

Study 16-RES 20: Heat Pump Water Heaters Impact Study

Type of Study: Impact Evaluation
Evaluation Conducted by: Navigant Consulting
Date Evaluation Conducted: 3/24/2017

Study Objective and Summary of Results:

The purpose of this study was to conduct research to quantify savings associated with heat pump water heaters (HPWHs) as well as identify customers' motivations and behavior patterns with respect to their purchase decisions and use of the technology. The scope of the study as specified in the original Stage 3 Plan (finalized in June 2016) intended to address the quantification of HPWH savings with an in-depth engineering analysis of HPWH data for program participants. An initial review of program data and available literature (Task 1) and a participant survey (Task 2) were conducted in order to lay the groundwork for the engineering analysis.

However, following the completion of Task 1 and Task 2, the engineering analysis (which would use simulations in order to determine savings impacts associated with different installation contexts and baselines) was put on hold in order to leverage the Residential Baseline Study (RES 1). The scope of the baseline study was adjusted to incorporate the metering of 30 HPWHs. Meter data collected through the baseline study will allow for the measurement of energy use of HPWHs installed in Massachusetts with varying installation contexts. This data can be used to update (or verify) the HPWH energy consumption term in the deemed savings calculation.

This summary report presents results related to the initial review of program data and available literature conducted in Task 1 and the participant survey conducted in Task 2. The update to current deemed savings value proposed in this report should be utilized by the PAs to assess retrospective program savings until more robust estimates of energy savings can be estimated using the data from the baseline study.

The study provides the following key findings:

Updates to Deemed Savings Calculations

- As a result of Task 1 and Task 2 findings (including the fact that several different home heating sources were cited by survey respondents), a blended deemed savings estimate for replacing electric resistance water heaters (ERWHs) with HPWHs was developed that includes space conditioning impacts and is a weighted average of the savings for several types of home heating equipment: an air-source heat pump, electric resistance baseboards, and fossil fuel-fired equipment (natural gas-fired, propane-fired, and oil-fired furnaces and boilers). The revised deemed savings estimate is 1652 kWh/yr.

- The revised deemed savings estimate only applies to replacing ERWHs with storage volume less than 55 gallons because the current Federal standard for electric storage water heaters with storage volume greater than 55 gallons can only be met by HPWHs.
- The revised savings estimate was calculated using the average EF ratings of HPWHs installed by customers participating in the Mass Save program during the 2014 and 2015 program years. PAs can tailor the above equation by using the average EF of the new generation HPWHs purchased by their customers.
- Impacts of a HPWH on space heating load were determined using Task 2 feedback indicating that 75% of HPWHs are installed in unfinished basements and by conservatively estimating that a HPWH installed in an unconditioned space has 50% of the impact of a HPWH installed in a conditioned space. Impacts of a HPWH on space cooling and dehumidification load were assumed to be negligible not included in this study, but estimates for these effects may be developed following Residential Baseline Study data collection.
- The blended value (weighted-average across all home heating sources) of the reduction in savings from increased space heating electricity consumption associated with HPWHs is 4.8%.
- A blended value (weighted-average across all home heating sources) of the fuel consumption penalty that accounts for the space conditioning impacts of HPWHs in homes heated with fossil-fuel fired furnaces and boilers is 0.67 MMBtu/yr.
- Broken out by fossil fuel type, the blended fuel consumption penalty of 0.67 MMBtu/yr equates to consumption penalties of 0.50 MMBtu/yr oil, 0.10 MMBtu/yr natural gas, and 0.07 MMBtu/yr propane.

Comment [RMW1]: Saying they are negligible, contradicts bullet in advantages in next section. Can we say "were not measured in this study but the Baseline Study is expected to produce an estimate of cooling and dehumidification benefits."

Comment [SF2]: We have added language to this effect.

