

## Combined Heat and Power Case Study

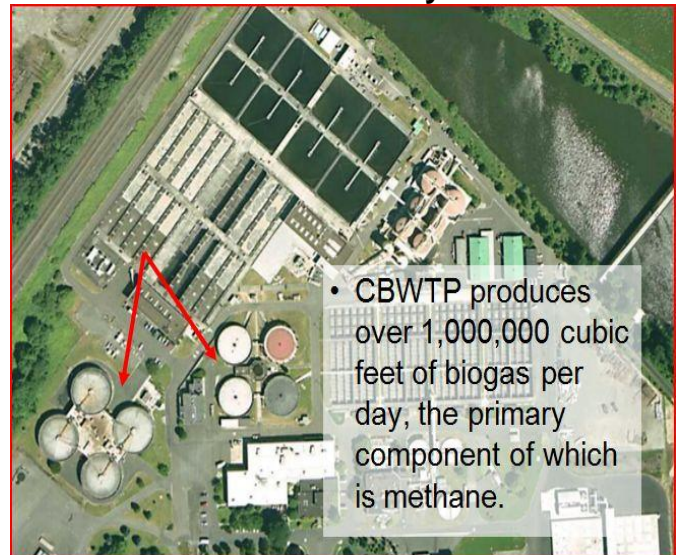
### Site Description

The Columbia Boulevard Wastewater Treatment Plant (CBWTP) is the largest wastewater plant in Oregon and is operated by the Portland Bureau of Environmental Services (BES). The facility is the collection point for about 1,800 miles of wastewater sewer pipes and includes 92 pumping stations. CBWTP treats 80-90 million gallons of sewage and wastewater each day.

The CBWTP wastewater treatment process produces about one million cubic feet of anaerobic digester gas each day and about 55 percent of the gas is methane. The plant has investigated several technologies over the years to reclaim this “biogas” for electrical power generation to reduce utility costs and has installed a number of these advanced systems.

As examples, in 1999 CBWTP installed the first anaerobic digester gas fuel cell power generation project in the Western U.S., a 200 kW system. High costs, primarily from maintenance, led to the system being decommissioned in 2005. The largest biogas powered system at the CBWTP includes two 850kW Internal Combustion (I/C) Generators installed in June 2008. The Microturbine project installed in 2003 and described below was a relatively small demonstration effort. The experience gained from the fuel cell project and especially from the Microturbine project was crucial to the successful deployment of the much larger I/C project brought on line in 2008.

### **Columbia Boulevard Wastewater Treatment Plant Microturbine Electricity Generation and Heat Recovery**



Columbia Boulevard Wastewater Treatment Plant  
Portland, Oregon

### Electricity Generation and Emissions

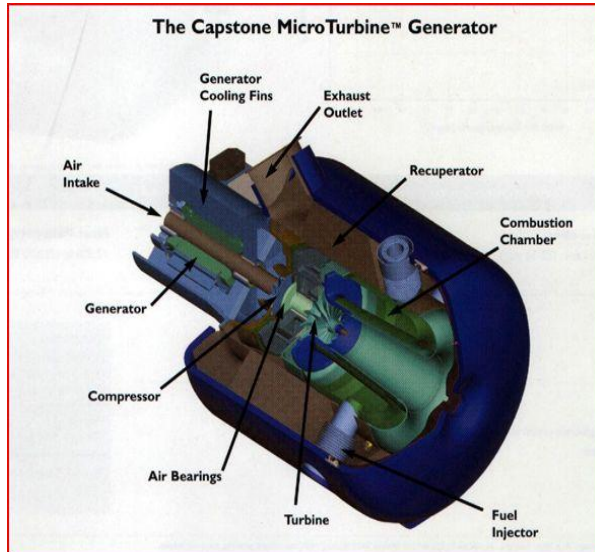
The Microturbine Electricity Generation system includes turbines, compressors, gas processing and electrical controls and switchgear:

- Four 30kW Capstone Microturbine units – installed total of 120kW; all 480Vac, 60Hz

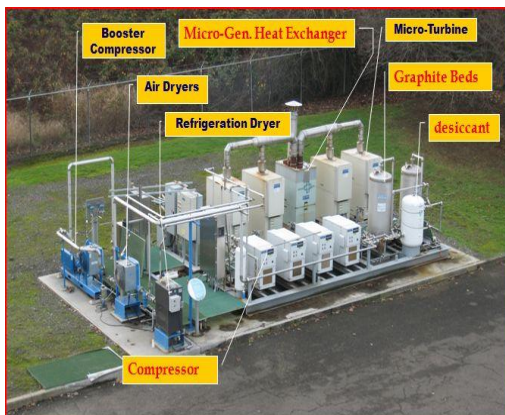
The system was designed to meet the following operational criteria:

- Efficiency –
  - Electrical – 27%
  - Thermal – 53%
  - Combined Heat Power – 80%
- Noise Level –
  - 65 dBA @ 33 ft.
  - 83 dBA @ 2 ft.
- Exhaust Emissions – NOX < 9PPM

## Microturbine Specification and Description

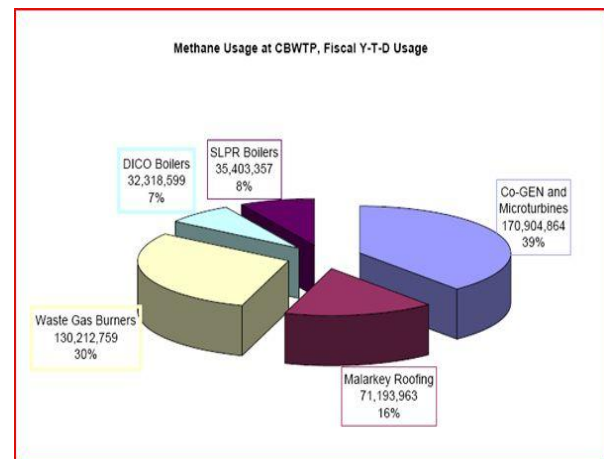


- Digester Gas (ADG) Supply/Treatment
  - Pressure – 75 PSI
  - Methane – 50-62%
  - CO<sub>2</sub> – 38-50%
  - H<sub>2</sub>S – 350 ppm
  - Siloxane – 25 ppmv
- Each Unit –
  - Flowrate – 750 SCF/Hr
  - Size – 2.5ftX5ftX6ft
  - Weight – 1,050 lb
  - Speed – 96,000 RPM
  - Exhaust Gas Heat Output – 290,000Btu/hr; 510F<sup>0</sup>

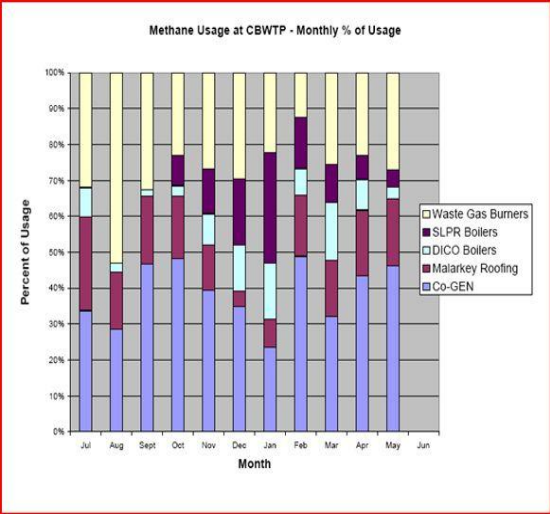


Typically, wastewater treatment plants like CBWTP flare or burn excess biogas. Using this fuel source to generate power provides the facility with a free, renewable energy source that displaces electricity from local utilities (likely generated from natural gas or coal fuels).

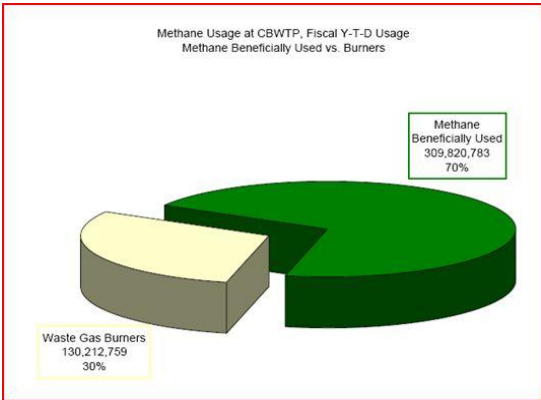
The combined 120kW output of the four Microturbines is enough electricity to power 60 – 75 single-family homes. In combination with the much larger I/C Generators, the Microturbines supply almost 40 percent of the daily power demand at the treatment plant using the digester biogas as the fuel.



