

Combined Heat and Power Case Study

Site Description

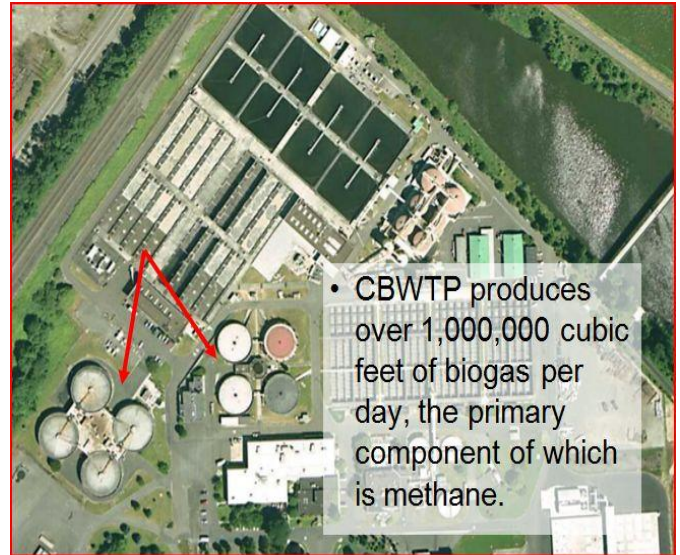
The Columbia Boulevard Wastewater Treatment Plant (CBWTP) is the largest wastewater plant in Oregon and is operated by the Portland Bureau of Environmental Services (BES). The facility is the collection point for about 1,800 miles of wastewater sewer pipes and includes 92 pumping stations. CBWTP treats 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, but the lessons learned helped in other biogas projects. CBWTP also installed four 30 kW Capstone microturbines in 2003. The microturbines are still operating and in June of 2008 two I/C GE/Jenbacher engines (1.7 MW total capacity) were added.

Columbia Boulevard Wastewater Treatment Plant

I/C Engine Electricity Generation and Heat Recovery



Columbia Boulevard Wastewater Treatment Plant
Portland, Oregon

Electricity Generation and Emissions

The Internal Combustion (I/C) Engine Electricity Generation and Heat Recovery system includes:

- Two 850 kW GE/Jenbacher Engine Generators, each rated at 4,160 Vac, 60 Hz

The system was designed to meet the following operational criteria:

- Efficiency –
 - Electrical – 37%
 - Thermal – 44%
 - Combined Heat Power – 81%
- Noise Level – 117 dBA @ 3 ft.

- Emissions – Lean-Burn Combustion
 - NOX – 2.0 g/bhp-hr (14 ppm/engine)
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I/C Engine Fuel Design Criteria

- Digester Gas Treatment
 - H₂S Scrubber – Iron Sponge
 - Moisture Removal – 40 deg F Dew Point
 - Siloxane Scrubber – Carbon
- Digester Gas Pressure and Flowrate
 - Digester Gas Composition
 - Methane – 50-62%
 - CO₂ – 38-50%
 - H₂S – 350 ppm
 - Siloxane – 25 ppmv
 - Pressure Boost – 1.2 – 2.9 PSI
 - Approximate Usage – 13,810 SCF/Hour/Unit

- 3,560 MBTU/Hr Heat Recovery (including exhaust heat recovery)
- Process Hot Water – Design
 - In Temperature – 167⁰ F
 - Out Temperature – 190⁰ F
 - Flowrate (GPM) – 250
- Process Hot Water – Measured
 - Change in Temperature – 20 degree F at 700 GPM

System Operation History

Typically, 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 1.7 MW produced by the two 850 kW reciprocating engine generators (labeled Co-Gen in the graphic below) offsets almost 40 percent of the daily power demand at the treatment plant.

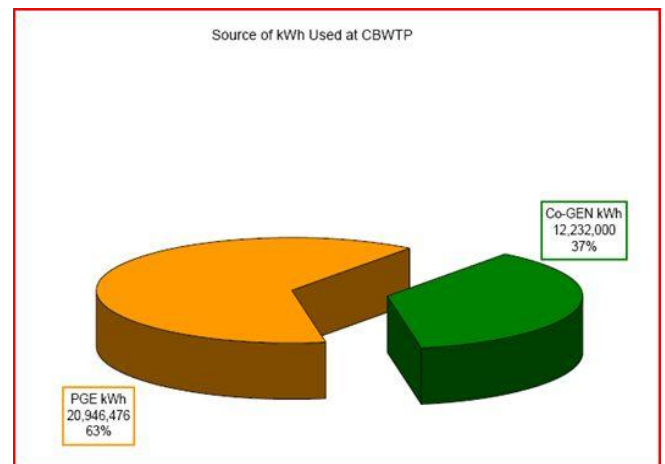


• 2008 – Two Combined Heat and Power Generators (Co-GEN) are installed and go on-line converting methane to electricity and heat.

