RESEARCH HIGHLIGHT

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Assessment of the Energy Performance of Two Gas Combo-Heating Systems

INTRODUCTION

Natural-gas-fired combination water-heating/space-heating systems, usually called "combo systems," consist of a hot water tank connected to an air handler/fan coil to supply both forced-air space heating and domestic hot-water heating.

Different manufacturers often supply combo system components, and installation practices are variable. These systems are rapidly gaining a share of the residential market, even though there is little infrastructure to support design, installation and servicing.

Although there are assessment standards for individual components of combo systems, there are no specific standards to assess their combined performance and no comparisons to other traditional heating methods.

This research project aimed to establish performance benchmarks for different types of residential combo systems. Objectives included:

- developing testing procedures for combo systems,
- benchmarking the performance of a power-vented water heater with air-handler unit—a typical combo system,
- benchmarking the performance of a high-efficiency combo system—for example, a high-efficiency, condensing water heater with air-handler unit,
- comparing the performance of these systems with each other and to a high-efficiency furnace and a separate, conventional, power-vented water heater.

RESEARCH PROGRAM

In late 1999, Enbridge Consumers Gas, Union Gas Limited and Natural Resources Canada set up a research project with the Advanced Combustion Technologies Laboratory (ACT), Canadian Gas Research Institute (CGRI) and the Canadian Centre for Housing Technology (CCHT) to assess the relative energy performance of different natural gas-fired combo systems.

The project assessed two combo systems. Combo 1 included a conventional, power-vented water heater. Combo 2 incorporated a high-efficiency condensing water heater. These water heaters, described in Table 1, were integrated with an air-handler unit with rated output of 21.4 kW (73,000 Btu/h).

Table 1 Key characteristics of the combos and benchmark equipment

Characteristic	Benchmark water heater	Combo 1	Combo 2	Benchmark furnace
Tank size/capacity—Litres (U.S. gal.)	189 (50)	189 (50)	129 (34)	—
Burner capacity—kW (BTU/hr)	19.1 (65,000)	23.5 (80,000)	29.3 (100,000)	14.7 (50,000)
Efficiency	67%	73%	93%	91%

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Both systems were evaluated at the Canadian Gas Research Institute's (CGRI's) laboratory to establish links between rated efficiencies and actual performance in the lab. Identical systems were then installed at the CCHT's test house facility to assess performance at typical operating conditions.

To evaluate the performance of a new technology, the CCHT twin-houses are first benchmarked under identical conditions, and then a single element is changed in the "Test" house. For this project, the combo systems were connected in parallel in the Test House and operated on alternating weeks in order to take advantage of varying outdoor conditions. Throughout the combo experiments, the Reference House operated a high-efficiency condensing furnace and a conventional power-vented water heater as specified in Table 1. The Test House operated under these same reference conditions throughout the benchmarking period.

A total of 32 days of testing for Combo 1 and 40 days of testing for Combo 2 were completed from February to May 2000 at the CCHT. Return and supply air temperatures, water temperatures, water flow rate, electrical consumption and gas consumption were monitored in both houses. Field operation efficiencies were calculated on a daily basis.

The combo water temperature was set to approximately 60°C (140°F) for both combos, and a common mixing valve was installed on the hot water supply line of both combo systems and set to 50°C (122°F). The benchmark hot water heater was set to 50°C (122°F). The total daily hot water draw was approximately 276 L (60.7gal.); composed of controlled shower, clothes washer, dishwasher, bath and kitchen tap draws.

Approximately halfway through the test period, an adjustment was made to the air handler airflow rate in the Test House to improve the heat exchange effectiveness of the air handler coil. The airflow rate at heating speed was increased from 344 L/s (730 cfm) to 566 L/s (1,200 cfm). The Combo systems were evaluated and compared at the two different speed settings.

FINDINGS

Some of the major findings of the combo experiments in the CCHT houses were as follows.

Combo 1

- Increasing the airflow rate through the heating coil in the air circulation duct showed no statistical change in Combo 1 consumption.
- Space-heating load did not affect domestic hot water delivery. Supply water to the mixing valve during water draws was between 50°C (122°F) and 58°C (136°F) in most cases.
- House space-heating demand was satisfied during the test period, maintaining house temperatures near the thermostat set point on even the coldest days (see Figure 2).
- The conventional water heater of this combo gained efficiency in combined water- and space-heating mode. The combined efficiency was highly dependent on the relationship between space- and water-heating loads—ranging from 55 per cent on warm days to 80 per cent on the coldest days.
- In warmer periods, this combo outperformed the benchmark configuration.

Combo 2

- Increasing the airflow rate through the heating coil in the air circulation duct resulted in additional savings in consumption over the low airflow configuration.
- Hot water draws were handled without any significant drop in water temperature—supply water to the mixing valve during water draws was between 52°C (125.6°F) and 57°C (134.6°F).
- The highest efficiencies were achieved in water-heating mode only—when undiluted cold supply water condenses more out of the combustion products than the warmer water returning from the air handler.
- Combo 2's performance was comparable to that of the high-efficiency furnace during heavy space-heating demand (combined efficiency of 85 per cent). In milder conditions, Combo 2 outperformed the reference system in combined efficiency. This difference is largely attributable to differences in the efficiencies of the two water heaters.

Combo 1 vs. Combo 2

The results obtained from the combo system tests at the CCHT were in line with the results from the CGRI laboratory tests. Throughout the project, both combo systems were able to satisfy the space-heating and water-heating demands of the Test House. In terms of energy use, Combo 2 outperformed Combo 1 by about 12 to14 per cent. The Combo 2 system also surpassed the Combo 1 system in satisfying simultaneous demands for space-heat and hot water. This superior performance was attributed to higher heat output of the burner and the narrower deadband of the water heater aquastat.

