The Climate Energy Micro-CHP System – Powered by Honda^{TM}: Interim Field Test Results

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ABSTRACT

With the emergence of ***Micro*** Combined Heat and Power (Micro-CHP) systems, single family residences can now pursue and realize the same benefits of cogeneration that commercial and industrial users have been appreciating for over one hundred years. However, as with any emerging technology, market acceptance and penetration is likely to be initially limited by lack of information and demonstrable results.

The grid connected Climate Energy Micro-CHP System is heat-led and will provide 1.0 to 1.2 kW of electricity and about 11,000 Btu/hr of thermal energy whenever there is a need for space heating. An auxiliary furnace or boiler (included with the system) satisfies the balance of the heat demand as required.

The Climate Energy Micro-CHP System saves energy and natural resources by providing heat and electricity more efficiently than a conventional central power plant, which in turn reduces harmful power plant emissions. Micro-CHP technologies can be used as an energy conservation tool, for enhanced T&D system reliability, in a demand response scenario, to reduce pollutant emissions, or simply to be "green".

Twelve (12) Climate Energy Micro-CHP pilot test systems were installed starting in December 2005. This paper documents the installation process in comparison to conventional space heating equipment, the interconnection process and permitting requirements, and quantifies the performance, economic, and environmental benefits of Micro-CHP within the single family residential sector.

Introduction

What Is Micro-CHP?

Often referred to as cogeneration, the term now mostly widely used is "combined heat and power" or CHP. This means the simultaneous production, and more importantly the simultaneous use, of heat and electric power from the same device or system. *Micro*-CHP is simply CHP sized for the individual home.

It's well known that making heat and power together in the same place, when technically practical, is a far more efficient use of limited and increasingly expensive fuel supplies. While the combined heat and power concept is old and widely practiced on the industrial scale, it's the "technically practical" part where Climate Energy contributes for individual homeowners. Technically practical implies that the equipment to do this must be affordable, reliable, quiet, safe, and maintainable.

The Climate Energy Warm Air Micro-CHP System

The first Climate Energy Micro-CHP field test systems combine a high efficiency 93% AFUE condensing gas furnace designed and manufactured by ECR International with a state of the art high efficiency natural gas fired engine generator module designed and manufactured by Honda Motor Company. Additional system components include the hybrid integration module, coolant lines and the system controller. The hybrid integration module transfers heat from the engine's cooling system to the space heating system via the coolant lines and a liquid to air heat exchanger. A Climate Energy Warm Air Micro-CHP system is shown in Figure 1.

Figure 1. The Climate Energy Warm Air Micro-CHP System

Source: Climate Energy. 2005

The Climate Energy Micro-CHP system is heat-led and generates electric power as a by-product of the normal operation of heating the home. The engine produces approximately 11,000 Btu's per hour of heat which is used to heat the dwelling while the generator simultaneously produces 1 kilowatt of very high quality electric power for consumption in the home (production model systems will produce 1.2 kilowatts of power). This means that the fuel normally used to keep a home warm is used twice, first to produce electric power and then to heat the home. Electric power is generated whenever heat is produced to satisfy normal space heating demands in the home (i.e. anytime the thermostat calls for heat).

During the winter when the heating demand is at its peak, the engine's heat output is augmented by operating the furnace. In this sense, the heating system has two stages, where stage one is the engine and stage two is the furnace. The goal is to operate the engine, with its modest heat output, close to 100% of the time throughout the heating season in order to maximize electricity production. When heat demand increases beyond what can be supplied by the engine alone, the larger capacity furnace (sized to meet the full heating load) kicks in to provide the balance. Electric power is produced in both stages of operation. In essence, whenever there is a demand for heat, the engine runs as much as possible, and the furnace operates as little as possible and only when absolutely necessary. The Micro-CHP system is designed to produce electric power and provide low level heat nearly continuously during the heating season.

Operating Performance

Power Generation and Energy Savings

The heat and power produced by the Climate Energy Micro-CHP system is generated at a very high thermal efficiency, approximately 93% assuming indoor installation where the cabinet heat contributes to the heated space. Laboratory performance data is summarized in Table 1.

