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Heat Pump Water Heater Market Research: Challenging Installations Scenarios

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Table of Contents

Executive Summary

In 2019 NEEA developed a framework for understanding and investigating scenarios associated with challenging installation scenarios for Heat Pump Water Heaters (HPWH) in existing single-family homes. This framework included a set of potential solutions for overcoming each scenario. While it is valuable to have a working framework for understanding and categorizing challenging installation scenarios, it is also important to estimate the prevalence of these scenarios in the regional housing stock and to understand how installers view the challenges and potential solutions. In addition, NEEA's HPWH intervention efforts would benefit from a better understanding of how plumbers or installers typically adapt when faced with each scenario.

NEEA contracted with Cadeo to conduct focused research designed to investigate NEEA's framework for challenging installation scenarios. Cadeo conducted several research activities based on the existing framework, each designed to test the framework and make recommendations for how the NEEA initiative team could improve the recommendation rate and installation volume for HPWH.

Information obtained here is expected to help NEEA staff engage collaboratively with HPWH installers by providing data-driven insights into installation challenges. With this information, NEEA hopes to develop enhanced education and training materials to help mitigate installation challenges and make this information available to installers and plumbers in the region. These data may also inform NEEA's work on future Federal water heating product standards by providing better information on the prevalence and difficulty of specific installations.

This study

This document is informed by four research activities, which occurred sequentially between July and November 2020.

- A **review of existing data** on water heater installation locations and prevalence of specific room or home characteristics that could present challenges. The primary source identified was the most recently completed Residential Building Stock Assessment (RBSA), although team members also reviewed prior evaluation and market reports, several of which documented reports of home conditions or installation locations that limit the applicability of HPWH.
- A **virtual focus group** of five recruited installers, all previously engaged with NEEA's Hot Water Solutions program, focused on exploring challenging installation scenarios, testing language to inform survey design, and listening to how installers described their experience with HPWH.
- **Interviews with four HPWH manufacturers**, focused on understanding the technical features of their products that lead to installation challenges, any product development designed to overcome installation challenges, feedback manufacturers receive from distributors or installers about challenges in the field, and how they communicate best practice installation guidance on installation.
- A **mixed-mode market survey** of plumber installers with HPWH installation experience designed to explore the prevalence of installation challenges, the perceived difficulty of overcoming challenges, the labor hours associated with challenging installations, and where they turn for information on installation practices.

1.1 Conclusions

Location, location, location. The likelihood of an installer recommending a HPWH is directly related to the location of the existing water heater. Installers rated garages and basements as locations they would be most likely to recommend a HPWH installation (79% and 48% respectively). Across the Northwest, these locations represent just under half of the existing electric water heaters, and garage locations are far more common in Oregon and Washington than Idaho or Montana. In the Northwest natural gas water heaters are most commonly found in garages.

Prevalence does not necessarily reflect difficulty. The challenging scenarios investigated here are not equal. A common scenario that is easy to address is not truly a barrier to installation. For example, while it is common for existing water heaters to be installed without a nearby drain for easy access, installers do not view this as a substantial challenge to managing condensate. It is the combination of prevalence *and* difficulty that creates challenges in the field.

Space requirements are the most challenging to overcome, however installers are willing to consider a variety of solutions. In NEEA's framework there are two aspects to space constraints: the first is a tight space, where the unit is simply difficult to fit, and the second is when a unit is installed in a small room, where the buildup of cold air might affect the performance of the unit. Installers rated both scenarios as somewhat difficult to overcome; particularly when the space is simply too tight for the new unit. In this scenario over half of installers indicated they would consider relocating the water heater.

Sixty to ninety percent of installers would stick with a HPWH in the face of challenging scenarios. In the survey, each solution set included an option for installers to indicate if they would recommend against a heat pump water heater. The portion of installers selecting this option varied by the challenge, reflecting the perceived difficulty of each scenario. When faced with insufficient space 50% of installers indicated they were likely to recommend against a HPWH and 52% indicated they would recommend relocating the water heater. However, for every other scenario approximately 60-90% of installers indicated they would not necessarily recommend against a HPWH.

Adjustments for condensate management and wiring are relatively common but not difficult to solve. Condensate drainage, wiring upgrades, or plumbing repair were strikingly lower in their rated difficulty. In none of these challenges did more than 15% of installers report they would be likely to recommend against a HPWH. NEEA should consider removing wiring and plumbing modification from the challenging installation framework.

Relocating the water heater is always an option. Several of the solution sets included an option for installers to consider relocating the water heater to accommodate a heat pump. This was a particularly important option for homes likely to be perceived as inappropriate candidates for HPWH—those with space constraints or where occupant complaints about noise or cold air are likely. It is worth noting that plumbers encounter challenges working in tight spaces regularly and may recommend relocating the water heater for a variety of reasons, such as to facilitate maintenance, to free up closet space, or to enable tank or equipment upgrades. Across all responses, the average time required to relocate a heat pump water heater is approximately 7.5 hours.

1.2 Opportunities

It is encouraging that challenging scenarios do not stop installers from recommending HPWH. Ultimately, widespread HPWH installations require installers who are willing to consider HPWH for all homes and confident that they can overcome challenging installation scenarios. If specific scenarios are perceived as too difficult, or if HPWH are not considered appropriate for certain homes, installers will recommend against a HPWH. Homeowners are unlikely to seek out and install a technology not presented to them by the expert they are depending on. This research indicates that installers are willing to consider solutions, and that information resources and product improvements could help them do this better.

Information resources

Promote mixing valves to encourage smaller units. A surprisingly low portion of installers reported they would be likely to increase set point temperature and add a mixing valve as a potential solution for space constraints, as this could enable installation of smaller units.[1] This could represent a familiarity or standard practice barrier, which could be overcome with training and information, particularly if it comes from the distributors and manufacturers installers turn to. This practice is common in Canada and in assisted living facilities that want to avoid scalding residents while addressing concerns about Legionella.

Track the room size requirements and investigate options for installations in small rooms. Clarifying and communicating the performance penalty associated with installing HPWH units in smaller rooms could assuage some fears about efficiency and product performance that prevent installers from considering small space installations. Manufacturers ship units with specific requirements for room volume, and installers could be proceeding cautiously to maintain warranty coverage. Additional research by the NEEA product team could document warranty requirements and clarify the efficiency penalty and other operational effects associated with these scenarios to expand installation options for main house locations.

