWSO4R07cT)	Provides predictive models to quantify plant operating energy requirements and predict the carbon footprint from wastewater treatment plants. CHP-SET tool complements the CHEApet tool output.
State of the Science on Biogas: Treatment, Co-Generation, and Utilization in High Temperature Fuel Cells and as a Vehicle Fuel (OWSO10C10a)	Details four key areas related to energy recovery from biogas. <ul style="list-style-type: none"> ■ The wide range of technologies available to remove or reduce the contaminants in biogas to make it suitable for energy recovery. ■ CHP technologies that simultaneously generate heat and electricity from biogas. ■ High-temperature fuel cells and their application using of biogas as a fuel source. ■ Direct use of biogas in natural gas vehicles or sold to the natural gas grid.
Energy Efficiency in Wastewater Treatment in North America: A Compendium of Best Practices and Case Studies of Novel Approaches (OWSO4R07e)	Includes case studies on many of the types of CHP systems addressed in the CHP-SET tool and elsewhere. Provides detailed information on the application of systems to recover heat and power from biogas.
Barriers to Biogas Use for Renewable Energy (OWSO11C10)	Overcoming the barriers to investing in biogas technologies, including: <ul style="list-style-type: none"> ■ Barriers that utilities face when considering biogas for heat or energy recovery. ■ Feedback on barriers from more than 200 utility participants across the U.S. ■ Strategies to help utilities overcome barriers to biogas use for renewable energy. ■ Recommendations to expand the production of renewable energy from biogas.

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