Table 1. Climate Energy Micro-CHP Engine Generator Thermal Efficiency

	[Btu/Hr]	[Watts]	[% of Total]
Energy Input (Firing Rate)	18,307	5,365	100.0
Electric Power Output	3,412	999	18.6
Thermal Output (Engine Coolant)	11,739	3,441	64.1
Cabinet Ventilation Heat Output	1,673	490	9.1
Cabinet Surface Heat Output	200	59	1.1
Stack Loss (Exhaust)	1,283	376	7.0

Source: Climate Energy Laboratory Evaluation. 2003

This means that 93% of the energy content of the fuel consumed to produce heat and electric power is transformed into useful energy. This is much higher than the thermal efficiency of conventional central power plants, typically only about 30% to 40%. Most central power plants convert fuel to heat and then only a portion of that heat to electricity. The portion of the heat not converted to electricity is typically dissipated without value into the environment.

The electric power produced by the Micro-CHP field test system displaces 1.0 kilowatt of electricity that the homeowner would otherwise purchase from the electric utility, while heating the home at a combined thermal efficiency of 93%. This saves energy and money for the consumer by lowering their electric bill, and conserves natural resources and reduces power plant emissions by virtue of the higher thermal efficiency.

Estimated Annual Operating Hours

Annual run time estimates for a Micro-CHP system are more complex than conventional heating systems since it is necessary to account for the relative contributions of the engine-generator and the furnace to the total energy usage. Total space heating energy usage is a function of the building size and design, and local weather conditions, normally characterized as heating degree days.

An annual simulation model for the application of the Micro-CHP system in residential buildings has been formulated in an Excel spreadsheet using Visual Basic for Applications. The simulation program reads TMY2 (Typical Meteorological Year) weather data files. A TMY2 file is a data set of hourly values of solar radiation and meteorological elements that represent a one year period based on sources from the National Solar Radiation Data Base. It consists of months selected from individual years and concatenated to form a complete year. TMY2 data sets are available for many U.S. locations and provide a means of characterizing the heating loads incurred during a "typical" year (RRDC, 2006).

The simulation model inputs include the heating energy intensity and floor areas of the residence, the performance characteristics of the Micro-CHP system and the local TMY2 weather data. Mean heating energy intensity values derived by Hua Wang for the New England region are shown in Table 2.

Table 2. Mean Heating Energy Intensity

	Apartment > 5 Units	Apartment 2-4 Units	Mobile Home	Single Attached Home	Single Detached Home
Mean Heating Energy Intensity [Btu/HDD/Sq. Ft.]	5.03	11.69	10.86	9.05	7.38

Source: Wang, Hua. 2003

The estimates of run time for the Micro-CHP system assume that the engine-generator runs continuously whenever there is a space heating demand that exceeds the thermal output of the engine. The model also assumes that the engine runs intermittently as needed to supply heat demands that are less than the thermal output of the engine. The TMY2 weather data is used to determine the level of expected heating demand. Using the simulation model, annual engine-generator run time hours versus heating degree days are estimated in Table 3 for a typical single family detached home of 2000 square feet.

Table 3. Estimated Engine-Generator Annual Run Time Hours For Single Family Detached Home, 2000 Square Feet

Heating Degree Days	Estimated Annual Operating Hours
4,000	3,000-3,500
5,000	3,500-4,000
6,000	4,000-4,500
7,000	4,500-5,000

Source: Climate Energy MCHP Simulation Model. 2005

The average annual electric power demand in northeastern U.S. homes is about 8,000 kWh per year, and in all U.S. homes is about 10,900 kWh per year (EIA, 2004). The Micro-CHP system will not provide all of that power. However, in climates with 6,000-7,000 annual heating degree days, typical for the northeast and much of the northern half of the country, it is expected to provide in the range of 4,000 to 5,000 kWh per year – a significant percentage. At an electric rate of $0.10 per kWh, this represents electric bill savings of $400 to $500 per year. Annual savings increase with increasing electric rates and colder climates (i.e. more run time).