Build a solution tree. Consider opportunities to link communication with installers about solving common installation challenges with a realistic decision tree or screening tool that can walk installers through solutions they might not otherwise consider. Linking program-based subsidies to a specific challenge or installation requirement could offset the labor cost for the homeowner and help installers identify more permanent solutions, such as relocating a water heater to a more appropriate space. The most challenging scenario is insufficient space. Communication and solution screening should focus on that first, as it would increase the odds that HPWHs are considered viable for a variety of home configurations.

Build on experience with natural gas units. Plumbers doing both gas and HPWH could be oriented to treat the HPWH requirements like those for natural gas. While most gas water heater owners stick with natural gas when they replace their units, the space and condensation management requirements for gas water heaters are similar to those required for HWHP.

Product development

Encourage manufacturers to focus on more diversity in size and configuration. This is likely to have the greatest impact in terms of expanding the viable market. The persistent challenges associated with

[1] Manufacturer installation and owners manuals typically include instructions for adding a mixing valve.

product size and concerns about noise point to the need to focus on product-specific solutions for main house installation challenges. Manufacturers report that they are aware of the most common challenges installers encounter in the field and continue to focus on product developments that would streamline installation and result in satisfied homeowners.

Support product innovation efforts associated with noise reduction. Concerns about occupant perceptions of noise emerged as a close second to those about product fit in interviews with manufacturers, and installer survey results indicate that noise continues to be a concern. While the decibel levels associated with operational noise have declined in recent years, complaints continue to flow from consumers bothered by the cycling of the unit, according to manufacturer's noise complaints are often about the specific pitch emitted by the equipment. This challenge is primarily an issue when the unit is installed near quiet spaces used for sleep or concentration. Manufacturers are aware of this and report working on product-level solutions.

Explore opportunities to expand product options. Emerging products are expected to help with some of the challenging scenarios, including space requirements and noise mitigation. Split systems avoid many of the main house installation challenges by radically changing the profile and installation requirements of the product by moving cold exhaust air, mechanical noise, and condensate outside. However, these systems are currently higher in price with low market uptake.

Improve the detail in the RBSA

As NEEA prepares to launch the next round of residential stock data collection, consider opportunities to improve the specificity and detail associated with the "main house" water heater installation category. Utility or mechanical rooms that contain laundry or other household mechanical equipment are often located away from quiet spaces and have options for condensate management. Improving the detail of data collected on main house installations could shed light on the portion of these that might require relocating the water heater.

Section 2 Introduction

For more than a decade, the Northwest Energy Efficiency Alliance (NEEA) has worked directly with the water heater market to identify and promote efficient heat pump water heater options that promise to reduce the energy required to heat and store residential hot water. Since 2013, NEEA's Heat Pump Water Heater Initiative has focused on engaging the water heater supply chain to build the market for HPWH, particularly after 2015 updates to the National Appliance Energy Conservation Act (NAECA) raised federal minimum efficiency requirements for large residential electric water heaters, effectively requiring heat pump technology.

Heat Pump Water Heaters (HPWH) remain less than 10% of the single-family electric water heater sales, with market evaluation research identifying persistent market and technical barriers to widespread adoption. Market barriers associated with cost, supply, and installation triggers are well documented in Initiative-sponsored Market Progress Evaluation Reports (MPERs) available at NEEA.org. What is less clear is the prevalence and installer perception of technical barriers associated with installing units when faced with specific existing home challenges.

In July 2020 NEEA contracted with Cadeo to conduct a focused research study, designed to investigate NEEA's framework for understanding "challenging install" scenarios that may be creating difficulties for installers who might otherwise recommend HPWHs. The framework, developed by NEEA in 2019, documents and defines several scenarios associated with challenging installations of HPWHs in existing single-family homes and identifies a set of potential solutions for overcoming each scenario.

Cadeo conducted several research activities to illuminate this framework for understanding and categorizing challenging installation scenario. The research objectives specifically included:

1 | Estimating the prevalence of these scenarios in the regional housing stock.
2 | Understanding the frequency with which installers encounter each scenario.
3 | Investigating the level of effort required to overcome challenges.
4 | Identifying where installers turn for information or solutions.

2.1 Methods

This document is informed by four sequential research tasks, each of which sought to obtain insights into the research objectives listed above.

- A **review of existing data** on water heater installation locations and prevalence of specific room or home characteristics that could present challenges. The primary source identified was the most recently completed regional Residential Building Stock Assessment (RBSA), although team members also reviewed prior evaluation and market reports, several of which documented reports of home conditions or installation locations that limit the applicability of HPWH.
- A **virtual focus group** of five recruited installers, known to be engaged with NEEA's Hot Water Solutions program, focused on exploring challenging installation scenarios, testing language to inform survey design, and listening to how installers described their experience with HPWH. These installers reported a range of experience with HPWH, with most reporting they had installed between 10-15 HPWH.
- **Interviews with four HPWH manufacturers** focused on understanding the technical features of their products that might lead to installation challenges or that are designed to overcome

installation challenges, feedback manufacturers receive from distributors or installers about challenges in the field, and how they communicate best practice installation guidance to installers.

- A **mixed-mode market survey** of plumber installers with HPWH installation experience designed to explore the prevalence of installation challenges, the perceived difficulty of overcoming challenges, the labor hours associated with challenging installations, and where they turn for information on installation practices.

Table 2-1 displays the number of respondents by method.

Table 2-1: Respondents by data collection method

Method	Respondents/Participants
Existing data review	NA
Virtual focus group	5
Interviews with HPWH manufacturers	4
Market survey of Northwest plumber installers	52

The installer survey proved more challenging than anticipated, requiring several adjustments in the field to reduce the survey length and improve response rates. Instead of asking all respondents about the time required for each solution set, we adjusted to only ask for these estimates when respondents were likely to recommend a given solution. We also reduced the number of questions focused on serviceability. In addition, we pivoted from phone only to mixed mode, inviting respondents to complete a survey through in-bound calling or through a web-based application. We also increased respondent incentives from $50 to $100 and "unblinded" the study, referring to NEEA's sponsorship as a means to improve the perceived legitimacy of the research. For a detailed disposition and discussion of response rate, see Appendix B.

2.2 Challenging Installation Scenarios

NEEA provided the research team with a framework for the challenging installation research, which emerged from product research and included barriers associated with room size, condensate management, the potential for negative occupant experience, and modifications to existing wiring or plumbing (Figure 2-1). Several of these scenarios have more than one dimension, each of which was explored through interviews and survey data collected to better understand the installer experience.

