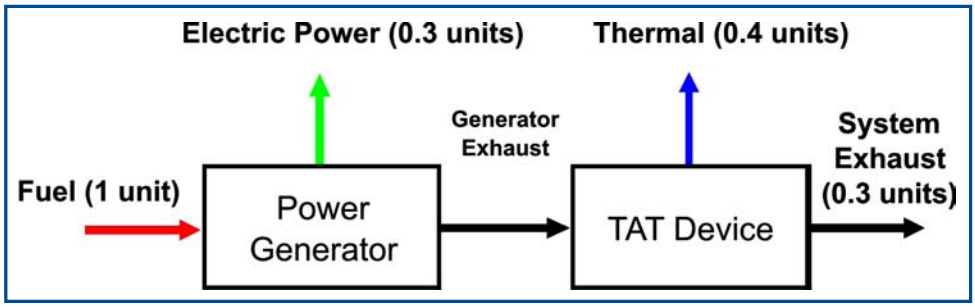
Development of a Packaged and Integrated Microturbine/ Chiller Combined Heat and Power (CHP) System

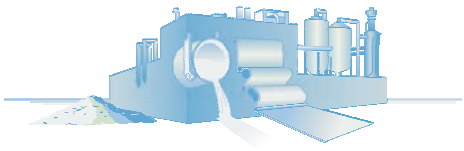
Increased Energy Efficiency and Productivity from a Packaged CHP System

Combined heat and power (CHP, also known as cogeneration) is the simultaneous production of electrical or mechanical energy and useful thermal energy from a single fuel. A CHP system can provide thermal energy for buildings or processes, while simultaneously generating a portion of the needed on-site electricity and utilizing typically wasted process heat (see the figure below for further details on the operation of a CHP system.) Properly designed CHP systems can be more than twice as efficient as the average U.S. fossil fuel power plant. Existing domestic CHP installations total approximately 85 GW of power. However, many of these installations represent solutions to specific customer needs that required considerable on-site assembly and engineering to have the major components operating synergistically. This customized approach is expensive and serves as a barrier to the further growth and utilization of CHP technology.

The project aims to address this barrier to industry adoption of CHP technology through the development, integration, validation, and verification of a 1 MW electrical (MWe) microturbine/chiller CHP system that can operate on or off the grid. The final product will be an integrated and packaged system that installs easily and does not have to be optimized on-site. This "plug and play" approach will allow for greater industry adoption of CHP technology.



Simplified CHP system block diagram: A combined heat and power (CHP) system consists of a power generator (such as a microturbine) that is used to produce electricity and a thermally activated technology device (such as a chiller) that captures the otherwise wasted power generator exhaust energy and recycles it into a useful thermal energy stream. The system shown above depicts a 30% electrically efficient power generator followed by a TAT device that converts ~60% of the generator exhaust into a useful thermal stream, yielding a CHP (or fuel utilization) efficiency of 70%.



Benefits for Our Industry and Our Nation

Successful project development and demonstration of the 1 MW microturbine/ chiller CHP system is expected to yield the following energy, environmental, and economic benefits:

- A 28% reduction in primary energy consumption and carbon dioxide emissions, as compared to conventional methods to deliver the same energy
- A 20%–30% lower installation cost as compared to current CHP offerings
- System emissions that can meet 2007 California Air Resources Board emissions standards

Applications in Our Nation's Industry

The potential applications of the microturbine/ chiller CHP technology are very broad because of the power-generating nature of the technology. The most attractive industrial applications are in the wood, agricultural products, chemicals, petroleum production, mining, and textiles industries. Potential commercial-sector markets for CHP microturbine systems include data centers, office buildings, restaurants, and retail services. Institutional market segments include hospital complexes, schools, university campuses, government buildings, and industrial power parks.

Project Description

The project goal is to define, develop, integrate, and validate at full scale the technology for a 1 MWe, microturbine-driven CHP packaged system for industrial or large commercial applications. The system will deliver nearly 500 refrigeration tons of chilled water, thereby exceeding a CHP single package efficiency of 80%.

Barriers

- Demonstration of reliable life-cycle energy costs
- Achievement of reliable and secure power
- Compliance with emissions regulations and interconnection codes

Pathways

The CHP system will utilize the Capstone Turbine Corporation C1000 microturbine package as the power generator and integrate it with an advanced technology double-effect absorption chiller sized to efficiently utilize the C1000 exhaust. Outputs will represent 86% of the input fuel energy.

After extensive design and performance optimization, the components for the system will be installed in a Stamford, Connecticut office building. The CHP system will be rigorously tested to validate the system controls and establish system performance. Upon satisfactory completion of these subtasks, the CHP system will be commissioned for service to the building. To verify the system's operation and response to real building demands, partner Endurant Energy will operate the system for one year. It is estimated that CHP chilling will provide 25% of the total annual chilled water requirements and eliminate the use of backup units during shoulder months. During the winter, the absorption chiller will be configured for the heating mode and will meet 45% of demand.

Milestones

The project start date is to be determined.

Year 1: Preliminary CHP system design, including completion of concept definition to establish technology requirements and control modes that are consistent with the system requirements

- Year 1: Detailed specification of final system design through system performance optimization
- Years 1–2: Installation, integration, and commissioning of the full-scale CHP system at the host site, subject to rigorous testing to validate the system control strategy and establish the system performance
- Years 2–3: Full-scale field verification through operation of the packaged CHP system at the host site over a one-year period

Commercialization

A rigorous stage-gated process will be employed to ensure successful technology development and product commercialization. The team members have successfully installed numerous CHP systems by offering high-quality, affordable products and mitigating market barriers. They will share experiences and lessons learned to install, integrate, validate, and successfully commercialize the 1 MWe CHP system at the host site, a necessary step for successful product commercialization. The 1 MWe CHP system is expected to penetrate the market if it is efficient, reliable, environmentally clean, and achieves a three- to five-year payback. This system is expected to enter the market space for baseload and cogeneration applications up to 5,000 kWe and has the potential for disruptive growth in distributed data centers.

Project Partners

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UTC Power Corporation
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Endurant Energy LLC
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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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