Generating Capacity and Net Metering

To understand why a generating capacity of 1.0 to 1.2 kilowatts was chosen as optimum, one must consider the regulatory nature of net metering.

During some portion of the day, particularly during occupied morning and evening hours, homes are expected to consume more power than the 1.0 kilowatt provided by the Micro-CHP system. During these times, the electric power produced by the Micro-CHP system would be completely absorbed in the home, reducing the amount of electricity purchased from the utility, and hence lowering the homeowner's electric bill. At times when the home electricity consumption is lower than 1.0 kilowatt, for example during nighttime hours, the excess power is sent to the grid and the electric meter spins backward as the system produces more electricity than is required in the home.

A net metering agreement with the electric utility allows customers to draw power from the grid or supply power to the grid during a billing period and the customer pays only for the net amount of power consumed during the period. The meter is read at the end of the billing period and the indicated kilowatt-hours are used to assess the bill. This provides a full retail credit to the consumer for excess power sent to the grid. Ten states currently mandate that electric utilities provide net metering to qualified small power producers utilizing combined heat and power systems.

However, under most net metering arrangements, there would be little or no value for any electric power generation in a particular month that is in excess of actual monthly usage. For example, full retail credit can not be taken for 1,200 kWh of production if monthly usage is only 1,000 kWh. The last 200 kWh of production would typically be credited at a much lower wholesale electric rate or not at all. This could occur in heat-led Micro-CHP system configurations in cold months (high heat usage) with over sized generators. This reduced value for overproduction of electric power would render the Micro-CHP system uneconomic anytime the monthly power production surpassed the actual monthly power consumption. It would be appropriate to shut down the generator under this condition at which point it no longer would provide a benefit to the owner. Furthermore, a larger generator would be expected to have a higher first cost, a larger footprint and perhaps a higher noise level. So over-sizing of the generator is to be avoided.

As noted previously, the average annual power consumption in all northeastern U.S. homes is on the order of 8,000 kWh (EIA, 2004). It is assumed that the typical purchaser of the Micro-CHP system would use somewhat more power, 10,000 or more kWh per year, or 833 kWh or more per month. The system is expected to run continuously in the winter months and would produce from 720 kWh per month (at 1.0 kW output) to 864 kWh per month (at 1.2 kW output) during these times. The system is sized so as not to exceed the typical monthly power usage during the winter months when it is expected to run continuously based on heat demand.

Carbon Dioxide Emissions

The amount of CO2 emissions from the combustion of fossil fuels used to generate electricity varies according to the carbon content and heating value of the fuel. The Btu content of fuels is a determinant of the number of kWh that can be produced and the carbon content is a determinant of the amount of CO2 released when the fuel is burned (DOE/EPA 2000).

Further, CO2 emissions from electric power generation are influenced by the efficiency with which fossil fuels are converted into electricity. In a typical power plant, about one-third of the energy contained in the fuel is converted into electricity, while the remainder is emitted as waste heat. Substantial improvements in generation efficiency can be achieved through the replacement of traditional power generators with more efficient technologies such as combined cycle generators and combined heat and power systems. In these types of systems, otherwise wasted heat is captured to produce additional electricity or to displace energy used for heating or cooling. Both strategies result in lower CO2 emissions (DOE/EPA 2000). Table 4 summarizes the CO2 emissions from various types of power generation.