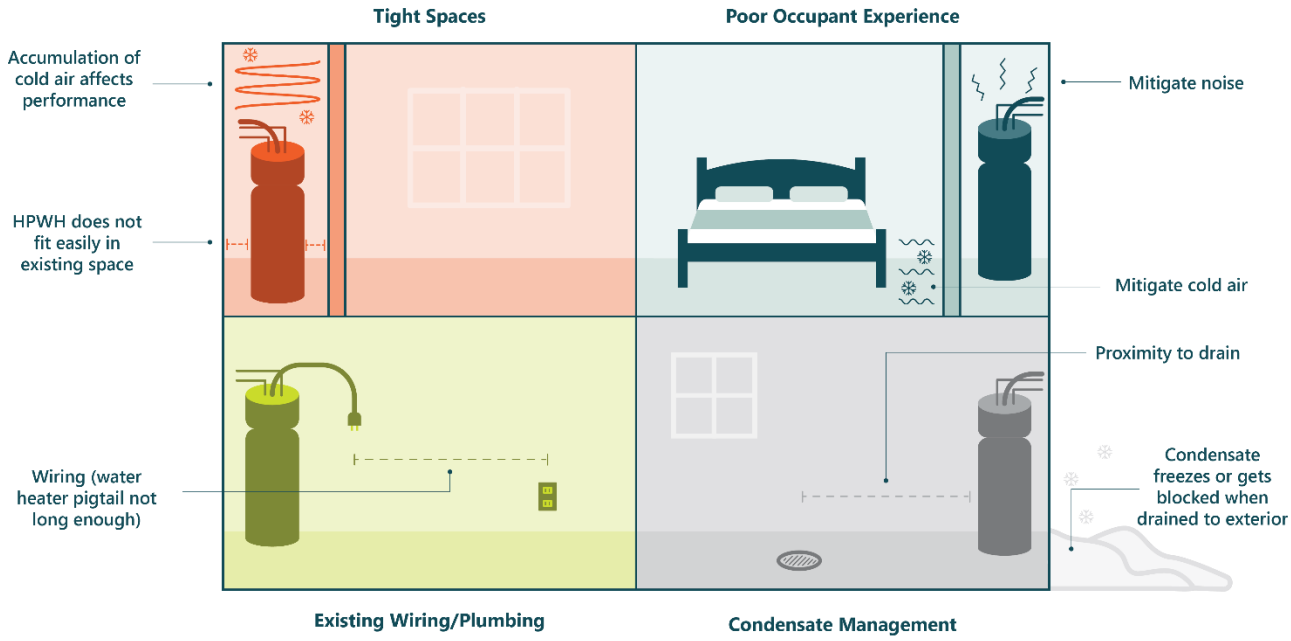


Figure 2-1: Illustration of installation challenges for HPWH

Space constraints

According to NEEA's framework, space can be an issue for HPWH when they require more space than similar electric resistance water heaters, either because of their larger size or because of operational requirements. There are two main domains associated with space constraints:

- A "tight fit" or limited clearance for the HPWH. HPWH tend to be larger than their electric resistance counterparts, which requires more physical space for installation, maintenance, and operation. Installers may find it difficult to install a HPWH in a "like for like" replacement when the prior electric tank was installed in a small space.
- Temperature depression, or a room where the buildup of cold air has the potential to affect product performance (primarily through increased reliance on electric resistance). Because HPWHs extract heat from the air around them and exhaust cold air, installations in small spaces isolated from heat sources could result in room temperatures that are too cold for efficient performance of the heat exchanger.[2] To ensure sufficient air flow HPWH typically require a room larger than 700 cubic feet per manufacturer's installation instructions.

Condensate management

NEEA's framework also notes that installers must address condensate drainage. Heat pump water heaters, unlike traditional electric resistance storage water heaters, extract moisture from the air, which can result in condensate that must be managed, typically through plumbing that conveys the condensate to a drain

[2] The operating temperature for the heat pump component varies by manufacturer and at the low-end ranges from 35-45 degrees Fahrenheit. At lower temperatures, the unit will operate but rely on electric resistance elements occasionally, which can affect the efficiency of the unit.

near the water heater or to the outside. To explore challenges associated with condensate management the survey asked about two scenarios:

- Proximity to drain. In some homes, a drain is not conveniently close, and, in some scenarios, there is no drain available. Installers will need to have a plan for managing the small amount of condensate created. There are several solutions to this dilemma, including installing a condensate pump or draining to a home's exterior.
- Condensate blockage. When condensate is drained to a home's exterior, it can be subject to blockage from plants, soil, or other outdoor elements. Condensate may also freeze in cold weather.

Potential for negative occupant experience

NEEA's framework includes challenges associated with mitigating for noise and cold air produced from normal HPWH operation. This challenge is related to the location of the existing water heater, as the proximity to living areas can affect the household experience of a new HPWH.

- Noise mitigation. When HPWH are installed in or near living areas, particularly those used for concentration or sleep, the noise from equipment cycling can disturb residents. This is typically only an issue when a unit is installed in a closet or other location within the main house. Installers will want to avoid call backs associated with unhappy customers and may recommend a different solution.
- Cold air mitigation. HPWH generate cold air that can affect occupant comfort when installed in conditioned space in the main house. The cold air is intermittent and can provide cooling or dehumidification to an otherwise damp environment, however installers and their customers could be concerned about exposure to cold air when the unit is cycling.

Existing wiring or plumbing

NEEA's framework includes scenarios in which an installer may need to make minor modifications to existing plumbing or wiring to install a new HPWH. These scenarios include homes in which:

- The new water heater is not close enough to an existing electrical connection, which could require minor electrical work to extend a pigtail connection or upgrade a legacy connection.
- Additional plumbing work may be required to connect the new HPWH unit, as many models are plumbed differently than the typical top-mounted plumbing for electric resistance units. Because the plumbing often needs to connect at the side, this can also aggravate concerns about tight spaces.

The team hypothesized that the likelihood and ease of overcoming each of these challenges would be closely associated with the location of the water heater within the existing floor plan, as some locations are more conducive to easy installation of a HPWH than others. Each are discussed in more depth in subsequent sections, including the prevalence and challenge-specific sets of solutions.

2.3 Existing Data Review

Stock Data

To establish an understanding of the likely prevalence of each challenging scenario, the team searched existing data sources for information on the location and room characteristics for water heater

installations in the Northwest. The best source of information on Northwest homes is the Residential Building Stock Assessment[3] (RBSA), a comprehensive study of the characteristics of existing single family housing stock using data from on-site assessments of more than 1,000 homes. The most recent RBSA, published in 2018, contains information on the location of water heaters, the proximity to a drain, and the size of the room containing the water heater. These data are not available for every home included in the study, nevertheless, they represent the most comprehensive source of information on existing water heater installations for the Northwest. For single family homes in the Northwest, the most common installation locations for electric resistance water heaters are in the main house (46%), followed by basement (25%), and garage installations (21%).

