Building America Case Study

Advanced Controls Improve Performance of Combination Space- and Water-Heating Systems

Minneapolis, Minnesota

PROJECT INFORMATION

Combined Space and Water Heating: Next Steps to Improved Performance

Location: Minneapolis, MN

Partners:

University of Minnesota and The Energy Conservatory

Center for Energy and Environment, *mncee.org*

Northern*STAR* Building America Partnership

Building Component: Space conditioning and water heating

Application: New and retrofit; single-family

Year Tested: 2011–2014

Applicable Climate Zones: Cold, very cold

PERFORMANCE DATA

Cost of energy-efficiency measure (including labor): $6000–$8000

Projected energy savings: 20%–25% heating, cooling, or overall savings

Projected energy cost savings: $200–$300/year

Many homes in the United States are becoming better insulated with tighter envelopes that have reduced their space-heating loads. In many cases a single heating plant can provide space heating and domestic water heating. This is called a combination (combi) system. It uses a high-efficiency, direct-vent burner that eliminates the safety issues associated with natural draft appliances.

Northern*STAR* Building America Partnership, a U.S. Department of Energy research team, has built on past research showing that combi systems that use condensing water heaters and boilers can provide both space and water heating with efficiencies of at least 90%. Condensing combi systems are still relatively new and complex. These systems often require onsite engineering and optimization to achieve desired performance. Northern*STAR* has demonstrated that improved controls have the potential to reduce some of this complexity and boost the measured performance.

Advanced controls improve the energy performance of combi systems. Combi energy efficiency is largely a factor of (1) the water temperature returning to the heating plant from the air handler and (2) burner cycling characteristics. Lower return temperatures and longer cycles produce higher system efficiency. All air handlers have a constant airflow rate and constant water circulation flow rate for the heating mode. To achieve the best performance, these flow rates must be adjusted to meet the house design heating load and minimize the return water temperature. Advanced controls allow for a range of heating capacities for a single system. Controls can modify set points to meet the current load on the system, increase runtime, and optimize operating conditions to maximize efficiency. The controls improve efficiency by allowing the system to operate at lower average return water temperature and longer cycles.

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Description

Combi system space-heating control modulates the system's output capacity to meet the demand of the home. The control improves efficiency, reduces energy use, reduces the installation complexity, and simplifies the installation and commissioning processes.

For more Information, see the Building America measure guideline report *Combined Space and Water Heating: Next Steps to Improved Performance* at *buildingamerica.gov*.

Image credit: All images were created by the Northern*STAR* team.

In addition to improving the efficiency and energy savings of combi systems, this project addressed their installation and design difficulties. Improved control can reduce the necessity of having a system designed and manually adjusted to narrowly defined and optimized parameters. Airflow and water-flow rate control would allow a single air handler to provide more efficient performance over a wider range of heating loads and should eliminate time-consuming manual adjustments to the airflow and water-flow rates. The installer can focus on assembling functional systems; the controller will optimize system operation. The need for custom engineering will thus be reduced.

The team analyzed two distinct temperature set point controls: (1) outdoor reset and/or turndown after the heating season and (2) space-heating modulation (water flow and airflow). Each control increases system efficiency, improves occupant comfort, saves energy, and simplifies the sizing and design process.

The Northern*STAR* team has completed three projects for combined space- and water-heating systems. Laboratory testing was conducted to support the design, optimization, and installation of more than 200 combi systems in single-family homes. A detailed field monitoring study was conducted in 20 homes before and after the systems were installed. This demonstrated an average 19% reduction in gas consumption for space and water heating. Laboratory tests were conducted to determine the potential benefits from set point temperature, water-flow and airflow modulation, and domestic hot water priority control.

Lessons Learned

- Combi systems can be installed with high-efficiency space- and water-heating equipment. These systems can save 15%–20% over standard equipment.
- Improved controls and multistage space heating operation can enhance the performance of even the best-designed combi systems.
- Improved controls allow for less site-specific design work and simpler installations.

Looking Ahead

Future work will build on Northern*STAR*'s knowledge and experience to develop system design and implementation guidelines for combi systems to provide system installation and operation parameters that are necessary to improve system performance and occupant comfort. The guidelines will address the needs of new-construction and retrofit applications in a variety of climate zones and with different space-conditioning and water-heating loads and different distribution systems.

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