Table 4. CO_2 Emissions Summary

Typical Power Generation Thermal Efficiencies		
Climate Energy Micro-CHP	93%	3,700 Btu/kWh
Conventional Coal Boiler	34%	10,000 Btu/kWh
Conventional Gas Boiler	31%	11,000 Btu/kWh
Gas Turbine Combined Cycle	50%	6,800 Btu/kWh
CO_2 Emissions per Fuel Input		
Coal	200 pounds/million Btu	
Natural Gas	120 pounds/million Btu	
CO_2 Emissions per Electric Power Output		
Climate Energy Micro-CHP	0.44 pounds/kWh	
Conventional Coal Boiler	2.1 pounds/kWh	
Conventional Gas Boiler	1.3 pounds/kWh	
Gas Turbine Combined Cycle	0.82 pounds/kWh	

Sources: Climate Energy Laboratory Evaluation. 2003; DOE/EPA. 2000; EIA. 2005; Nadel, et al. 2001

Combined heat and power systems, whether large-scale commercial/industrial systems or small-scale systems such as the Micro-CHP, provide real and undisputed environmental benefits. They do this by reducing the amount of fossil fuel that must be burned to provide heat and electric power, in comparison to the conventional approach of taking electric power from the grid while using a separate heat source for space heating.

The Micro-CHP system has three additional environmental benefits:

1. A high overall efficiency

2. The use of a "clean" fuel (natural gas) and advanced combustion and pollution control technologies (oxygen sensor, catalytic converter) to yield extremely low pollutant emission rates
3. The electric power produced by the Micro-CHP system displaces central power plant emissions.

Half of the U.S. electric power is generated by burning coal (EIA 2005) in plants with efficiencies between 30% and 40% (DOE/EPA 2000). Table 4 shows that the Micro-CHP system releases less than a quarter of the CO_2 emissions of a typical coal fired power plant on a pounds per kWh basis, and about half that of the latest combined cycle gas turbine technology.

Enhanced Comfort

The Micro-CHP system is designed to provide enhanced thermal comfort during the heating season by delivering continuous low level heat at a low flow rate to the dwelling (90 - 95 °F air at 300 - 500 CFM). This approach to heating is expected to reduce temperature swings and the cycling normally experienced with typical home heating appliances. Constant operation also draws more air through the heating system, enhancing the operation of air filters, purifiers, and humidifiers, and helping improve indoor air quality.

In addition the furnace utilizes a variable-speed electronically commutated motor (ECM) for the circulating air blower. ECM type blowers are recognized for their lower power consumption at low speed thus reducing fan power compared to the permanent split capacitor type motors used in typical furnaces.

Quiet Operation

Laboratory and field testing have shown the Micro-CHP system engine generator to be extremely quiet – only 44 dBA at 1 meter (Honda Motor Company 2005, 1-4 and 1-9). This sound level is quieter than the 55-65 dBA of an operating refrigerator (EPA 2003).

Low Maintenance

On the heating side, required service is the same as for any similar residential furnace or boiler system. On the engine-generator side, a routine service procedure similar to an automotive tune-up is required every 6,000 operating hours - about every 1 to 2 years. The service includes oil and filter change, air filter cleaning, breather/separator change, spark plug replacement and routine adjustment. It should take about an hour, with parts estimated to cost $80-$100 retail. The system controller alerts the owner and the dealer when the service interval is approaching. This routine service is expected to be included with the sale of the Micro-CHP system and will be performed by the dealer.

Internet Connected

The system controller is connected to the Internet for remote monitoring, control, troubleshooting, diagnostics and service messages – streamlining the system's control and maintenance. The end user, the installing contractor, the utility, and Climate Energy are all able to communicate with the Micro-CHP system in accordance with their programmed security levels. A broadband cable or DSL Internet service is required. This connectivity could allow an electric utility to utilize the Micro-CHP system in a demand response scenario.

Secure Comfort

The standard field test systems and first year's production models will shut off immediately if the grid goes down and stay off as long as the grid remains down. They will automatically restart once grid power is restored.

Advanced systems are under development that will provide up to 2 kW of continuous power in the case of a grid outage. These systems will also have the ability to start up without grid power in the event the system is between run cycles when grid power is lost. This will keep the heat on if the grid goes down, maintaining indoor comfort, prevent winter freeze ups, and provide some residual power for convenience and appliance outlets.

About 500 watts would be consumed by the heating system. The convenience outlets would have 800-1,000 watts available and would typically be used for temporary lights, radio, and TV usage during a grid outage. The appliance outlet would have another 500 watts available and would be dedicated to a single appliance such as a refrigerator, freezer, sump pump, or garage door opener.

