Field Evaluation of Heat Pump Water Heaters in the Northeast

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Introduction

Program administrators in the Northeast have recently supported a number of residential pilot studies. One such study focused on quantifying the performance of heat pump water heaters (HPWH) installations. The purpose of this pilot was to better understand the real-world potential of this newly released residential water heating technology through in situ metering and analysis. Program administrators used the analysis developed in the study to screen HPWHs for cost-effectiveness in the northeast region, and to determine an appropriate incentive level to push the technology into the market.

Heat pump water heaters are primarily designed as replacements for traditional electric resistance water heaters and are able to achieve higher efficiencies through use of the vapor compression heat pump cycle. Auxiliary electric resistance elements are also installed for reliability and quicker hot water recovery. Most heat pumps operate as hybrid devices, meaning they use the heat pump whenever possible, but built-in controls switch to conventional resistance heating when there are large hot water needs.

Methods

This evaluation quantified the in-situ performance of three recently-released HPWH products for over one year. The evaluation aimed to answer questions about the optimal installation criteria of HPWHs in the Northeast, what is the expected water heating efficiencies of HPWHs installed in basements, how variables such as ambient temperature, temperature set points, and hot water demand affect HPWH performance, whether or not the examined models met the delivered hot water setpoint temperatures, and how satisfied homeowners were with the product.

Of the 14 units monitored, ten were General Electric GeoSpring™ models (50 gallon units), two were Stiebel Eltron Accelera®300 models (80 gallon units), and two were AO Smith Voltex® models (one 60 gallon and one 80 gallon unit). The sites were chosen in the residential markets of the sponsoring program administrators. Three of the homes had existing oil water heaters, one had a propane water heater, and the remaining were electric resistance water heaters (ERWHs). Though a small sample set, the overall performance of these 14 HPWHs has been enlightening and shows great promise for this technology.

Data collected on site included inlet and outlet water and air temperatures, hot water flow, as well as energy consumption of the compressor, heating element, and entire system. From the collected data, certain performance parameters were calculated for each installation. Performance parameters include average COPs and % time spent in electric resistance mode. Performance was examined with respect to water usage over time.

In order to determine how well HPWHs perform compared to other water heating systems, the evaluation also examined the utility bill savings for HPWHs over other fuel type systems. The other water heating systems included natural gas, fuel oil, and propane, each with various system efficiencies, and electric resistance heating. The cost of the various systems were also compiled and compared.

Findings

In general, these HPWHs were more than twice as efficient as a traditional electric resistance tank water heater; though there are large variations in overall efficiency as performance is dependent on ambient temperature/relative humidity, mains temperature, hot water setpoint temperature, and water usage (consumption and concentration).

Homeowners were generally satisfied with hot water delivery, efficiency, noise, and other characteristics. Ten out of the eleven survey respondents said that they would recommend a HPWH to a friend or family member. The one dissenting homeowner had issue with the noise of their HPWH as they had a home office in the room adjoining the basement mechanical room.

While HPWHs are a promising technology, installation and maintenance is slightly more complicated than a traditional electric resistance water heater. One of the potential installation issues with HPWHs is that they tend to be larger and heavier than traditional electric resistance tanks. The size may limit where the units can be installed. Another potential issue is that HPWHs extract heat from the surrounding air, so there is an impact on space conditioning loads that may need to be off-set by a heating system. The full extent of the space conditioning impact is still being researched. A "Selection and Quality Installation Guide" for HPWHs was developed for use in utility incentive programs to inform installers and home owners about proper maintenance and installation of HPWH units.