Table 2-2: RBSA Data: Electric Storage Water Heater Installation Location

Room	ID	MT	OR	WA	Total
Main House	44%	54%	45%	46%	46%
Basement	43%	32%	19%	23%	25%
Garage	5%	8%	27%	22%	21%
Crawlspace	5%	3%	6%	3%	4%
Exterior	1%	1%	1%	1%	1%
Other	0%	0%	0%	2%	1%
Unknown	3%	2%	2%	3%	3%
Total	100%	100%	100%	100%	100%

Source: Analysis of RBSA Data; filtered to include single family and manufactured homes. Electric storage water heaters only. Data reflect 2019 updates and alternate weighting options.

In colder climates, best represented by Idaho and Montana, it is less common for electric water heaters to be installed in garages where pipes might freeze. In these states, basement installations are more common than garage installations. Note that in interviews with manufacturers and in survey development discussions, we determined that "main house" was not a sufficiently descriptive category. In the survey we added "utility room" as a proxy for a main house installation that would likely be compatible with HPWH installations because these rooms typically have other noisy mechanical equipment (such as laundry or furnace) and have doors that close them off from the rest of the house. Incorporating additional distinction about "main house" installations in the upcoming RBSA would provide additional insight into the true prevalence of installations within occupied conditioned living area.

The distribution water heaters by location is slightly different for natural gas equipment. Garages are more common than main house and basement installations.

[3] NEEA sponsors regular residential and commercial building stock assessments. For more information on the RBSA or to access the report and data, see https://neea.org/data/residential-building-stock-assessment.

Table 2-3: RBSA Data: Natural Gas Water Heater Installation Location

Room	ID	MT	OR	WA	Total
Main House	20%	33%	19%	25%	23%
Basement	24%	39%	22%	24%	25%
Garage	54%	11%	56%	45%	47%
Crawlspace	0%	15%	1%	4%	3%
Exterior	0%	0%	0%	0%	0%
Other	0%	0%	0%	1%	1%
Unknown	2%	3%	2%	0%	1%
Total	100%	100%	100%	100%	100%

Source: Analysis of RBSA Data; filtered to include single family and manufactured homes. Natural gas water heaters only. Data reflect 2019 RBSA database updates and alternate weighting options.

The RBSA included several additional questions that could shed light on the prevalence of certain constraints associated with specific location characteristics (Table 2-4). Each of these asks about an enabling condition—a feature that would support easy installation of a HPWH: proximity to a drain, room size, and vertical clearance. These data provide a conservative estimate of homes with sufficient space for HPWHs, as each element is more constrained than technical requirements for HPWH. Manufacturers require a room greater than 700 cubic feet and seven feet of vertical space.[4] Similarly, a drain can be more than four feet away and serve condensation drainage requirements perfectly well. These data indicate that there is likely sufficient space for HPWH for *at least* 58% of homes.

Table 2-4: RBSA Data: Water Heater Installation Location Features

Question	Yes	No	Unknown	Total
Is water heater within four feet of a drain?	22%	68%	10%	100%
Is the water heater installed in a room greater than 1,000 cubic feet?	58%	41%	2%	100%
Is there greater than eight feet of vertical space for the water heater?	60%	39%	2%	100%

Source: Analysis of RBSA Data. Data are filtered to single family and manufactured homes with electric or natural gas storage tank water heaters. These also reflect 2019 RBSA database updates and alternate weighting options.

Other Research

In addition to RBSA data we reviewed existing sources produced by NEEA including: a 2018 Water Heater Market Characterization Report prepared by Russell Research, NEEA's Northwest Heat Pump Water Heater

[4] Specific manufacturer requirements vary—owner's manuals indicate a range of 700-1,000 cubic feet in 2020/2021.

Initiative Market Progress Evaluation Report #5 (MPER #5), prepared by NMR Group in 2019, a 2019 Heat Pump Water Heater Market Synthesis Report prepared by Owl Research Partners, and previous challenging HPWH product installation analysis work prepared for internal NEEA use.[5]

In general, these documents seek to illuminate progress and market adaptations to updated Federal standards, residential building codes, and supply chain developments. Survey research, typically with installers or homeowners, provide some insight into installation challenges.

The most recently completed MPER (MPER #5) documented some of the challenges associated with complex installations, including make-up air requirements that reduce opportunities in small spaces, size and configurations of HPWH that require additional problem solving, and ventilation practices perceived as "stealing heat" through the exhaust of cool air.[6] In a survey of program-affiliated installers included in MPER 5, respondents indicated that approximately half (51%) of the homes they service could readily accommodate a HPWH. Consistent with the RBSA data on prevalence, about half of installers indicated that they sometimes encounter challenges associated with proximity to condensate drainage, while 31% report "always" or "most of the time" encountering this.

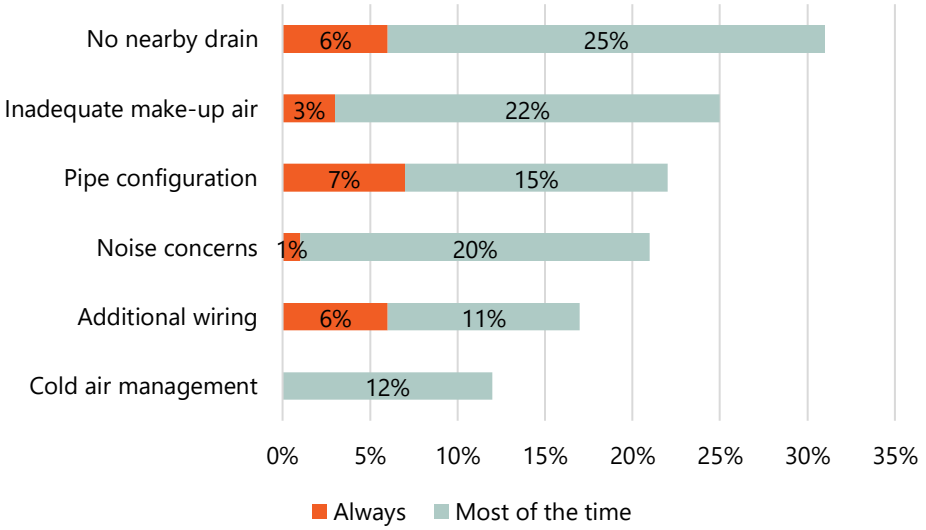


Figure 2-2: Survey data from MPER 5: Portion of Installers and Prevalence of Common Challenges.