Heat dump capability will be provided, allowing the Micro-CHP system to operate during a summertime grid outage as well.

Field Test Program

In preparation for the release of production model Micro-CHP systems in late 2006, Climate Energy began installing field test systems in Eastern Massachusetts in November of 2005. The pilot testing has focused on Eastern Massachusetts for several reasons:

1. Climate Energy is located in the Boston area
2. Net metering for Micro-CHP is a statutory requirement in Massachusetts
3. Interconnection follows a simplified process for equipment of this type (IEEE compliant inverter based distributed generation systems under 10 kW)
4. The local gas utility, Keyspan Energy Delivery and local and state code officials have been very supportive of the development efforts.

In addition, Climate Energy has worked closely with Keyspan Home Energy Services (KHES), the installation and service subsidiary of Keyspan Energy Delivery. KHES is the largest installer of heating and cooling equipment in New England. KHES has provided input on the design and development of the Climate Energy system to help insure that it meets the needs of the installer and service community. They have also helped to provide a better understanding of various code requirements. KHES has performed the installation of the field test systems.

Twelve Micro-CHP field test systems have been installed to date. The sites range from private single family residences to a model home to a small commercial maintenance facility. A summary of the field test installations is shown in Table 5. A typical field test installation is shown in Figure 2.

Installation Process

The mechanical installation of the furnace portion of the Micro-CHP system is identical to the installation of any typical high efficiency condensing furnace. The required connections are:

- Sheet metal ductwork for supply and return air
- PVC pipe for vent and air intake
- ½" black pipe for gas connection
- 120 VAC power from circuit breaker in electrical panel
- Condensate drain line and/or condensate pump
- Installation of communicating thermostat and connection to system controller

Additional connections for the engine generator module include:

- PVC pipe for vent connection
- ½" black pipe for gas connection
- 240 VAC power from circuit breaker in electrical panel
- Condensate drain line
- Coolant lines to hybrid integration module on furnace (quick connects)
- Some electric utilities require an external disconnect switch

Additional Connections for the Micro-CHP system controller include:

- High speed broadband Internet connection for two way communication
- Communication cable between system controller and engine generator control

Because these were pre-production model field test systems and because UL certification was pending, additional safety controls were utilized that would not typically be used for a production model Micro-CHP system. These additional controls and connections included:

- Carbon monoxide and smoke detector
- Combustible gas detector
- Pressure switch to monitor flow in engine vent (exhaust) pipe

The Internet connection would normally be provided by the consumer's Internet service provider in the form of an RJ-45 network jack installed near the Micro-CHP system. The system controller simply plugs into the network jack in the same way personal computers are networked. Wireless network configurations may also be used where desired. Standard Ethernet protocols apply.

Aside from the Internet connection, the skills/trades already required to install a high efficiency furnace are the very same ones required to install the Micro-CHP system. Climate Energy systems will be installed by Climate Energy certified heating and cooling dealers.

Table 5. Field Test Installations

Site #	Interconnection Date	Dwelling Type	Installation Location	Furnace Size (Input MBH)
5	12/1/2005	Operations Facility	Workshop	100
6	2/14/2006	Home	Basement	60
7	2/17/2006	Model Home/Office	Basement	100
8	3/1/2006	Home	Basement	60
9	3/1/2006	Home	Basement	80
10	3/23/2006	Home	Basement	60
11	2/28/2006	Home	Basement	80
12	3/21/2006	Home	Basement	80
13	3/21/2006	Home	Basement	60
14	3/21/2006	Home	Basement	80
15	3/21/2006	Home	Basement	60
16	3/9/2006	Home	Basement	80

Source: Climate Energy. 2006

Figure 2. A Typical Field Test Installation (Site #6)

Source: Climate Energy. 2006

Interconnection Process

An important difference between installing a Micro-CHP system versus a conventional heating system is the legal requirement for obtaining permission to interconnect the Micro-CHP system with the electric grid. Following proper interconnection procedures is important to insure that the distributed generation system properly synchronizes with the grid and doesn't cause any disturbances in grid performance, and that utility service personnel servicing the transmission and distribution network are protected from stray power in the case of a grid outage. Typical interconnection standards require that various parameters such as voltage and frequency must remain within certain tolerances or the generator must immediately disconnect from the grid. These requirements are outlined in the IEEE-1547 Standard for Interconnecting Distributed Resources with Electric Power Systems. The IEEE standard is incorporated in the UL-1741 standard entitled Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources.