Feedback from Customer Survey

- Over 20% of replaced water heaters were less than 9 years old and close to 8% were less than 6 years old, indicating there is some evidence of early replacement.
- 15% of rebate recipients replaced oil-fired storage water heaters. Another 12% replaced water heaters that were not ERWHs (including indirect, propane storage, electric tankless, and gas storage).
- Approximately 40% of all HPWH purchasers downsized, with the main reason cited that a larger water heater was no longer needed. Hot water runouts are not a common problem.
- 94% of customers are utilizing the water heater in heat pump mode (39% use "efficiency mode" and 55% use "hybrid mode"). 5% of customers do not know the operational setting of their HPWH.
- For those who replaced ERWHs, the primary home heating system fuels cited were fuel oil (49%) and electricity (26%) were the top two.
- 76% of respondents have noticed a change in comfort level in their homes; 89% of these customers report that the change has been positive.

- 94% of respondents are satisfied with their HPWH. Respondents cited bill savings, energy savings, performance, and dehumidification benefits as reasons for being satisfied. Dehumidification was the most frequently cited comfort benefit.

Summary of Advantages of HPWHs

- Approximately 50% energy cost savings compared to an ERWH
- Reduction in emissions of greenhouse gases
- Can help cool and dehumidify home
- High customer satisfaction
- Federal tax credit (through the end of 2016) and Mass Save rebate

Summary of Disadvantages of HPWHs

- No energy cost savings compared to a natural gas-fired water heater
- Exhausts cool air and adds to home heating load
- High first cost (~\$500-\$1,000 premium, excluding incentives)
- Noise (louder than a refrigerator but quieter than a dehumidifier)
- Not good for installation in a small space – manufacturers require 750-1000 cubic feet of air volume around an installed HPWH

Core Initiatives to which the Results of the Study Apply:

- Residential New Construction (Electric Only)
- Residential Heating and Cooling (Electric Only)

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Update deemed savings value to assess retrospective program savings (1652 kWh/year with average fossil fuel penalties of 0.50 MMBtu/yr oil, 0.10 MMBtu/yr natural gas, and 0.07 MMBtu/yr propane).

Recommendation 2: Once the HPWH metering data from Residential Baseline study become available, determine whether to proceed with the re-scope and execution of Task 4 - Engineering Analysis of the HPWH impact study, which is intended to develop improved and forward-looking energy savings and demand savings values.

Recommendation 3: Track the water heater industry transition to uniform energy factor (UEF) metric.

Recommendation 4: Given the savings and high level of satisfaction expressed by customers, continue to support and encourage the adoption of HPWH technology.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affected Program Results and Its Significance:

This study provides the PAs with a deemed savings estimate and fuel consumption penalties for HPWHs that include space conditioning impacts and can be used to assess retrospective program savings.

Feedback from the customer survey conducted for Task 2 provides details from program participants on the characteristics of homes in which HPWHs were installed and of the water heaters being replaced. The feedback also includes the level of satisfaction with HPWHs and the prevalence of effects on comfort level and hot water delivery.

Overview of Study Method:

For Task 2, an online survey was conducted of customers who received the HPWH rebate during the 2014 or 2015 program years, using stratified random sampling with proportionate allocation by region. Survey fielding included targets by stratum based on this allocation. Invitations to take the online survey were sent to 2,054 program participants. Of those who received a survey invitation, 339 customers completed the survey (a 17% response rate). Additional comparisons between the survey sample and the entire population of rebate recipients were made in order to confirm the representativeness of the survey sample. These comparisons relate to the tank size and age of the water heaters replaced by HPWHs, as well as the installation location of HPWHs. In all cases, the survey sample and larger population displayed similar characteristics.

For developing deemed savings and space conditioning impact estimates, a literature review was conducted and calculations were performed using Excel. Data and conclusions in the literature (developed based on HPWH testing and simulation) were used to estimate space conditioning impacts of HPWHs in this study.

Application of Results: Retroactively

A copy of the complete study can be found in Appendix X, Study 16-XX.