



Fuel Cells and Biogas

Fuel cells generate electricity using an electrochemical reaction, not combustion, so there are no polluting emissions, only water and heat as by-products. Many fuel cells are fueled with hydrogen, which can be derived from a wide range of traditional and renewable sources, including biogas.

Many facilities, such as wastewater treatment plants (WWTP), landfills, food/beverage processing facilities, wineries, breweries, dairies, large industrial factory farms and confined animal feeding operations (CAFOs), generate tons of organic waste as a byproduct of daily operations, be it sewage, effluent, food or animal waste, all of which can be expensive to remove and burdensome to store. These sites often use an anaerobic digester to convert the organic waste into methane or anaerobic digester gas (ADG), and then burn the ADG, in a combustion-based generator or flare it into the atmosphere to dispose of it. Although ADG is considered carbon-neutral since it is derived from an organic (non-fossil) source, flaring or burning leads to releases of direct and indirect GHGs and other air pollutants. Since ADG contains hydrogen, which is the fuel of choice for fuel cells, a cleaner, more efficient option is to use the gas in a fuel cell to generate electricity and heat for the plant, following a gas cleanup step.

Many states consider fuel cells a clean energy technology and ADG, an organic waste product, as a renewable fuel source under renewable portfolio standards (RPS) and utility green power programs. State agencies often offer grants, low-interest loans, or other assistance to encourage deployment of these technologies. California's Self Generation Incentive Program (SGIP), for example, provides facilities in the state \$4,500/kilowatt (kW) for fuel cell systems that use a biogas feedstock, nearly double the subsidy for natural gas-powered fuel cells.

Fuel cells can provide primary power, backup power or CHP, and since they can be installed as part of the electric grid, or in parallel to it, fuel cells can provide reliable power without disruption due to grid failure or blackouts. The excess heat can be captured to provide hot water or space heating and, when installed as CHP systems, fuel cells are achieving 90% efficiency and higher. The excess heat from the fuel cell can also be directed to the anaerobic digester to generate ADG, which can then be fed back into the fuel cell, which continues the process. A fuel cell system running off ADG also leads to tremendous savings from eliminating the need for costly waste removal.

Fuel Cells and Biogas in Operation

Fuel cells were first demonstrated using ADG in the late 1990s, and today, fuel cells operate at WWTPs in California and New York.

Fountain Valley Tri-Generation - A successful demonstration took place at the Orange County Sanitation District's wastewater treatment plant in Fountain Valley, California, where an ADG-powered fuel cell to generate not only power and heat, but also hydrogen, making it the world's first demonstration of "tri-generation" at a WWTP. The hydrogen supplied an onsite hydrogen fueling station that is accessible to the public and sufficient to provide fuel for 25 to 50 fuel cell electric vehicles daily. The project was

supported by the DOE, California Air Resources Board, Orange County Sanitation District, academia, and private industry, and its success has led to several new tri-generation projects.

BMW - BMW operates 350+ fuel cell-powered forklifts, tuggers and stackers at its Spartanburg manufacturing plant, with a 700 kilograms (kg)/day hydrogen fueling pump. Methane gas powers a portion of the plant's total energy requirements, collected from the local Palmetto landfill and cleaned, compressed and delivered to the plant via a 9.5-mile pipeline. BMW is working with several partners to develop a method to convert some of this methane gas onsite into hydrogen for the fuel cell forklifts, funded, in part, by a grant from DOE.

Gills Onions - Gills Onions, an onion processor in Oxnard, California, installed an Advanced Energy Recovery System (AERS) in July 2009 to convert its 300,000 pounds of onion waste a day into biogas for two 300-kW fuel cells. Despite some initial technical issues, the AERS has generated 17 gigawatt-hours (GWh) of electricity since its commission. After stack replacements, the fuel cell system performance markedly increased and the company anticipates that the fuel cells will supply almost 50 percent of the overall electricity needs and will further reduce operational costs. In addition, the company reports saving \$800,000 in 2012 in electricity and labor costs associated with the disposal of onion remains. The company is also selling the remaining pulp as cattle feed.



Microsoft - Microsoft's new facility in Cheyenne, Wyoming, is the world's first zero-carbon data center. This research and development (R&D) pilot project is testing a small-scale data center powered by a 300-kW fuel cell system. It utilizes methane from Cheyenne's wastewater treatment plant – a potent greenhouse gas (GHG) precursor generated during the treatment process – as the source of hydrogen for the fuel cell system. Microsoft will use information gained from the demonstration to model how a biogas-powered fuel cell could be applied to a larger Microsoft facility.

Sierra Nevada Brewing Co. – Installed four 250-kW (1 MW total) fuel cells at its Chico, California, brewery in 2005. Biogas is currently being collected and fed into Sierra Nevada's boilers to offset the natural gas required to run the systems. The company's long term goal is to have only the biogas running in the fuel cells.

Directed Biogas

Most companies can't locate a fuel cell near a biogas source, but there is another option to take advantage of this renewable fuel: "directed biogas." With this option, an equivalent amount of "scrubbed" (contaminants removed) and pressurized biogas is injected monthly into a natural gas pipeline. A facility that enters into a contract to use directed biogas may not actually consume that biogas in their fuel cell, but instead, the biogas becomes available to all locations along the pipeline once injected, offsetting a portion of natural gas regardless of the end-user. California's Self Generation Incentive Program (SGIP), which provides funding to encourage stationary fuel cell installations, permits the use of both onsite and directed biogas. Companies taking advantage of this option in the state include Adobe, Coca-Cola/Odwalla, Cox Enterprises, eBay, Fireman's Fund, and NTT America.