In a net metering environment such as Massachusetts, the physical act of interconnecting with the grid is as simple as connecting 240 VAC utility power from the household electrical panel to the engine generator module in the Climate Energy Micro-CHP system. The utility provides a two-way capable electric meter.

The bureaucratic side of the interconnection is somewhat more involved. Many states have developed uniform interconnection standards for distributed generation systems and these tend to vary by state. Other states have not adopted uniform standards and the regulations vary by utility or locality. The website www.dsireusa.org, the Database of State Incentives for Renewable Energy (DSIRE) is a comprehensive source of information on state, local, and utility based interconnection and net metering requirements, as well as information on incentives that promote renewable energy. Established in 1995, DSIRE is an ongoing project of the Interstate Renewable Energy Council (IREC), funded by the U.S. Department of Energy and managed by the North Carolina Solar Center.

In Massachusetts, the standard tariff provides simplified treatment for small IEEE-compliant, inverter-based interconnections less than 10 kW such as the Climate Energy Micro-CHP system. For these systems, there are no fees for the interconnection approval process, and applications must be processed within 15 days. However, if the proposed interconnection is on a distribution network circuit, the utility may charge a $100 fee to review the network protector's interaction with the system. External disconnects may be required at the local electric utility's discretion.

The process begins with the application form being filled out and submitted to the local electric utility. For distributed generation systems that are UL-1741 listed and labeled (thus IEEE-1547 compliant), the approval is effectively a rubber stamp. Once the utility receives and accepts the application, they issue an application number along with copies of the Interconnection Agreement and Power Purchase Agreement. This typically takes 3-5 days.

Once the installation is complete the local electrical inspector performs an inspection and issues a Certificate of Completion upon determination that the system has been installed in accordance with local electrical codes. The Certificate of Completion and the executed Interconnection Agreement and Power Purchase Agreement are then submitted to the utility.

Next the utility schedules a witness test to verify that the generator properly disconnects from the grid upon loss of grid power. This test is typically witnessed by a representative of the local electric utility. Upon successful completion of the witness test, permission to operate is granted by the utility and the Micro-CHP system is officially put in service. The entire interconnection approval process typically takes 3-4 weeks.

In an emergency replacement scenario where the pre-existing furnace fails during the heating season, the homeowner would have an immediate need for a replacement heating system.

A Climate Energy Micro-CHP system can be installed immediately, with the engine generator remaining in the off position. The system can be run in furnace-only mode until such time that the interconnection approval has been granted, and then the generator can be switched on.

Interim Field Test Results

Over 150 parameters relating to engine-generator and furnace performance were monitored. The data was transmitted to Climate Energy via the Micro-CHP system's Internet connection on a 10 second basis. Operating hours through April 24, 2006, along with electric power and thermal outputs are shown in Table 6. There are no equipment failures to report.

Thorough analysis will be performed at the end of the '05-'06 heating season using data from each test site and each site's current year and prior year electric and gas usage to determine annual electric production and energy cost savings for each Micro-CHP field test system. Site #6, has been partially analyzed and the data corrected for differences in utility costs and heating degree days between last year and this year. Results are summarized in Table 7. In cases where potential differences in utilization patterns from year to year are recognized (not the case at site #6) we will attempt to account for those differences.

