Microturbine/Combined Heat and Power (CHP)

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 six microturbine/combined heat and power (CHP) systems that generate electricity at the point of use.[1] Collaborators included the State of Colorado, the New York State Energy Research and Development Authority (NYSERDA), and the EPA CHP Partnership. Several of the verified technologies also included heat recovery systems that capture excess thermal energy from the system and use it to heat water and/or spaces.

Test Description and Results

Large- and medium-scale turbines have been used by electric utilities since the 1950s. Recent advances have allowed for smaller turbines (i.e., microturbines) to be developed. Because they are relatively new, reliable performance data are needed. ETV has responded by verifying the performance of six microturbines, four of which included heat recovery (**Table 1**). The technologies were tested at residential, commercial, institutional, and industrial facilities. Power production, power quality, and emission performance were verified during each test. Carbon dioxide (CO_2) and nitrogen oxides (NO_X) emissions concentrations and rates were verified during each test and carbon monoxide (CO), total hydrocarbon (THC), methane, and other emissions were verified for some tests. ETV also measured heat recovery rates, thermal efficiency, and total system efficiency at selected loads for systems with heat recovery. In certain cases, ETV also estimated CO_2 and NO_X reductions compared to emissions generated by electricity obtained from the grid and heat obtained from a conventional technology, either for the test site or for hypothetical sites. **Table 2** lists selected performance data for the verified microturbines/CHP systems. More detailed performance data are available in the verification reports for each of the technologies and can be found at http://www.epa.gov/etv/vt-ggt.html.

Electric Utility Emissions and Microturbines 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 THC. Each of these emissions can have significant environmental and health effects. CO_2 and methane are greenhouse gases linked to global climate change. CO, THC, and the various compounds in the NO_X family cause a wide variety of health and environmental impacts.

Microturbines are well suited to providing electricity at the point of use because of their small size, flexibility in connection methods, ability to be arrayed in parallel to serve larger loads, ability to provide reliable energy, and low-emissions profile. By generating electricity at the point of use, microturbines reduce the need to generate electricity from sources such as large electric utility plants. When coupled with heat recovery systems that capture excess thermal energy to heat water and/or spaces, microturbines also reduce the need to use conventional heating technologies such as boilers and furnaces, which emit significant quantities of CO_2, NO_X, and CO. When well-matched to building or facility needs in a properly designed combined heat and power (CHP) application, microturbines can increase operational efficiency and avoid power transmission losses, thereby reducing overall emissions and net fuel consumption.

Table 1. Verified Microturbine and CHP Technologies

Technology Name	Electricity Generating Capacity (kilowatts, kW)	Includes Heat Recovery for CHP?	Additional Information
Mariah Energy Corporation Heat PlusPower™ System	30	Yes	Tested at a 12-unit condominium site that combines a street-level retail or office space with basement, and a one- or two-level residence above.
Ingersoll-Rand Energy Systems IR PowerWorks™ 70 kW Microturbine System	70	Yes	Tested at a 60,000 square-foot skilled nursing facility providing care for approximately 120 residents.
Honeywell Power Systems, Inc. Parallon® 75 kW Turbogenerator	75	No	Tested at a 55,000 square-foot university office building.
Honeywell Power Systems, Inc. Parallon® 75 kW Turbogenerator with CO Emissions Control	75	No	Same technology as above, but with installation of optional CO emissions control equipment.
Capstone Turbine Corporation 30 kW Microturbine System	30	Yes	Tested system operates on biogas recovered from animal waste generated at a swine farm.
Capstone Turbine Corporation 60 kW Microturbine CHP System	60	Yes	Tested at a 57,000 square-foot commercial supermarket.

[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.

Selected Outcomes of Verified Microturbine/CHP Technologies

Available sales data indicate that a capacity of 13 megawatts (MW) of ETV-verified microturbines (in CHP applications) have been installed in the United States since the verifications were completed in 2001 – 2006. ETV estimates that these systems have:

- Reduced CO_2 emissions by 36,000 tons per year and NO_X emissions by approximately 120 tons per year with associated climate change, environmental, and human health benefits
- Reduced emissions of other greenhouse gases and pollutants, with additional environmental and human health benefits
- Reduced natural resource consumption by utilizing renewable fuels (such as biogas) or by increasing efficiency (and reducing net fuel consumption) when well-matched to building or facility needs in a properly designed CHP application.

Assuming annual sales continue at the same rate as in 2005, ETV estimates the total installed capacity of ETV-verified microturbine/CHP systems should reach 42 MW in the next five years, reducing CO_2 between 83,000 and 150,000 tons per year and NO_X between 490 and 530 tons per year. The use of biogas as a fuel in one of the verified microturbine/CHP systems can result also in the conservation of finite natural resources and potentially result in cost savings for the user.

References

U.S. EPA, *2006. ETV Case Studies: Demonstrating Program Outcomes, Volume II*. EPA/600/R-06/082. September. (Primary source)

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

A Verified Microturbine Technology

Table 2. Selected Performance of Microturbines	
Power Production[A]	
Electrical efficiency	20.4% - 26.2%
Thermal efficiency[B]	7.2% - 47.2%
Total system efficiency[B]	33.4 % - 71.8 %
Emissions	
CO_2 emissions rates	1.34 to 3.9 lbs/kWh[C]
NO_x emissions rates	4.67×10^{-5} to 4.48×10^{-3} lbs/kWh[C]

[A] At full load, under normal operation.
[B] For the four systems with heat recovery.
[C] lbs/kWh = pounds per kilowatt-hour

A Verified Microturbine Technology

ETV Greenhouse Gas Technology Center

David Kirchgessner, EPA Project Officer
kirchgessner.david@epa.gov
Tel: (919) 541-4021

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

EPA/600/F-06/018
October 2006

www.epa.gov/etv