AUTONOMOUS SYSTEMS FOR RESIDENTIAL SPACE HEATING

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INTRODUCTION

Natural gas heating systems are widely used for residential space heating where the fuel is available and the climate requires such equipment. Several technology improvements were achieved over the years with respect to energy efficiency, noise reduction, design, or electronic control. In all cases, new natural gas systems still require a secondary source of energy (electricity) to operate the controls and the output energy distribution devices, either in the form of warm air or hot water.

At the same time, severe climate conditions, such as the January 1998 ice storm in North East America or unreliable distribution network, could easily disrupt electricity distribution and thus the operation of the heating system. An autonomous system connected solely to the natural gas network is therefore an interesting option for end users.

The Natural Gas Technologies Centre (NGTC), on behalf of the Gaz Métropolitain Limited Partnership (GMLP), developed, built, and tested several new autonomous concepts. Each heating system use natural gas as the fuel and the source of electricity is either produced from natural gas or obtained from a stored form (battery). The new autonomous heating systems were based on the following concepts:

- a natural gas powered generator,
- a battery coupled with electronic control devices or
- new concepts of cogeneration producing heat and electricity simultaneously (two concepts were developed).

AUTONOMOUS SYSTEMS

When designing an autonomous heating system, several approaches exist. In all cases, a secondary system is installed to provide an electricity supply in the event of electric distribution network failure. The electric unit could either be:

- mounted next to an existing equipment to make up for a temporary power failure (an “auxiliary” or “emergency-type” system) or
- integrated into the equipment and operated only with natural gas (a “complete” autonomous system).

An auxiliary-type autonomy could be composed of a battery and an inverter which will allow the end user to operate the key components of the heating system (blower and controls) for up to ten hours. Another way to gain autonomy through an auxiliary system is to use a natural gas powered generator. In both cases, the integration of an auxiliary power unit directly into a furnace is challenging. The controls used on the latter equipment require a high quality electric supply.

In a cogeneration mode, it is possible to achieve various degree of autonomy. A system using a thermoelectric generator will provide a long-term emergency supply of electricity. When coupled to a forced-air heating system, the thermoelectric generator will produce enough electricity and heat to maintain the indoor temperature of a typical residence (approximately 125 m^2) at a comfortable level, even with an outside temperature as low as –13°C. Below this temperature the system will provide for partial heating with the interior temperature dropping below the set point only during the period of cold outdoor temperature. This is far better than having no heat available.

With cogeneration, it is also possible to get a complete autonomy. By using low pressure steam produced from a natural gas boiler, a unit composed of a turbine, a blower, an alternator, and a heat exchanger can be designed.

The steam is used to activate the turbine and as a source of energy to heat up the space. The turbine in turn drives the alternator and the blower. Such a system is more complex, more expensive, and targeted for niche applications.

The research and development work regarding the two latter concepts shows that a residence could maintain its heating capability even during a rather long power outage.

SYSTEMS IMPROVEMENTS

Of the four concepts, two systems (generator and battery/inverter) were used as emergency units. They provided enough electricity to operate a furnace for a limited period of time, i.e. during a short power outage. Two systems (thermoelectric generator and micro steam-turbine) were used as complete autonomous units. In all cases, the integration of the electric power output with the furnace and the cost are the major challenges.

When designing an autonomous system based on a forced-air furnace, the primary choice is a high-performance, low-power requirement equipment. These new furnaces contain several electronic controls. As the quality of the electric power input (frequency, voltage) is critical, the interface between the electrical source and the heating equipment is challenging. Two options are available: selecting a high quality inverter providing a superior output, or a simpler furnace without sophisticated controls.

Autonomy also depends on the cost of the equipment. Adding a generator, a battery-inverter set, a thermopile, or a turbine will increase the price by a factor of 50 to 200%. The high cost of equipment would thus be a drawback. Following a severe storm with disruption of the electric grid supply, the end users have a high interest to invest in an autonomous system but this interest decreases over time.

CONCLUSION

Four autonomous heating systems suitable for residential applications were successfully completed and results of operation monitored. Two auxiliary systems supplied energy only in the form of electricity. A battery/inverter supplied enough energy to operate a furnace while the natural gas generators were suitable to operate simultaneously several pieces of equipment (lamps, furnace, refrigerator, etc.). Two completely autonomous systems supplied energy also in the form of heat. The thermopile, operating in a cogeneration mode, supplied 100 W to operate a furnace and 3400 W of heat. The system using the steam micro-turbine supplied over 25 kW of heat. All these systems provided autonomy in the event of the electric grid system failure.

Additional work is required to improve the interface between the alternate electric sources and the heating equipment. In addition, selecting high quality and low cost parts is essential in order to design reliable and affordable autonomous systems.