Russell Research's 2018 Market Characterization discusses the effect of "like for like" sales in existing homes that avoid installation difficulties that might require additional labor and other costs but does not elaborate on prevalence. This report documented very little direct-to-consumer advertising of water heaters, indicating that installers have the greatest influence on end-user purchase decisions. Overcoming their reluctance to tackle installation difficulties will be an important component of increasing sales.

[5] For a complete list of sources, see Appendix C.
[6] Previous NEEA research investigated interaction factors associated with HPWH and found that this can vary substantially depending on proximity to the thermostat, which is unlikely to be a problem for most homes. https://neea.org/resources/interaction-between-heat-pump-water-heaters-or-other-internal-point-source-loads-and-a-central-heating-system.

The importance of installer expectations and the willingness of installers to recommend solutions for common challenges can affect overall adoption. While MPER research has documented high satisfaction among HPWH owners, it remains difficult to ensure that HPWH are always part of the choice architecture that guides homeowner selection—for this to happen, the installer experts contacted by homeowners would need to ensure that HPWH are mentioned, that they are included as a bid option, and that solutions to installation challenges are reasonable. The next section summarizes the data collected from installers and manufacturers on the third item: perceptions on the solutions to installation challenges.

Section 3 Specific Barriers

3.1 Installer Experience and Installation Time

While not directly related to existing home configuration, installer experience is associated with confidence and increases the odds that a given installer has had sufficient exposure to "real world" installations to confidently bid and recommend HPWH in existing homes. Previous regional water heater market characterization research prepared by Russell Research in 2018 confirmed that plumbers are the primary installers of water heaters, and they report that consumers typically want the "quickest, cheapest, and least disruptive solution." This research documented the tendency of plumbers to make recommendations on basic information (fuel, size of space, size of household), which may not provide sufficient detail to support confidently recommending a HPWH. Thirty-four percent of water heater purchasers surveyed by Russell Research in 2018 reported that installation difficulty was one of their top three concerns prior to choosing a new water heater.[7] The importance of installers in the decision-making and bidding process is the reason for the survey of plumber/installers completed for this project.

Surveyed installers represent a cross section of the market and represent the experience of installers within the Northwest market. The surveyed installers provided information on their years of experience, volume of water heater installation jobs, and their location. The sampled installers represented all four states and substantial experience in plumbing (Table 3-1).

Table 3-1. Surveyed Installers: Experience

Number of HPWH installed in last two years	Count	Percent
Less than 10	18	35%
10 to less than 20	14	27%
20 to less than 30	4	8%
30 or more	16	31%
Tenure installing water heaters	**Count**	**Percent**
Less than 10 years	4	8%
10 to less than 20 years	12	23%
20 to less than 30 years	11	21%
30 years or longer	25	48%

Plumbers consider the location of the existing water heater when making recommendations about replacement equipment. In the survey, installers reported the likelihood that they would recommend a HPWH in different installation locations (Table 3-2). Garage installations are the most favored, followed by basements and utility rooms. Very few installers will recommend a HPWH when it will be installed in a closet in the main house.

[7] Russell Research, 2018.

Table 3-2. Installers likelihood to recommend HPWH, by location ("4" or "5" on 1-to-5 scale) n=52

Location	Portion likely to recommend
Garage	79%
Basement	48%
Utility room	40%
Closet in main house	6%

HPWH are known to require additional time to install relative to their electric resistance counterparts, as the heat pump requires condensation management, and the existing plumbing connections do not always flow through a penetration at the top of the tank. In survey responses, installers estimated the time required to install a "typical" water heater and a heat pump water heater, respectively. Their responses indicate that HPWH require about 1.6-2.0 more hours to install (Table 3-2).

Table 3-3. Average installation time (in hours) for "typical" water heater vs. HPWH (n=52)

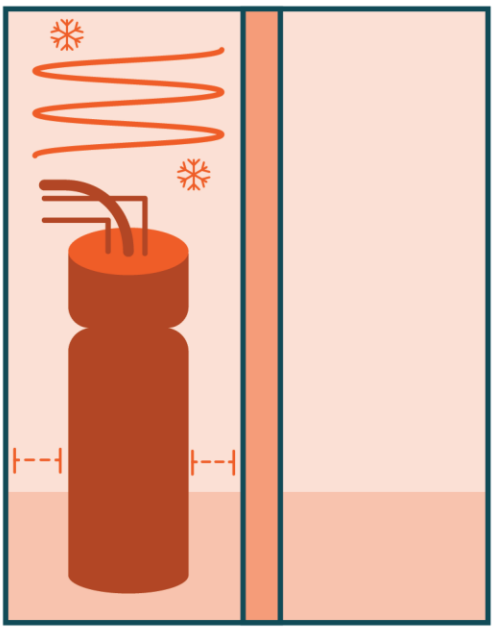
Installation time*	Mean	Median
Typical water heater	2.6	2.0
Heat pump water heater	4.2	4.0

**Full distribution is available in Appendix A, Tables X and Y, Figure X.*

Installers provided labor hour estimates for each of the solution sets presented in the survey. A summary graph is available in Figure 4-1, in Section 4.

3.2 Tight Spaces

According to NEEA's challenging installation framework, HPWHs can be larger than their electric resistance only counterparts due to the heat pump equipment located on top of the tank. This design element requires more physical space for installation, maintenance, and operation.



3.2.1 Manufacturer perspective

Manufacturers stated that the most consistent issue for HPWH installation is space constraints in existing homes. In interviews, they described this as less about fitting the new equipment in than ensuring sufficient air flow and access for heat exchange. Manufacturers report being very specific about space requirements to ensure the equipment is functioning properly, something many plumbing contractors are not used to calculating.

While an installer can recommend a homeowner consider relocating the water heater, in general installers must work with the space available. According to one manufacturer, ensuring specific space requires installers to assess and qualify the space (ensure it is appropriate for a HPWH) by assessing the volume of air in the room, and then the clearance. Plumbers need to calculate cubic feet and make a plan for venting or a louvered door if the room is less than 700 cubic feet. Once the volume of the room is established, the installer will then need to confirm sufficient clearance, for the unit specifically and for maintenance.