GE/Jenbacher I/C Engine-Generator

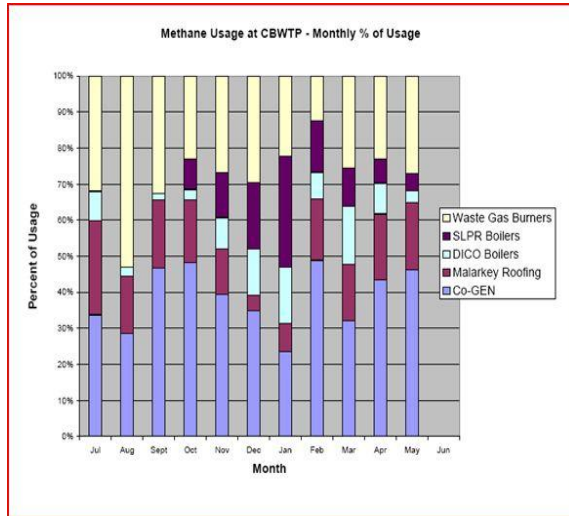
I/C Engine Heat Recovery

- Hot Water per Unit – Heat Transfer Jacket Water Loop
 - In Temperature – 170⁰ F
 - Out Temperature – 200⁰ F
 - Flowrate (GPM) – 250
- Exhaust Gas Temperature – 980⁰ F

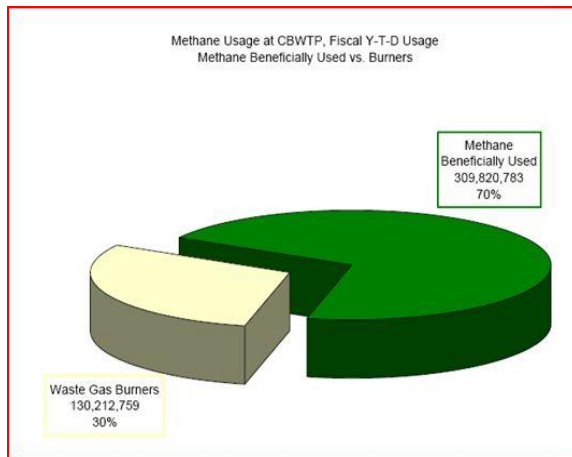


This project has resulted in significant environmental benefits because instead of flaring a large portion of the methane (one of the most powerful greenhouse gases), most of the gas is now used for power generation on-site. Although CO₂ is still released from burning the biogas in the

engines, it offsets the CO₂ 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 amount specific to the I/C engines is labeled Co-Gen)

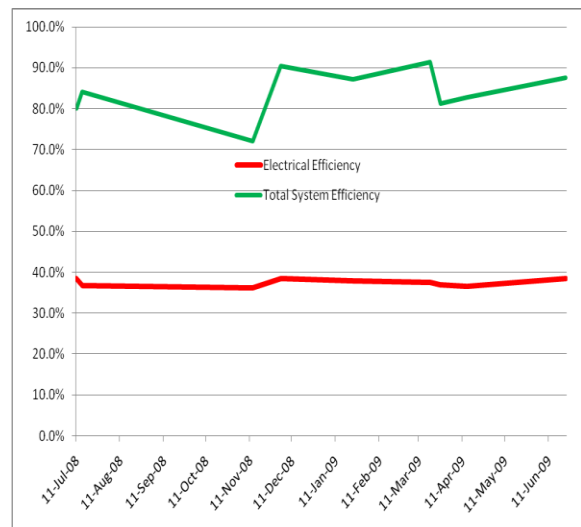


The generators were brought on-line June 2008 and consume about 50 percent of the biogas produced at the plant. Some of the remaining biogas is consumed by four microturbines installed by CBWTP in 2003; a portion is sold to a local roofing company; and until additional I/C generators are brought on-line, excess biogas will continue to be flared.



In addition to reducing the treatment plant electricity demand and cost, the I/C Engine design incorporates a heat recovery subsystem. This heat recovery process reclaims heat from the engines to heat digesters used to further convert process biosolids into soil enhancement material sold and then trucked to farming operations in Eastern Oregon.

Although the reciprocating engines have only been in operation since June 2008, the operational data collected indicates the operational performance bid by the contractor is very close to the design criteria specified by the City in its RFP. For each of the 850 kW engines, the specification required an electrical conversion efficiency of 37 percent. The measured efficiency of the system for the first year of service is shown in the next graphic.



Financial Statistics

The new reciprocating engines cost the City about \$8.96M, but this equipment and installation cost was partially offset by two incentive programs:

- A \$362,000 cash incentive from the Energy Trust of Oregon; and
- The Oregon Department of Energy Business Tax Credit (BETC) program

that offsets 25 – 30 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.

In summary, the total project cost of the CBWTP I/C Engine Electricity Generation and Heat Recovery System including design and design services during construction, equipment, electrical, building, digester (biogas) gas treatment, and installation totaled about \$8.96 million.

Cost –
Engines/Electrical Switchgear = \$1,444,000
Install (incl. Gas treatment) = \$5,346,000
Design, Const Admin, Startup = \$2,170,000
Total Cost = \$8,960,000
(\$5,270/kW)

Cost reduced by the combined Oregon Energy Trust/BETC (effective 25% credit - \$2.24M)
Final Cost = \$6,720,000
(\$3,950/kW)

In addition to these one-time credit incentives, the long-term savings would have justified the project. Although the environmental benefits are substantial, after considering up-front investment and annual maintenance costs, the system will result in savings of utility electricity costs of about \$1,200 each day.

Lessons Learned

- 1) Waste Heat – Previous biogas recovery process systems deployed by CBWTP did not take full advantage of the energy

available to help heat the sludge digesters; this design does.

- 2) Immediate and continuing coordination with the local utility is highly recommended. The original system concept allowed for independent operation from the grid to maintain plant operation on loss of utility power. Due to utility safety concerns and bringing up large motor loads, the system operation was changed to only directly offset plant grid power consumption. The system is fully synchronized with the utility grid.
- 3) Based on previous systems deployed, the design specified rigorous scrubbing of the digester gas prior to being burned in the engines.

Involved CHP Organizations:

City of Portland – Bureau of Environmental Services; project management and CBWTP, startup and operation
Camp Dresser & McKee Inc. (CDM) - design engineering consultant firm
James W. Fowler Co. – general contractor
GE/Jenbacher – engine-generator supplier
Oregon Energy Trust – grant funding
Oregon Department of Energy – BETC certification
Portland General Electric – electric power utility

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