Table 6. Interim Field Test Data as of April 24, 2006

Test Site #	Engine Runtime [Hours]	Generator Power Output [kWh]	Engine Thermal Output [10^6Btu]	Furnace Runtime [Hours]	Furnace Thermal Output [10^6Btu]	Total Thermal Output [10^6Btu]	Portion of Thermal Load Satisfied by Engine [%]	Portion of Thermal Load Satisfied by Furnace [%]
5	2771	2771	32.5	0	0	32.5	100.0	0.0
6	1164	1164	13.7	92.6	5.2	18.8	72.6	27.4
7	985	985	11.6	225.6	21.0	32.5	35.5	64.5
8	370	370	4.3	46.3	2.6	6.9	62.7	37.3
9	545	545	6.4	22.5	1.7	8.1	79.3	20.7
10	410	410	4.8	12.0	0.7	5.5	87.8	12.2
11	558	558	6.6	86.7	6.5	13.0	50.4	49.6
12	468	468	5.5	55.1	4.1	9.6	57.3	42.7
13	311	311	3.7	7.1	0.4	4.0	90.2	9.8
14	310	310	3.6	15.0	1.1	4.8	76.5	23.5
15	358	358	4.2	30.6	1.7	5.9	71.1	28.9
16	586	586	6.9	90.0	6.7	13.6	50.7	49.3

Note: Site #5 the furnace is not being utilized.
Source: Climate Energy. 2006

For site #6 the net monthly utility bill savings for the February/March timeframe is $130.89. This number is expected to be typical for the bulk of the winter when the Micro-CHP system should run nearly continuously. The monthly savings will decline in the shoulder heating seasons in the early spring and late fall as the Micro-CHP system cycles on and off according to heat demand, and will fall to zero in the summer when the Micro-CHP system doesn't run. The utility costs shown in Table 7 are actual costs for site #6 and are typical for eastern Massachusetts. A full year's worth of data is required to put a meaningful value on annual savings.

Table 7. Site #6 Monthly Utility Cost Savings – February/March, 2006

Without Micro-CHP		***With Micro-CHP***		
Metered Electric Power [kWh/Day]	**Cost for Electric Power**	**Metered Electric Power [kWh/Day]**	**Cost for Electric Power**	**Net Monthly Electric Cost Savings**
34.07	$210.85	9.55	$63.73	$147.12
Based on Nominal Electricity Cost $0.20 per kWh + $6.43 Monthly Service Charge				
Metered Gas Usage [Therms/Day]	**Cost for Gas**	**Metered Gas Usage [Therms/Day]**	**Cost for Gas**	**Net Monthly Additional Gas Cost**
6.55	$313.91	6.90	$330.14	$16.23
Based on Nominal Gas Cost $1.546 per Therm + $10.12 Monthly Service Charge				
Net Monthly Utility Bill Savings $147.12 - $16.23 = $130.89				

Source: Climate Energy. 2006

Conclusion

The Climate Energy Warm Air Micro-CHP system combines two technologies, an advanced warm air heating system (furnace) and a state of the art natural gas fired engine generator. This hybrid heat and power system yields benefits far surpassing what each component can provide alone. By recycling the heat from the engine generator back into the heating system the homeowner is able to use the heat twice, first to produce power and then to heat their home. Following in the tracks of today's hybrid automobiles, this hybrid for the home saves energy and natural resources, and reduces utility bills, by burning less fuel than today's conventional central power plant and separate heating system. This in turn reduces harmful power plant emissions.

The system is installed by a heating and cooling dealer with a small amount of additional training. The field testing demonstrates that the Micro-CHP system is practical, reliable, quiet, the right capacity, safe, and maintainable. Climate Energy believes that this Micro-CHP system fills an important market gap by providing an affordable, reliable and widely applicable means to significantly reduce the energy consumption and environmental impact of homes without any sacrifice in convenience, comfort or aesthetics and without any change in common building design and construction practices. It accomplishes this while providing desirable new user features such as enhanced indoor comfort and the Internet connected heating system.

The Climate Energy Micro-CHP system integrates mature existing technologies. It is here today, it is not simply an idealized vision of what the future might hold.

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