One manufacturer noted that urban areas and multifamily retrofits are the hardest, as they are likely to be the most space constrained. Similarly, single family homes with existing water heater in a tight space can be difficult to work in in general. As one manufacturer said, *"Water heaters are often relegated to a back corner… then the installer tries to cram a HPWH in."* According to another manufacturer, space constraints can force a homeowner to choose a smaller size, resulting in complaints about hot water supply.

3.2.2 Installer perspectives

The focus group provided an opportunity for the research team to ask open-ended questions about challenges encountered in the field. Problems related to product fit characterize the most challenging scenario described by installers participating in the focus group. When asked about their most challenging heat pump water heater installations, almost all installers described a scenario in which tight spaces made it difficult to complete an installation. Installers discussed the limited options to address tight spaces– either trying to make it fit or recommending a different product. Attempting to make a HPWH fit by recommending minor remodeling or taking out walls or ceilings, adds time and increases costs. As one installer described, *"…if you are making it fit, sometimes that can add another thousand dollars to the job."* When faced with problems related to product fit, installers indicated they would likely recommend a different water heater. In the focus group discussion, installers did not bring up issues related to excessive cold air or product performance, focusing instead on the challenges associated with fit. It is important to

keep in mind that plumbers are often forced to work in cramped spaces and that challenges associated with difficulties accessing and updating plumbing are not necessarily unique to HPWH.

Surveyed installers also indicated that tight spaces are the most challenging scenario to overcome. The details of their responses are provided in the discussion below.

Prevalence

Installers estimated the percentage of homes in their area likely to have issues associated with insufficient space for a HPWH on two domains: fitting the equipment and ensuring sufficient air flow (Table 3-4). Respondents then rated the perceived difficulty of overcoming each challenge. Approximately 38% of all homes will have issues with these challenges. Perhaps more importantly, these challenges are perceived as difficult to overcome, with over half of respondents rating it a "4" or "5" on a five-point scale of difficulty.

Table 3-4. Portion of homes with space constraints, perceived difficulty of overcoming. (n=52)

Challenge	Estimate of homes likely to have issue			Average*	% Respondents rating challenge as difficult
	Less than 25%	25-49%	More than 50%		
HPWH will not fit in existing space	33%	21%	46%	38%	62%
Insufficient airflow in existing space (room too cold)	40%	19%	40%	38%	52%

**Average value calculated from the respondent distribution.*

Solutions

NEEA's framework identified a set of solutions for overcoming each challenging scenario, organized as options for each domain. The survey separated issues associated with fitting the appliance in the space from the airflow issues. Installers rated the likelihood that they would recommend several common solutions for installing HPWHs when the equipment will not easily fit in the space or when the room was too small to ensure sufficient airflow. They were also asked about other solutions. Relocating the water heater emerged as the most likely recommended solution when a HPWH did not fit in the existing space. Other solutions offered when the HPWH will not fit included five respondents who would recommend the customer choose a different water heater (including tankless and electric resistance) and five who would recommend carpentry or room modification. Ducting to manage exhaust or supply air emerged as the most likely recommended solution for insufficient airflow. Other solutions offered when insufficient airflow created concerns about performance included two recommendations for choosing a different water heater and adding a fan to the ducting.

The distribution of installer responses by solution set is presented in Figure 3-1.

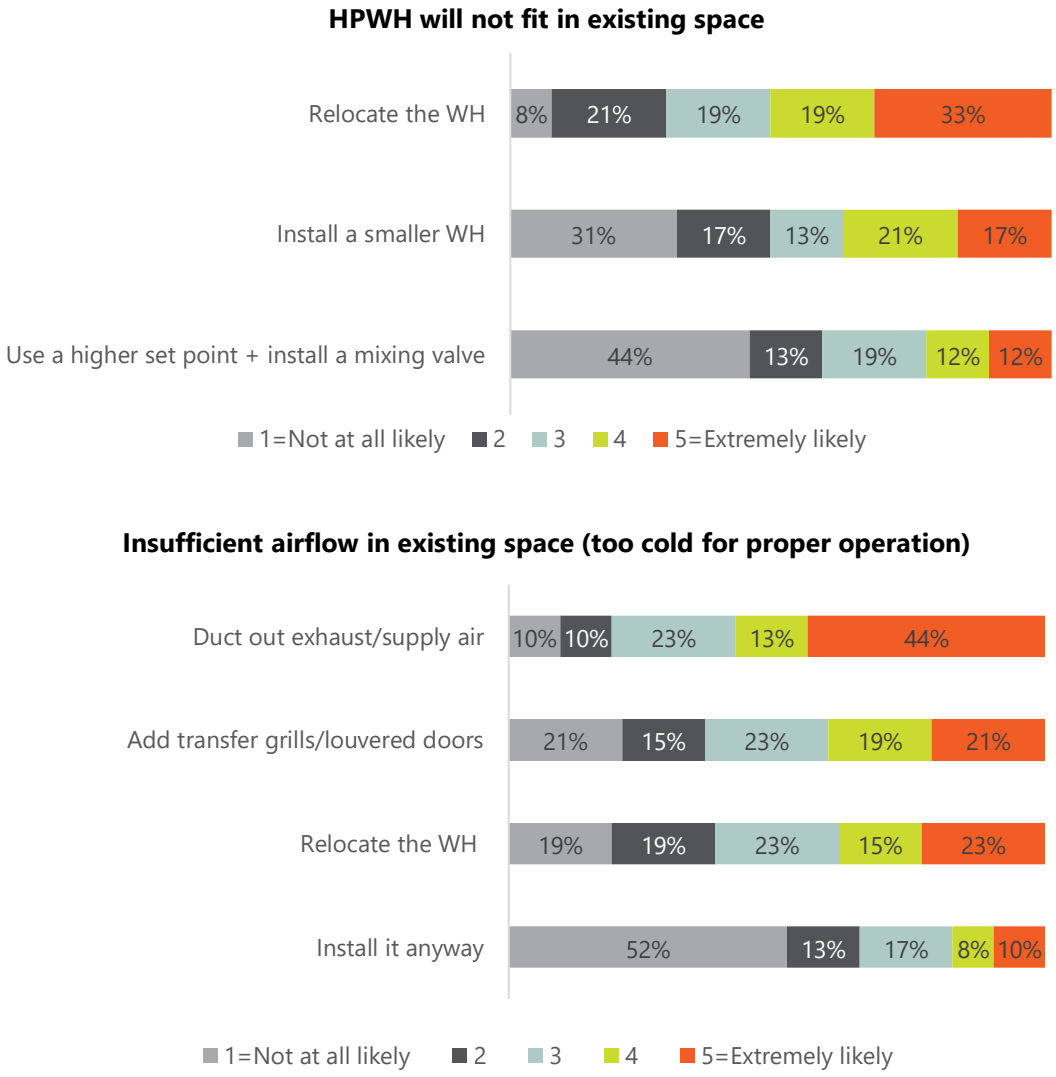


Figure 3-1. Likelihood installers would select solutions for space constraints (n=52)

