



Building America Case Study

Technology Solutions for New and Existing Homes

Optimizing Hydronic System Performance in Residential Applications

Ithaca, New York

PROJECT INFORMATION

Project Name: Condensing Boiler Optimization

Location: Ithaca, NY

Partners:

Ithaca Neighborhood Housing Services, www.ithacahs.org; Appropriate Designs, www.hydronicpros.com; HTP, www.htproducts.com; Peerless, www.peerlessboilers.com; Grundfos, us.grundfos.com; Bell & Gossett, www.bell-gossett.com; Emerson Swan, www.emersonswan.com.

Consortium for Advanced Residential Buildings, www.carb-swa.com

Building Component: Space heating, water heating

Application: New; single and multifamily

Year Tested: 2012-2013

Applicable Climate Zone(s): 4,5,6,7

PERFORMANCE DATA

Cost of Energy Efficiency Measure (including labor): \$6,100-\$8,200

Projected Energy Savings:
= 14% heating savings

Projected Energy Cost Savings:
= \$100/year for the homes tested

Condensing boiler technology has been around for many years and has proven to be a durable, reliable method of heating. Based on previous research efforts, however, it is apparent that these types of systems are not designed and installed to achieve maximum efficiency. For example, in order to protect their equipment in the field, manufacturers of low-mass condensing boilers typically recommend design strategies and components that ensure steady, high flow rates through the heat exchangers, such as primary-secondary piping, which ultimately result in decreased efficiency.

There is also a significant lack of information for contractors on how to configure these systems to optimize overall efficiency. For example, there is little guidance on selecting the best settings for the boiler reset curve or how to measure and set flow rates in the system to ensure that the return temperatures are low enough to promote condensing. Finally, recovery from setback was extremely slow in all homes evaluated and often was not achieved.

In response to these findings, researchers from Steven Winter Associates, Inc., the lead for the Consortium for Advanced Residential Buildings, a U.S. Department of Energy Building America team, worked with Appropriate Designs, HTP, Peerless, Grundfos, Bell & Gossett, and Emerson Swan to develop hydronic system designs that would address these issues and result in higher overall system efficiencies and improved response times.

The goals of this research were to assess several combinations of these components and make recommendations for cost-effective, responsive, energy-efficient packages. Three natural gas-fired systems were analyzed: (1) a modulating, condensing boiler with a tankless coil for domestic water heating; (2) a high-mass condensing water heater with an external brazed plate heat exchanger for supplying space heating; and (3) a modulating, condensing boiler with a standard primary loop and an indirect tank. The third system was also tested with a buffer tank between the heating zones and the boiler to analyze the effects of added mass on cycling and overall system efficiency.

SYSTEMS TESTED



House #1: modulating condensing boiler with an integral tankless coil for domestic hot water and under floor radiant tubing



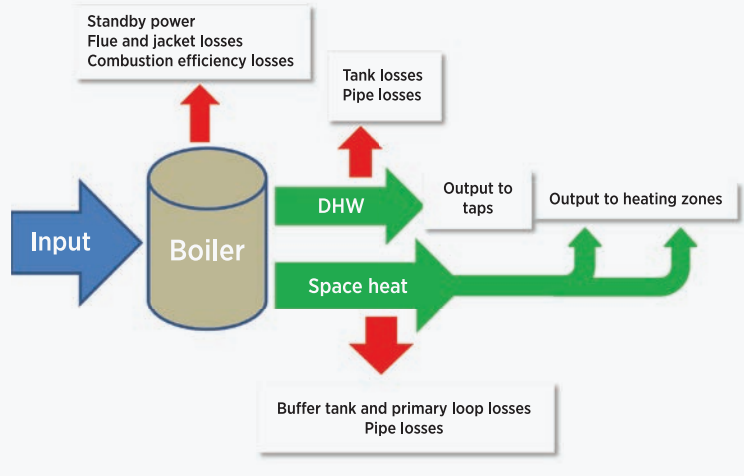
House #2: high-mass, modulating, condensing water heater; variable-speed pumps; baseboard convectors; no primary-secondary piping



House #3: low-mass, modulating condensing boiler; indirect domestic hot water tank; variable-speed pumps; baseboard convectors. A buffer tank was compared to primary-secondary piping. Constant temperature operation was compared to thermostat setback.

For more Information, see the Building America report, *Optimizing Hydronic System Performance in Residential Applications*, at www.buildingamerica.gov

Image credit: All images were created by the CARB team.



The flowchart provides an overview of the system end uses and the corresponding losses.

Lessons Learned

- Even though short-term tests revealed combustion efficiencies ranging from the upper 80%'s to the upper 90%'s, long-term data show that standby losses can be as large as 20% to 30%.
- Using thermostat setback and boost controls for recovery resulted in reduced cycling and less energy consumption than systems operated in constant temperature mode.
- Inadequate baseboard capacity results in increased runtimes and standby losses, and an overall decrease in system efficiency.
- For modulating condensing boilers, design the system to meet the design heating load such that the return temperature does not exceed 130°F. For condensing water heaters, design the system to meet the design heating load such that the tank temperature does not exceed 130°F.
- Insulate exposed supply and return piping to the heating zones and the indirect domestic hot water (DHW) tank, especially in unconditioned spaces. Additional insulation is also recommended around storage tanks located in unconditioned spaces.

Looking Ahead

A few research questions remain. In-field testing of the benefits of post-purge to the DHW tank would be useful. (This process minimizes standby losses by sending the heat remaining in the boiler when it is turned off to the DHW tank.) Does post-purge result in the same savings under constant temperature operation as it would if setback is used? What are the tradeoffs?