This project has resulted in significant environmental benefits because instead of flaring a large portion of the methane (one of the most powerful greenhouse gases), most of the gas is now used for power generation on-site. Although CO<sub>2</sub> is still released from expanding the biogas to drive the Microturbines, it offsets the CO<sub>2</sub> that would be emitted by the electric utility serving the treatment plant. The portion of biogas used beneficially to save utility costs is shown below (the portion for the Microturbines is combined with the I/C engines and labeled Co-Gen).



The Microturbine project was brought on-line April 2003, but only consumes a relatively small portion of the biogas produced at the plant. A much larger portion of the remaining biogas is consumed by four I/C Generators installed by CBWTP in 2008; a portion is sold to a local roofing company; and until additional I/C Generators are brought on-line, excess biogas will continue to be flared.



Microturbines using anaerobic digester gas as a fuel is an emerging technology. The Microturbine system experienced continuing problems immediately after start-up, and at least one of the units was off-line most of the time. The greatest technical challenge is adequate scrubbing of the biogas to remove pollutants before the gas is compressed and then expanded through the turbines. BES operation of the turbines ASERTTI CHP Case Study

determined that controlling moisture content, and hydrogen sulfide and siloxane gas concentrations was critical to keeping the turbines on-line. As examples of these issues, the original installation had to be modified because the desiccant bed provided inadequate drying of the gas and staff determined that an additional gas dryer was needed 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 in order to maintain a positive pressure, thereby eliminating the possibility of a leak creating an explosive air fuel mixture going into the hot compressors.

The Microturbine design includes a subsystem to recover exhaust heat then used to provide heat to the digester complex. This subsystem has operated well since startup. Overall operation of the Microturbine system has been successful after much effort to improve the manufacturer's subsystems designed to reduce moisture and impurities in the feed biogas, and the technology was considered for additional capacity in 2005 when BES began looking into the feasibility of generating more energy on-site from excess digester gas. However the Microturbines were not the best fit for the expansion due to space constraints and maintenance costs.

**Financial Statistics**

When construction of the Microturbine project was completed in April 2003, the total project cost for the turbines, compressors, heat recovery, gas processing and electrical including construction was \$346,000.

BES was able to reduce the project cost to the City using the Oregon Department of Energy Business Tax Credit (BETC) program that can offset up to 25 percent of the cost for installing renewable energy

projects. In this case savings to the City resulted in slightly more than 10 percent of the project cost.

Although the treatment plant is owned by the City of Portland, and the City is not eligible for the BETC, state law allows the credit to be paid indirectly in the form of a “pass-through”. This provision was written into the tax law to allow cities to take advantage of the BETC by selling the credits to private companies. The business pays the City and is then credited by the state.

The total project cost of the CBWTP Microturbine electricity generation and heat recovery system including design, equipment, electrical, building, digester (biogas) gas treatment, and installation is summarized below:

Cost –  
Microturbines and Electrical Switchgear = \$300,000  
Design and Installation Cost = \$46,000  
**Total Cost = \$346,000**  
(\$2,883/kW)

Cost reduced by the BETC (effective 10% credit)  
**Final Cost = \$309,000**  
(\$2,575/kW)

In addition to the one-time credit incentive, the project usage of the biogas fuel avoids purchasing electricity. The system produces over 893,520 kWh annually resulting in annual savings from the avoided utility electricity consumption of over \$61,000. In addition to savings of electricity consumption, there are numerous environmental benefits including eliminating emissions of nearly 540 tons of CO<sub>2</sub> annually.

### Lessons Learned

In light of all the technical issues, an evaluation was made of microturbines operating at four other wastewater

treatment facilities using ADG. All these facilities had encountered problems with the manufacturer’s subsystem for treating the gas from the digester before compressing the feed gas and then expanding it through the Microturbine(s) to generate electricity. Gas treatment issues and other specific problems included:

- Water in the microturbines;
- Siloxane deposits;
- Higher than expected costs for fuel preparation and maintenance;
- Need to find a cost effective gas pretreatment approach for specific applications; and
- Problems with slow or non-responsive manufacturers and distributors.

### Involved Organizations:

City of Portland – Bureau of Environmental Services; project management and CBWTP, installation, startup, and operation  
Design – Brown and Caldwell  
System Integrator – MWH (microturbine, gas compressors, gas treatment, heat recovery)  
Capstone Micro Turbines  
Oregon Department of Energy – BETC certification  
Portland General Electric – electric power utility

### For further information, contact:

**David Terry, Executive Director**  
**ASERTTI**  
**(703) 395-1076**  
[Dterry@ASERTTI.org](mailto:Dterry@ASERTTI.org)  
[www.ASERTTI.org](http://www.ASERTTI.org)