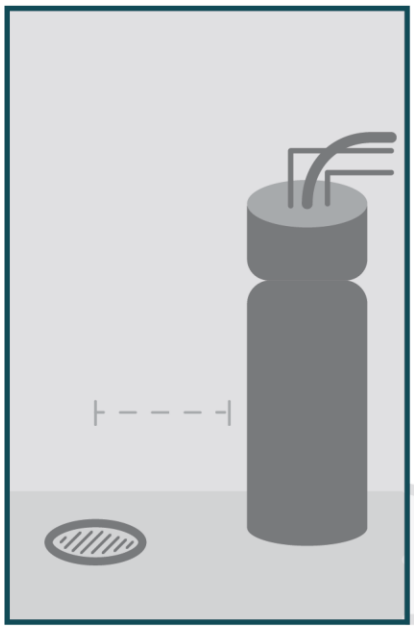
Those reporting they were likely to recommend any of the proposed solutions provided an estimate of the additional hours required. Only those that indicated they were likely to deploy a solution were asked to estimate the additional labor hours required.[8] Very few installers indicated that they would go ahead and install a HPWH in a small room and risk excessive buildup of cold air (only nine of the 52 indicated they were likely to do this, and their responses indicate doing so would require additional labor). Most would either recommend relocating the water heater or find a way to duct for exhaust or supply air.

[8] Note: the first three survey respondents were asked to estimate additional labor hours for all solutions, however this created an unacceptable survey length. The survey was subsequently adjusted to only ask this follow up of those likely to have experience with a given solution.

Table 3-5. "Likely" solutions and estimated hours to address

Solution	Installer "likely" to choose		Average additional hours required
HPWH will not fit	Count	Percent	
Relocate the WH (n=52)	27	52%	5.4
Install a smaller WH (n=52)	20	38%	2.5
Use a higher set point + install a mixing valve (n=52)	12	23%	1.8
Insufficient airflow in existing space (too cold)	Count	Percent	
Duct out exhaust/supply air (n=52)	30	58%	3.2
Add transfer grills/louvered doors (n=52)	21	40%	2.0
Relocate the WH (n=52)	20	38%	4.9
Install it anyway (n=52)	9	17%	3.4

3.3 Condensate Management



HPWHs extract moisture from the air which collects in a condensate pan. The volume of condensate depends on the moisture in the air. In high air moisture situations, there is enough volume that it must be drained away. NEEA's challenging installation framework acknowledges that the existing water heater may not be conveniently located next to a drain, requiring the installer to add drain piping during installation.

3.3.1 Manufacturer perspective

Proximity to condensate drain is low on the list of challenges, according to manufacturers, who note that it is rare that the condensate line is a "real" barrier. Condensate management is a new practice for plumbers used to electric resistance units, and manufacturers report that installers will resist or complain about the condensate line, even when it is relatively easy to address. The prevalence of the issue reflects housing construction practices in specific areas. Manufacturers mentioned that it is common to find basements with no floor drains on the East Coast, which tend to require a condensate pump, while in Florida the prevalence of garage installations makes dealing with condensate fairly easy.

Basement or utility room installations in which the water heater is installed near the condensing gas furnace and/or central air conditioning evaporator coil are often resolved by using the same condensate

drain as the heating and cooling equipment. Several manufacturers described the need to confirm that unlike gas water heaters, HPWH condensate is not acidic, and is therefore easier to manage.

When condensate drainage is an issue, a permanent solution is to install a condensate pump to ensure any condensate can be piped to an effective drain. One manufacture noted that that the only time condensate becomes an issue is in an upstairs installation, with no drain nearby. In these scenarios, the plumber can plumb through the floor without an issue. Adding a pump can add cost to the installation, but it is not considered a major challenge. Manufacturers also noted many local codes require new water heaters to be installed with a pan and a pump nearby to mitigate damage from leaks. In this scenario the pump could also support condensate drainage.

Draining through an exterior wall for condensate drainage is rare, and concerns about freezing even more rare. Manufacturers reported that while they were aware of the possibility, they had not heard complaints about it, even among installations in Maine, Minnesota, or Michigan where subfreezing weather is common. Manufacturers speculated that this is because HPWH generate a small amount of condensate and that freezing temperatures tend to occur when the air is very dry, reducing the condensate substantially.

3.3.2 Installer perspective

According to installers in the focus group, configuring condensate drainage is a routine part of their job and installers typically expect to spend one to two hours addressing condensate. In many cases, there is a simple solution, like routing to a nearby drain. When there is no drain available, installers may need to run a line to the exterior of a customer's home, which takes time and labor to install and risks freezing in colder climates. While adding a drain line is not difficult, it often requires installers to spend time in cramped crawlspaces installing piping and re-wiring the installation space to have access to an outlet for a condensate pump. As one installer noted, *"sometimes they're simple. If the water heater is in a garage you just punch a hole right through the wall. Other times you're running 20-30 feet with a condensate pump, and then you got to find an outlet to plug that in."* Installers typically plan for an hour of their time for basic condensate drain configuration, or up to two hours extra for more challenging configurations. As one installer put it, *"The PVC [pipe] is cheap, but the time it takes to do it is not."*

Prevalence

Installers estimated the percentage of homes in their area likely to have issues associated with condensate drainage and to rate the perceived difficulty of overcoming this challenge (Table 3-6). Because installers answered questions about prevalence with a percentage, the range varied. To facilitate understanding, we created three bins, and present the portion reporting that fewer than 25%, 25-49% and more than 50% of the homes in their area are likely to have challenges with condensate drainage. The average is calculated from all responses and is akin to a regional average.

Table 3-6. Portion of homes with condensate management challenges, and perceived difficulty

Challenge	Percentage of homes likely to have issue			Average	% Respondents rating challenge as difficult[9]
	Less than 25%	25-49%	More than 50%		
Issues associated with condensate drainage (n=52)	35%	15%	50%	46%	Drain proximity 19% Concerns about freezing/blockage 22%*

**Only those that had plumbed condensate through an exterior wall were asked to rate the difficulty of addressing concerns about freezing or blockage (n=37)*

Solutions

The survey separated issues associated with drain location from those associated with piping condensate to drain to the exterior of a home. First, installers rated the likelihood that they would recommend several common solutions for overcoming issues with drain location and were asked if there were other solutions. Other solutions offered when solving for lack of access to a drain included two installers that mentioned draining the condensate to the outside (although they were unlikely to recommend this), two more that recommended adding a floor drain, and one mention of plumbing to a utility sink through an air break.

