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Product Technology

RESIDENTIAL COMBINED HEAT AND POWER PILOT PROGRAM IN MASSACHUSETTS

OVERVIEW

There is an increasing urgency for affordable, reliable and practical means to reduce energy consumption and environmental impact in the residential and small commercial markets. Considerable strides have been made in the energy efficiency of home appliances and lighting and in the performance of windows, insulation and weatherization techniques.

Alternative forms of energy are also emerging in the residential market; however, they are not always cost effective or feasible options for existing homes. The Micro Combined Heat and Power system (MCHP) offers another option for energy savings through an existing infrastructure that is applicable in most residential homes, and has a relatively short term return on investment.

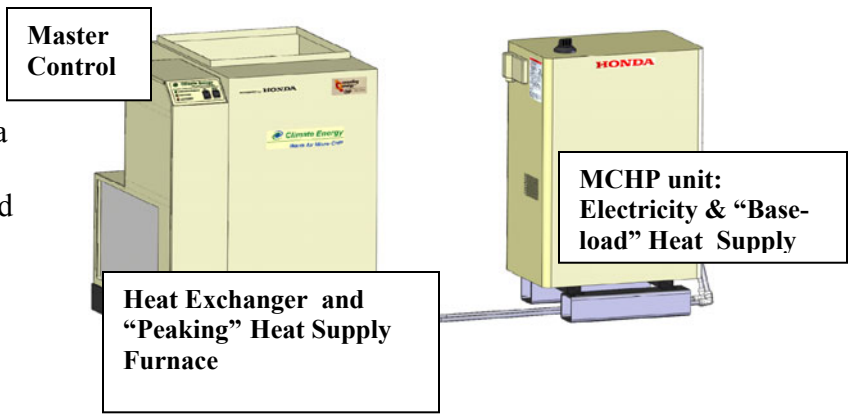
MICRO CHP

Combined Heat and Power (CHP) or cogeneration, has been used in large commercial and industrial applications for years and has been shown to significantly reduce energy expenses and minimize emissions. CHP technology has been modified for the residential and small commercial markets, known as Micro CHP or MCHP. Similar to CHP systems, the MCHP

technology can provide a secure and highly efficient method of generating electricity and heat at the point of use. In the electricity generation process, waste heat is recovered and utilized for space heating, creating tremendous efficiencies. Due to the avoidance of transmission losses experienced with grid supplied power, MCHP achieves a reduction of the primary fuel use, converting 85% to 93% of the available fuel energy to useful heat and power. The simultaneous generation of heat and power also translates into important emission reductions compared to conventional sources of heat and power such as the power plant and stand alone heating equipment.

The Climate Energy freewatt™ MCHP system is the first grid connected, space heating appliance in the U.S. The freewatt system was designed by Climate Energy to be a replacement for gas fired, warm air furnaces (boiler and hydronic versions are in development) in retrofit and new construction applications. The system consists of four major components: a 93% Annual Fuel Utilization Efficiency (AFUE), high efficiency gas fired, furnace manufactured by ECR International; a gas-fired engine generator manufactured by Honda; a system controller; and a cogeneration heat exchanger, which transfers heat from the engine's cooling system to the space heating system through coolant lines and a liquid-to-air heat exchanger. (See diagram 1)

The freewatt system runs on a demand for space heating, and generates electric power as a



byproduct of the normal operation of the home. The engine provides approximately 11,000 btus per hour of thermal energy to the furnace. Simultaneously, the generator produces 1.2 kilowatts (kW) of electric power for the home. It is this process that maximizes the fuel to produce electric power and produce heat to satisfy the heating demand. The condensing furnace augments the 11,000 btus with the additional heat necessary to reach the homeowner's desired temperature.

During periods of the day when more than 1.2 kW is consumed in a home, the electric power will be fully utilized and additional draw will come through the electric meter. However, when the home's consumption drops below 1.2kW, such as at night, the excess power goes back to the grid, spinning the electric meter backwards. A net metering agreement with the electric utility allows customers to pay for only what they consume. In areas where net metering is not allowed, the benefits of this system to the homeowner are negligible.

The generator component of the freewatt is a Honda unit and there are over 30,000 Honda MCHP systems installed in Japan today. The freewatt has the capability to provide back up power and grid support without any sacrifice in thermal comfort or compromise in building design. It provides an alternative option for energy savings, which can be integrated with the existing infrastructure of the heating system in a home.

Market barriers are minimized for this new technology, because the freewatt system is a heating system and can be introduced to the market through the existing HVAC market. Wholesale and distribution houses could include the freewatt system in their product lines.

With proper training, heating contractors (and electricians) could sell, install and service the systems. In addition, remote monitoring and advanced diagnostics could minimize the guess work from a service call as well as limit the number of service calls.

The freewatt is monitored through a broadband internet connection that can be accessed by Climate Energy, the service provider, and the homeowner. Such connections could be used by utilities for demand response purposes and provide another business opportunity for heating system contractors and energy system operators.

