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A Macro Market for Micro-CHP?

With rising fuel prices and an electric grid near maximal capacity, the economic benefits of good CHP applications in multifamily buildings can be substantial to both the investor and the local utility.

by Dominique Lempereur and Richard Tesoriero

Combined Heat and Power (CHP) plants simultaneously generate electricity and heat at the point of use and can achieve fuel conversion efficiencies of up to 90%. Compare this to a traditional remote central power plant, where electricity is generated at 35%–55% efficiency and then transmitted over long distances, while the remaining 45%–65% of waste heat is left behind because it's not easily transported. The advantage for CHP plants is that they receive primary energy, often in the form of natural gas, with the waste heat "still inside." While CHP systems typically have electrical efficiencies of only 22%–29%, the recoverable thermal energy of 50%–65% can bring the overall fuel conversion efficiency to 90%. With growing environmental awareness and an increasing desire to reduce carbon emissions, this efficiency difference is too large to ignore. And of course, with rising fuel prices and an electric grid near maximal capacity, the economic benefits of good CHP applications can be substantial to both the investor and the local utility.

How Low Can You Go?

During the energy crisis of the 1970s, large industrial plants, hospitals, and other large energy users were the primary target for CHP applications, due to the economies of scale for multimegawatt plants. By 2002, over 50 gigawatts (GW) of CHP had been installed nationwide, generating approximately 7% of the nation's electricity. As the CHP market evolved, manufacturers of reciprocating internal combustion engines and microturbines offered a range of smaller CHP models, ranging from 30 kW to 100 kW. These models are a good fit for commercial buildings, hotels, and multifamily buildings larger than several units. With the deregulation of utilities and the continued development of standard grid interconnect protocols, the CHP industry is becoming more established. More recently, the development and commercialization of micro-CHP units in Europe and Japan may point the way to a new class of system that further exploits the idea of distributed CHP generation.

The European Community Cogeneration Directive has defined micro-CHP as cogeneration units capable of generating 50 kW or less of electrical output. Elsewhere, micro-CHP has been defined as systems of less than 16 amps per phase, implying 3.5 kW for single-phase units and 11 kW for three-phase units. Some in the industry claim that the only "true" micro-CHP is one that is targeted to a single home and is limited to approximately 3 kW. An interesting cluster of micro-CHP products has emerged in the global marketplace that meet these requirements. Two of these products, the freewatt and ecopower are actively distributed in the United States (see Table 1).

Freewatt

Recently introduced by Climate Energy in Massachusetts, the Freewatt is powered by Honda's high-endurance, reciprocating internal combustion engine—the engine that powered the similar 1kW Ecowill in over 50,000 Japanese installations. The Freewatt is UL 1471 Certified for Grid Interconnection and has won some awards, including the 2006 Popular Mechanics Breakthrough Product of the Year. With 1 kW of electrical generation, the unit is targeted toward individual homes.

ecopower

The ecopower was developed in 2000 by PowerPlus Technology, a subsidiary of Vaillant, one of Europe's top five boiler manufacturers. To date, over 1,600 units have been sold in Europe. The ecopower was recently introduced to the North American market by Marathon Engine Systems (MES) of Wisconsin, which manufactures the engine that powers the system.

The ecopower is a packaged, gas-driven, 270 cm^3 monocylinder engine. It includes an innovative power-modulating control that allows for full modulation between 2.0 kW and 4.7 kW when the system is operated with natural gas. The system can also burn propane with similar performance characteristics. Thermal energy can be recovered to produce hot water at 167˚F at a rate of 42,700 Btu per hour. When operating continuously the unit can generate approximately 1,600 gallons of 125˚F water per day. Acoustic side panels muffle noise from the unit; at 56 decibels (dBA), the ecopower is quieter than a dishwasher and only about as loud as a refrigerator.

One of the most innovative performance characteristics of the ecopower technology is the patented electronic control unit that keeps the throttle valve fully open at all speeds to ensure optimal replenishment of the cylinder. As a result, the highest possible

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The ecopower unit is assembled at the test facility of Marathon Engine Systems, East Troy, Wisconsin.

efficiency is obtained throughout the range of operation speeds. Overall efficiency can reach up to 90% (25% electric and 65% thermal). This is better than the efficiency achieved by many other CHP engines, and far better than the minimum annual efficiency of 62% generally required by CHP incentive programs. Furthermore, optimized gas combustion and catalytic exhaust treatment reduce NOx emissions below 0.1 lb/MWh—more than 10 times lower than the level required by current CHP incentive programs.

