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TECHBRIEF
Environmental Technology Verification Program
ETV

Fuel Cells

The U.S. EPA Environmental Technology Verification (ETV) Program's Greenhouse Gas Technology (GHG) Center, operated by Southern Research Institute under a cooperative agreement with EPA, has verified the performance of three fuel cell technologies that generate electricity at the point of use.[1] The GHG Center has collaborated with the New York State Energy Research and Development Authority (NYSERDA) to evaluate the performance of these technologies. These fuel cells reduce the need to generate electricity from sources such as large electric utility plants, which emit significant quantities of carbon dioxide (CO_2), nitrogen oxides (NO_X), and carbon monoxide (CO).

Test Description and Results

The first polymer electrolyte membrane (PEM) fuel cell and phosphoric acid fuel cell (PAFC) were developed in the 1960s and 1970s, respectively. Reliable performance data are needed on fuel cell technologies which have seen limited commercialization. The ETV Program responded by completing three verifications for two stationary fuel cell technologies (**Table 1**): a small PEM fuel cell, sized for residential-scale use, and a larger PAFC technology, sized for commercial or institutional use. In the ETV tests, the latter technology operated on biogas from landfills and a wastewater treatment plant. In one test, ETV also verified the potential for heat recovery. During each test, the ETV Program verified power production and emissions performance. ETV verified power quality for all three technologies. **Table 2** lists selected performance data of the verified fuel cells. More detailed performance data are available in the verification reports for each of the technologies and can be found at the GHG verified technologies list under the **advance energy** category at: http://www.epa.gov/nrmrl/std/etv/vt-ggt.html#advanceenergy.

Electric Utility Emissions and Fuel Cells at a Glance

EPA estimates that in 2002 the United States emitted almost 6.4 billion tons of CO_2 and nearly 22 million tons of NO_X. Electricity generation accounted for 39% of the total CO_2 emissions and 21% of the total NO_X emissions. Other pollutants are also emitted during electricity generation, including CO and total hydrocarbons (THCs). Each of these emissions can have significant environmental and health effects. CO_2 and methane are greenhouse gases linked to global climate change. CO, THCs, and the various compounds in the NO_X family, as well as derivatives formed when NO_X reacts in the environment, cause a wide variety of health and environmental impacts.

Fuel cells use hydrogen, or another fuel converted to hydrogen, to electrochemically generate electricity. Because they can be installed at the point of use, power transmission losses that range from 4.7% - 7.8% can be avoided. When well-matched to a facility's needs in a properly designed combined heat and power (CHP) application, net fuel consumption and overall emissions can also be reduced. Fuel cells can also reduce natural resource consumption, since they can be designed to operate using biogas from animal waste, wastewater treatment plants, landfills, and other sources. Although their use is voluntary, federal, state, and local governments have undertaken a number of activities to promote the use of fuel cells. These activities include demonstration projects, regulations or standards, education partnerships, procurement standards, and business incentives.

Table 1. Verified Fuel Cell Technologies

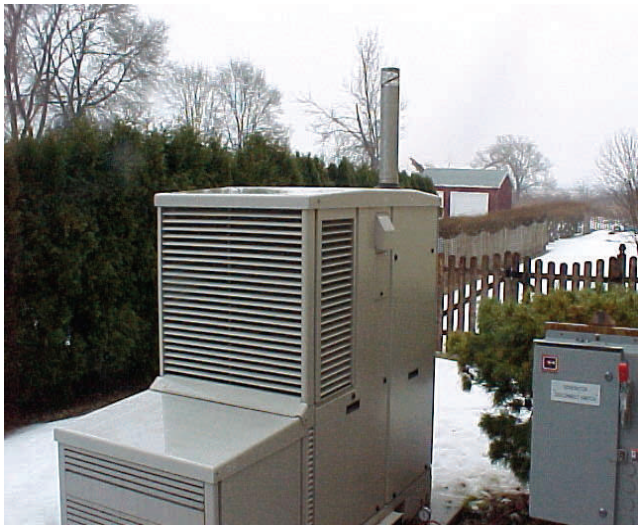
Technology Name	Electricity Generating Capacity (kilowatts, kW)	Additional Information
DFC 300A Molten Carbonate Fuel Cell	250	• A natural gas fueled molten carbonate fuel cell from which excess heat is recovered on-site for use.
Plug Power SU1 Fuel Cell System	6	• A polymer electrolyte membrane (PEM) fuel cell. Tested at a private residence in Lewiston, New York. Included a fuel reformulation system to operate using natural gas. Excess power generated by the fuel cell, but not used by the residence, was directed to the electric utility grid. Verified in 2003.
UTC Fuel Cells, LLC PC25™ Fuel Cell[A]	200	• A phosphoric acid fuel cell (PAFC). Tested at municipal solid waste landfills in California and Connecticut. Included a gas processing unit to operate using landfill gas. The electricity produced was directed to a local grid system and sold to utility companies. Verified in 1998. • A phosphoric acid fuel cell (PAFC). Tested at a wastewater treatment facility in Brooklyn, New York. Included a gas processing unit to operate using anaerobic digester gas. Power produced by the fuel cell offset the need to purchase electricity from the facility's local utility. Verified in 2004.

[A] UTC Fuel Cells, LLC was known as International Fuel Cells Corporation in 1998, when the first verification was completed. The technology has since been renamed as the PureCell™ 200.

[1] The ETV Program operates largely as a public-private partnership through competitive cooperative agreements with non-profit research institutes. The program provides objective quality-assured data on the performance of commercial-ready technologies. ETV does not endorse the purchase or sale of any products and services mentioned in this document.

Table 2. Selected Performance of Verified Fuel Cells	
Power Production[A]	
Electrical efficiency	23.8% to 48.0%
Potential thermal efficiency[B]	56.9%
Potential total system efficiency[B]	93.8%
Emissions	
CO_2 emissions rates	1.03 to 1.66 lbs/kWh[C]

[A] At full load, under normal operation.
[B] In one test, ETV also verified the potential for heat recovery.
[C] lbs/kWh = pounds per kilowatt-hour



Plug Power Fuel Cell

UTC Fuel Cell

Selected Outcomes of Verified Fuel Cells

Available sales data indicate that a capacity of 15 megawatts (MW) of ETV-verified fuel cells have been installed in the United States since the verifications were completed. ETV estimates that these systems have:

- Reduced CO_2 emissions by 17,000 tons per year and NO_X by 120 tons per year, with associated climate change, environmental, and human health benefits.
- Increased utilization of renewable fuels resulting in reductions in the consumption of natural resources. (Note: systems that utilize anaerobic digester gas represent 2 MW of the installed capacity and are responsible for 14,000 tons per year of the CO_2 reductions estimated above.)

Assuming annual sales continue at the same rate as in 2005, ETV estimates the total installed capacity of ETV-verified fuel cells should reach 34 MW in the next five years, reducing CO_2 by 41,000 tons per year and NO_X by 270 tons per year. Many of the fuel cells would utilize renewable fuels, such as anaerobic digester gas, resulting in reductions in natural resource consumption. The percentage of fuel cells installed in combined heat and power (CHP) applications is also projected to increase to 38% of the installed capacity.

ETV Greenhouse Gas Technology Center

Lee Beck, US EPA Project Manager,
beck.lee@epa.gov, Tel: (919) 541-0617

Tim Hansen, Southern Research Institute
hansen@sri.org, Tel: (919) 806-3456

DFC 300A Molten Carbonate Fuel Cell

References

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U.S. EPA ETV, http://www.epa.gov/etv.

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