Advanced Generation: Microturbine Systems

DER Distributed Energy Resources

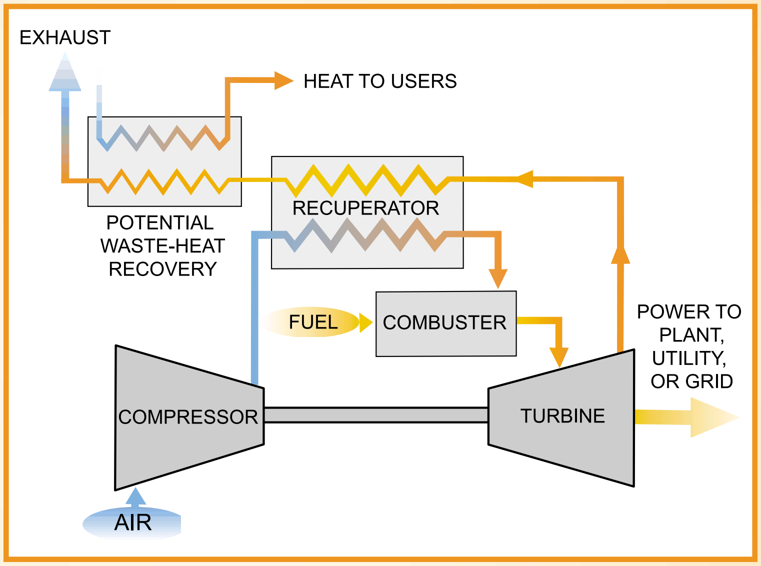
Tech Brief

Distributed Energy Resources (DER) are a suite of onsite, grid-connected or stand-alone technology systems that can be integrated into residential, commercial, or institutional buildings and/or industrial facilities. These energy systems include distributed generation, renewable energy, and hybrid generation technologies; energy storage; thermally activated technologies that use recoverable heat for cooling, heating, or power; transmission and delivery mechanisms; control and communication technologies; and demand-side energy management tools. Such decentralized resources offer advantages over conventional grid electricity by offering end users a diversified fuel supply; higher power reliability, quality, and efficiency; lower emissions; and greater flexibility to respond to changing energy needs.

Microturbines are a new type of combustion turbine for use in stationary energy generation applications. About the size of a refrigerator, microturbines produce 25 to 500 kW of energy and can be located on sites with limited space for power production. Waste heat recovery can be used in advanced cooling, heating, and power (CHP) systems to achieve energy efficiency levels greater than 80 percent.

Microturbine generator units are comprised of a compressor, combustor, turbine, alternator, recuperator, and generator. In a simple-cycle turbine (without a recuperator), compressed air is mixed with fuel and burned under constant pressure conditions. The resulting hot gas is allowed to expand through a turbine to perform work.

Recuperated units use a heat exchanger (recuperator or regenerator) that recovers some of the heat from the turbine exhaust and transfers it to the incoming air stream for combustion in the turbine. By using recuperators that capture and return waste exhaust heat, existing microturbine systems can reach 25 to 30 percent cycle efficiency. The incorporation of advanced materials, such as ceramics and thermal barrier coatings, could further improve their efficiency by enabling a significant increase in engine operating temperature.



Typical split shaft microturbine

Microturbines offer many advantages over other technologies for small-scale power generation, including the ability to provide reliable backup power, provide power for remote locations, and peak shave. Other advantages include less maintenance and longer lifetimes because of a small number of moving parts, compact size, lighter weight, greater efficiency, lower emissions, and quicker starting. Microturbines also offer opportunities to use waste fuels such as landfill gas.

Market Potential

- Because of their compact size and low operation and maintenance costs, microturbines are expected to capture a significant share of the distributed generation market.
- Scalability lends technology to modular buildout of high-density electric load facilities, which need high power reliability

Environmental Benefits

- Low greenhouse gas emissions
- Relatively low noise

Applications

Microturbine systems can be used in commercial, institutional, and industrial applications. Users with serious concerns about the reliability of grid power quality may be interested in installing continuous onsite power generation. During system emergencies or short-term price spikes, users may need to provide peak shaving of less than 1,000 hours of operation per year.

Microturbines are modular and in various configurations can be adapted to changing power demand. High-density electric load facilities, which need large amounts of highly reliable power, may use microturbines increasingly to meet their changing energy needs. Other applications for microturbines include back-up power; remote power; CHP systems; mechanical drive; and resource recovery of waste fuels.


Capstone Microturbines

Program Goals and Activities

The U.S. Department of Energy's Office of Power Technologies is currently leading a national effort to design, develop, test, and demonstrate a new generation of microturbine systems for distributed energy resource applications. Advanced microturbines will be cleaner, more fuel efficient and fuel-flexible, more reliable and durable, and lower in cost than the first-generation products entering the market today. The Advanced Microturbine Systems Program focuses on the following performance targets for the next generation of microturbine products:

- **High Efficiency**—The target for fuel-to-electricity conversion efficiency is at least 40 percent.
- **Environment**—The NO_x target for emissions is less than seven parts per million in practical operating ranges.
- **Durability**—The goal is 11,000 hours of operation between major overhauls and a service life of at least 45,000 hours.
- **Cost of Power**—The target is achieving installed cost lower than $500 per kilowatt, a cost of electricity competitive with current technologies.
- **Fuel Flexibility**—The next generation of microturbine products should be capable of using different kinds of fuels, including natural gas, diesel, ethanol, landfill gas, and other biomass-derived liquids and gases.

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For further information:

Office of Power Technologies
www.eren.doe.gov/power/

Distributed Energy Resources
www.eren.doe.gov/der/

Partners:

Baseline Testing

- National Rural Electric Cooperative Association (NRECA)
- Southern California Edison
- University of California-Irvine

Advanced Microturbine Technology Development

- Capstone
- General Electric
- Honeywell Power Systems
- Ingersoll Rand
- Solar Turbines
- United Technologies Research Center

Supporting Materials Technology

- Argonne National Laboratory
- Honeywell Advanced Ceramics
- Kyocera Industrial Ceramics
- NASA
- Oak Ridge National Laboratory
- University of Dayton Research Institute

Contact:

Debbie Haught
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
Tel: 202-586-2211
debbie.haught@ee.doe.gov