CONCLUSIONS AND IMPLICATIONS FOR THE HOUSING INDUSTRY

The calculated efficiencies for the two combo systems during heavy space-heating demands were well in line with the combined annual efficiency (CAE) claimed by the manufacturers. Laboratory and field tests at the CCHT have demonstrated that Combo systems can meet real-life demands for combination space- and water-heating loads in a dwelling. The use of the mixing valve permits the higher water-heater aquastat setting, providing space heating while still ensuring that hot water demands for domestic use are met with only small variations in the supply temperature.

Figure 1 Combo system water heaters installed parallel to the reference water heater

As the first side-by-side testing completed at the CCHT, this project also demonstrated the capabilities of the twin-house facility to evaluate new technologies.

A full report on this project is available from the Canadian Centre for Housing Technology at **http://www.ccht-cctr.gc.ca**

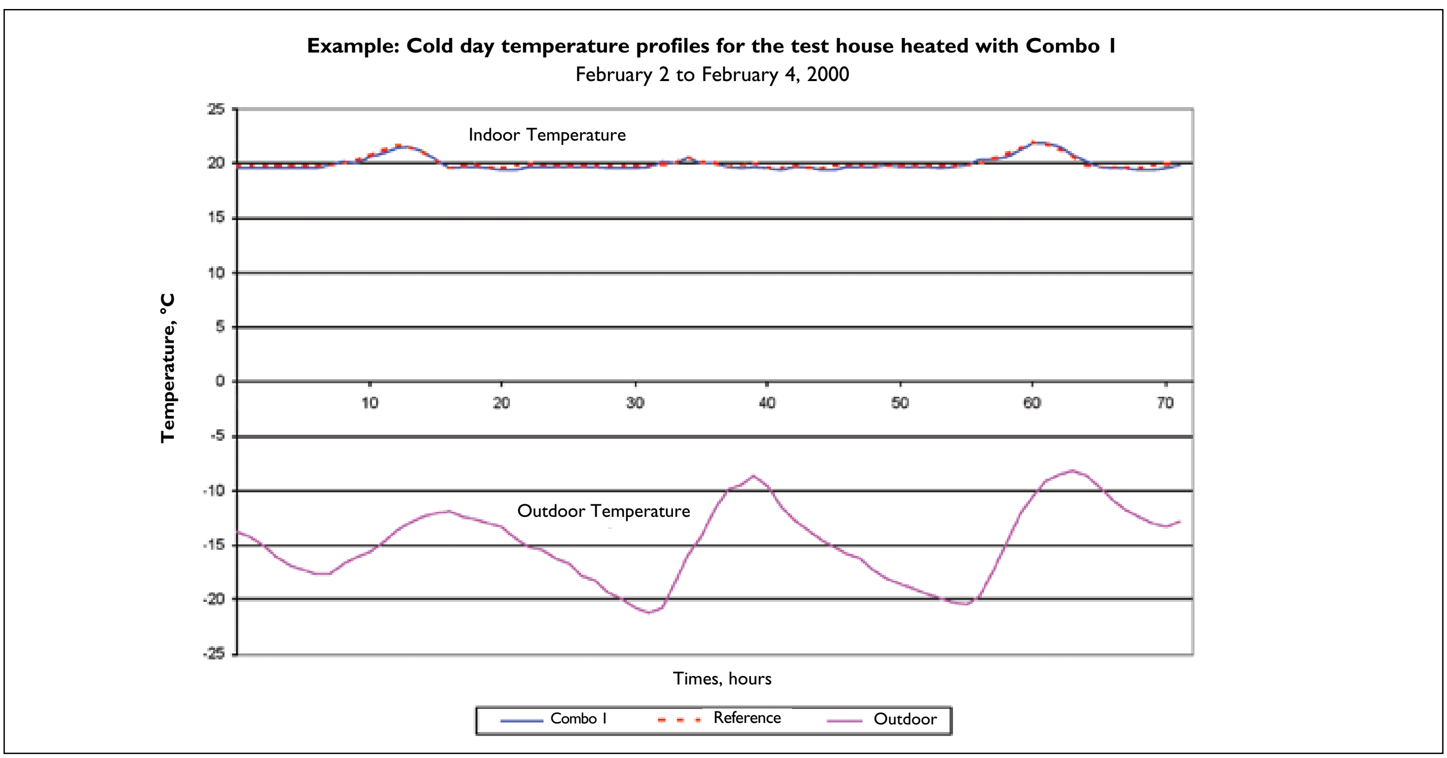

Figure 2 Example of indoor and outdoor temperatures in the test house during a cold period with the Combo 1 heating system

The Canadian Centre for Housing Technology

Canada Mortgage and Housing Corporation (CMHC), The National Research Council (NRC) and Natural Resources Canada (NRCan) jointly operate the Canadian Centre for Housing Technology (CCHT).

CCHT is a unique research, testing and demonstration resource for innovative technology in housing. CCHT's mission is to accelerate the development of new housing technologies and their acceptance in the marketplace.

CCHT operates a Twin-House Research Facility, which offers an intensively monitored, real-world environment. Each of the two identical, two-storey houses has a full basement. The houses, 223 m^2 (2,400 sq. ft.) each, are built to R-2000 standards.

For more information about the CCHT Twin-House Research Facility and other CCHT capabilities, visit http://www.ccht-cctr.gc.ca.

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Housing Research at CMHC

Under Part IX of the ***National Housing Act***, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

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