Maintenance of the long-life engine is required after each 4,000 hours of operation; it consists of replacing the oil, oil filter, spark plug, and plug wire, which are easily accessible from a side panel. The ecopower is equipped with a computerized system that allows for the monitoring and storage of operating data. These data can be downloaded onto a laptop computer from an RS485-interface located in the rear panel of the unit.

Multifamily Micro-CHP Applications

The multifamily building market is a unique niche for CHP projects. On one hand, this market offers a great potential for such projects, given the large number of multifamily buildings nationwide, and the technical advantage of having predictable domestic hot water (DHW) loads. On the other hand, a CHP project requires a very specific combination of thermal load, electric load, and electric metering in order to be a cost-effective investment (see "Energy Savings in a Manattan Co-op," p.24).

With the increasing price of electricity, owners and property managers are motivated to have utility companies directly meter occupant electric usage. This often gives occupants an incentive to reduce their electric usage by as much as 20%. It also relieves owners and property managers of the administrative and financial costs

Table 1. Micro-CHP Options

Size (kW)	Product Name	Prime Mover	Country	Manufacturer / Distributor	Parent Company	Installations
5.3	DACHS	IC engine	Germany	SenerTec	Baxi Group	>8,000
5.0	Genelight	IC engine	Japan	Yanmar	-	unknown
4.7	ecopower	IC engine	Germany / USA	PowerPlus Technology/ Marathon Engine Systems	Vaillant	>1,400
1.2	WhisperGen	Sterling engine	New Zealand	Whisper Tech	-	Unknown
1.0	Ecowill/ Freewatt	IC engine	Japan / USA	Climate Energy	Honda	> 50,000

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This ecopower 4.7 kW installation is operating in a large single-family home in West Port, Connecticut.

of paying master meter charges and collecting the submetered electric charges from occupants. However, direct-metered buildings tend to have a lower electric baseload, one that cannot be cost-effectively served by CHPs in currently available sizes of 30–100 kW.

Steven Winter Associates (SWA) assesses the potential for CHP in multifamily buildings with Multicogen, a multifamily building CHP screening tool. This tool was designed and developed by SWA under contract with the New York State Energy Research and Development Authority (NYSERDA). (See "Multifamily Takes Baby Steps to CHP," *HE* Nov/Dec '06, p. 8.) Aided by the use of this screening tool, we have found that the installation of the smallest available CHP unit, a 30 kW microturbine, often requires the building to be master metered for electricity, and to have a minimum of 80 apartments to ensure a sufficient year-round DHW thermal load. Outside of large metropolitan areas, multifamily buildings are generally smaller than 50 apartments and tend to be direct metered. Once a building is installed with direct utility meters, most will remain in this metering configuration, because of the capital costs and administrative burden of switching to master metering.

In short, because there are no suitably sized CHPs, and because most multifamily buildings are direct metered, many potential CHP applications are lost, and with them the opportunity to save energy. However, the modular use of micro-CHPs can help to fill this gap in the market.

Preliminary design and calculations show that one ecopower unit set for electric load following can supply electricity to all common-area lighting and exhaust fans of a 32-apartment building while supplying about 50% of the overall DHW loads. This configuration allows for an optimized utilization of recoverable thermal energy. The ecopower is a modular system that can connect up to eight units, thus allowing for output capacity up to 40 kW and filling the gap between residential micro-CHP application (1 kW) and the 30 kW–100 kW CHP systems.

Through a NYSERDA pilot project, Steven Winter Associates plans to demonstrate the advantages of this packaged, modular micro-CHP concept and to test a new EcoIsland unit that includes battery backup and a DC/AC inverter to allow grid-independent operation of the ecopower for critical backup power. The main goals of the project are to begin standardizing the engineering, permitting, and grid interconnection processes for micro-CHP projects in New York; to document the actual performance of the units over a one-year period; and to confirm the actual benefits of micro-CHP with 15-minute data logging of CHP parameters. He

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For more information:

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