PILOT TEST

Climate Energy, KeySpan Energy Delivery, and KeySpan Home Energy Services partnered to launch a pilot test program with the freewatt in eastern Massachusetts. A total of 22 certified systems have been installed in homes to be monitored for operating performance. The beta site installations were a result of funding collaboration from KeySpan, Braintree Electric Light Department, the Low Income Affordability Network and the Massachusetts Technology Collaborative. Remote monitoring of the systems is possible by connecting the system controller to the Internet. Each site in the pilot test is equipped with a broadband connection so the system can be monitored, controlled, and diagnosed from Climate Energy's lab.

KeySpan Energy Delivery is evaluating the installation process, the interconnection processes, and any operating results for comparison with the performance of conventional

warm air furnaces to determine overall efficiency, energy savings, emissions reductions, and enhanced comfort of homeowners.

Net metering is critical to realizing energy savings through the use of the system. KeySpan Energy Delivery's evaluation study is only addressing the benefits of the system with effective net metering arrangements. Results of the evaluation will be used to properly design a Micro CHP energy efficiency program through KeySpan's Energy Management Department.

Results, Achievements, and Concepts

Despite a mild winter in 2006, the initial test sites showed overall energy cost savings between 30 and 35 percent of the freewatt system compared to heating systems with an AFUE less than 80 percent. The energy savings reflect combined electricity and natural gas savings. In applications where the previous heating systems had less than an 80 percent AFUE rating, the energy cost savings hovered around 35 percent. Systems with an AFUE of 80% or higher that were replaced for the beta unit showed savings on average of 30 percent. And, in applications where the replaced heating systems had a 90 percent AFUE or greater, the savings resulted in approximately 25 percent reduction in combined energy costs. However, the natural gas consumption shows minor increases due to the additional draw from the Honda generator. CO_2 emissions were curbed by 25-28 percent, on average throughout the beta sites.

Benefit Cost Ratio

The development of a benefit-cost ratio for the system took into account some actual data derived from the test sites and included standard assumptions used in evaluating high efficiency furnaces. The base case was an 80 percent AFUE furnace, and the measurement assumed that the freewatt system would act as a replacement unit and not an early retirement system. The useful life of the system as suggested by Climate Energy was estimated at 15 years, 5 years less than most high efficiency furnaces. The incremental cost, kW production per hour, and annual run hours were also provided by Climate Energy.

The incremental cost considered in the analysis did include the installed cost based on the actual installation cost ($13,000) of the freewatt system compared to the installed cost of a new, stand alone furnace system ($6500). Electric power output of 1.2 kWh, the actual output for the production models, was also included as a factor. Estimating annual run time is more complex with the freewatt system than with stand-alone heating systems because incorporating the engine generator with the run time of the furnace is critical. Due to the 11,000 btu output of the generator, the run time of the generator actually exceeds the run time for the furnace, but both units are considered as a whole system. Climate Energy assumes that the engine generator runs continually when the space heating demand exceeds the 11,000 btu output. KeySpan estimated 4,500 hours as the annual run time factor for a typical single-family, detached home of 2,000 square feet in the greater Boston area.

The freewatt system requires additional natural gas to power the Honda generator, in comparison to a stand alone heating system. KeySpan estimated a 7 percent increase in gas consumption for a high efficiency (90% AFUE) furnace as a factor.

The analysis of annual estimated savings in gas (mmbtu) combined with the annual estimated savings in electricity (KWh) resulted in a benefit-cost ratio (BCR) of 2.54. A BCR over 2.0 for gas equipment is a very encouraging indication of energy savings.

Leading factors:

Useful Life	15 years
Annual Run Time	4,500 hours
Incremental Cost	$6,500
Annual kWh Production	1.2 * 4,500 hours = 5400 kWh
Annual btu Output (mmbtu)	13,840 * 4,500 hours = 62.28 mmbtu

Results

Annual Savings from Basecase to Furnace w/ MCHP (mmbtu)	71.6 mmbtu
kWh Savings from Basecase to HE Furnace w/ MCHP	5502.0 kWh

Program Development

The calculated benefit-cost ratio includes avoided costs, not retail costs, and is substantial enough for KeySpan to adopt an incentive for the 200 production models to be released in

2007. The initial cost of the installed unit is $13,000, which is a market barrier to product adoption and market penetration. KeySpan is offering a $2,000 incentive through its Building Practices and Demonstration Program Pilot Program to customers interested in the freewatt system. Homeowners that purchase the system and take advantage of KeySpan's incentive are required to provide KeySpan with one year's worth of electricity and gas consumption data for further analysis. Future monitoring will be valuable to determine longer term effects on energy consumption and savings over time.

CONCLUSION

This is a technology that provides a bridge to the gap between conventional appliances and renewable energy alternatives for residential and small commercial customers. The cost effectiveness of the MCHP is more practical than many renewable options, and the infrastructure exists through the conventional heating equipment market to bring the MCHP system into the marketplace through heating contractors and distributors. The MCHP market will expand with continued adoption and development of the technology. Climate Energy is scheduled to introduce and test a hydronic MCHP unit in the Fall of 2006 and a combination warm air and hydronic system in the Fall of 2007.

Production models for 2007 are limited to 200 models, however co-gen ready furnaces can be installed in anticipation of adding the MCHP unit at a later date.