CHP Case Studies in the Pacific Northwest

Columbia Boulevard Wastewater Treatment Plant

Environmental Services City of Portland

320 kW Fuel Cell and Microturbine Power Plants

Aerial View of Portland's Columbia Boulevard Wastewater Treatment Facility

Site Description

The Columbia Boulevard Wastewater Treatment Plant (CBWTP) in Portland, Oregon 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 80-90 million gallons/day of sewage. 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 bio-solids 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 bio-solids processing are anaerobic digesters that use the action of bacteria to break down the solids and in the process produce a combustible gas composed primarily of methane and carbon dioxide (600 Btu/scf.) The City sells some gas to a nearby industry, heats plant buildings and digesters with some, and flares the rest.

In 1993, Portland became the first U.S. city to adopt 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 generators and an uninterruptible power system (UPS).

At the same time, the City of Portland made a deal with Portland General Electric 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 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.

Plant Configuration

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 (H_2S) 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 he ADG from 7" of water to 75psig.

Energy/Financial Analysis

For the initial fuel cell project, David Tooze of the Energy Division of the Portland Office of Sustainable Development was instrumental in negotiating the financial package which included a collection of grants, credits, and rebates that cut the effective cost of the project in half.

The total price of the nominal 200kW ONSI fuel cell installation was $1.3 million. However, the facility received a $200K Department of Defense grant, a $247K green power credit from Portland General Electric, and a $10K grant from the Oregon Department of Environmental Quality.

200 kW ONSI PC25C Fuel Cell Power Plant

In addition, the facility was able to pass through the Oregon Building Energy Tax Credit to their financing institution. The resulting “negative interest” lease amounted to an additional $194K project credit. The price for the installation was brought down to $645K.

Total Project Cost	$1,300,000
Grants and Rebates	
DOE/DOD	$200,000
PGE Renewable Energy Rebate	$247,000
Oregon Office of Energy	$14,000
Oregon Business Energy Tax Credit and Lease	$194,000
Net Project Cost to Portland	$645,000

The later microturbine installation cost $340K with a BETC cost-back of $40K for a net cost of $1,200/kW.

Maintenance costs average about 2 cents/kWh for the fuel cell and about 1.5 cents/kWh for the microturbines.

The fuel cell provides about $60K per year in net operating savings; the microturbines are expected to provide somewhat higher savings at $70-80,000 per year.

Operating Experience and Results

One of the biggest challenges for operating 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 (H_2S), chlorine compounds, and organic silicon compounds called *siloxanes*. The chlorine and H_2S introduce acids that damage the prime movers. The siloxanes cause deposition of silicon dioxide (SiO_2) 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

4 Capstone 30 kW Microturbines with Central Heat Recovery

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 H_2S monitors to measure the very 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 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 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. Both of these changes were made by UTC at no cost to the facility.

Environmental Profile

The fuel cell is an extremely clean running source of power. There is virtually no NO_x produced.

The microturbines are guaranteed to operate at less than 9 ppm of NO_x. Both the fuel cell and the microturbine plants produce less NO_x 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.

Future Plans

The City of Portland plans to have a website with pictures on the generation plants and real-time information on their operation.

The facility is considering adding 1,500 kW of generation capacity to run on the remaining surplus digester gas. They are looking into a lean burn reciprocating engine plant that might be developed as a private public partnership.

Environmental Services is considering adding generation to Tryon Creek, its second wastewater treatment plant located in Lake Oswego.

There is also interest in installing a 52 kW Stirling engine system

Organizational Profile

Fuel Cell Plant
Equipment: United Technology Corporation, ONSI
Engineering and Siting: Brown and Caldwell
Microturbine Plant
Equipment: Capstone Turbine Corporation
Engineering Design: Montgomery-Watson-Harza
Installation: City of Portland, Environmental Services
Local Electric Utility: Portland General Electric Company
Start-up support: EC Company

Contacts

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