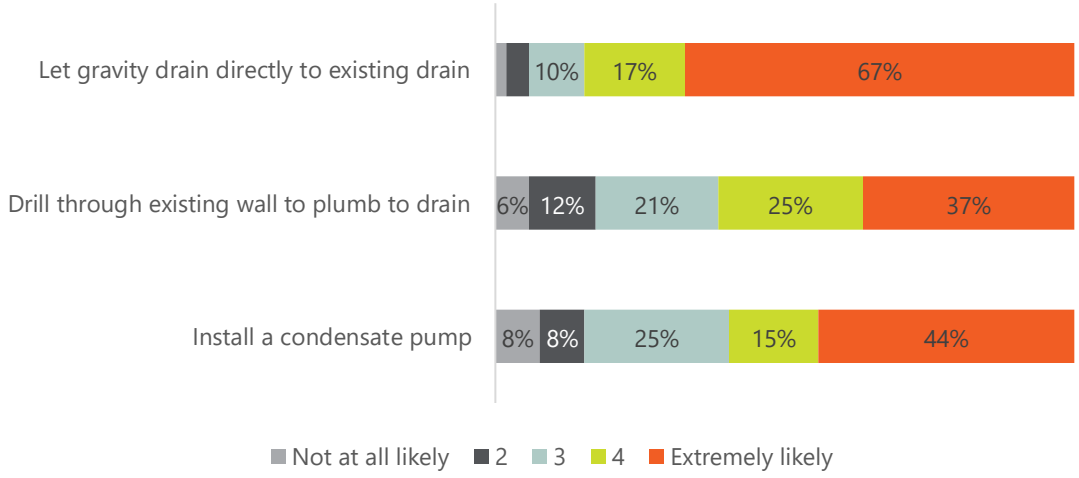


Figure 3-2. Potential solutions for condensate drainage in HPWH installations (n=52)

Installers were then asked if they had ever piped condensate so that it drains to the exterior of a home. Thirty-seven, or 71% reported they had. To ensure respondents had enough experience to respond meaningfully, only those that had reported having piped condensate to drain to the exterior of a home were asked about likelihood of recommending several common solutions to address concerns about condensate freezing or becoming blocked in this scenario. Eleven of the 37 installers with experience in exterior draining offered other solutions, the most common—mentioned by six —was to insulate pipes, followed by four respondents that described specific attention to drainage slope and quality.

[9] Rated "4" or "5" on a five-point scale.

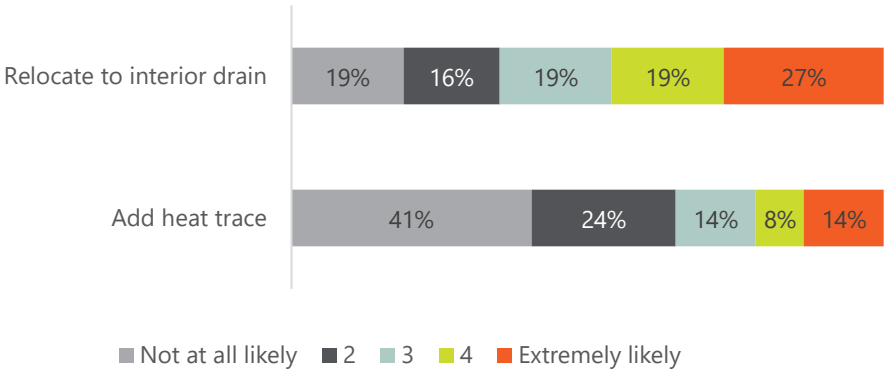


Figure 3-3. Potential solutions to avoid freezing or blockage in exterior drainage (n=37)

Those reporting they were likely to recommend any of the proposed solutions provided an estimate of the additional hours required.

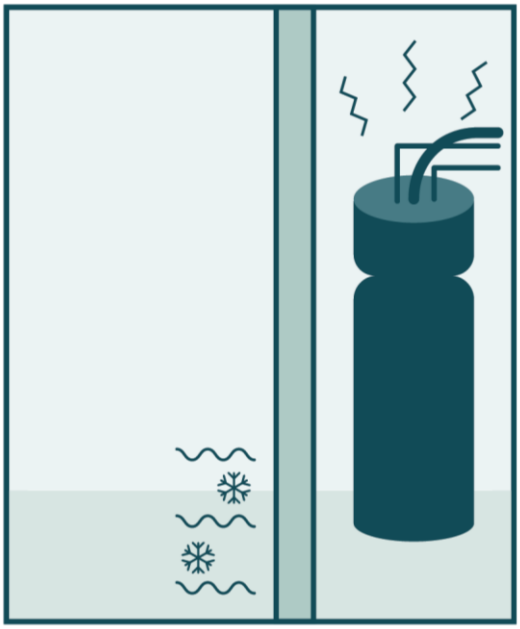
Table 3-7. Estimated additional hours associated with condensate solutions

Challenge/Solution	Installer "likely" to choose		Average additional hours required
Proximity to drain	Count	Percent	
Let gravity drain directly to existing drain (n=52)	44	85%	1.1
Drill through existing wall to plumb to drain (n=52)	32	62%	1.5
Install a condensate pump (n=52)	31	60%	1.3
Concerns about freezing or blockage when condensate drained to exterior	Count	Percent	
Relocate [condensate line] to interior drain (n=37)	17	46%	2.1*
Add heat trace (n=37)	8	22%	1.0

**Removed two outlier values of 8 and 11 hours respectively. These estimates indicate that the respondent interpreted this solution as move the water heater to an interior drain rather than piping the condensate to an interior drain.*

3.4 Mitigation for Noise and Cold Air

NEEA's challenging installation framework acknowledges that, relative to their electric resistance counterparts, HPWH generate audible operational noise. The specific decibel level output varies by manufacturer and has improved greatly in most recent models (45-55 decibels, or comparable to the background noise from a portable fan or refrigerator cycling). Concerns about noise mostly emerge when the water heater is installed in the living space, particularly near a bedroom, where occupants might be aware of the noise when the unit cycles on. Noise is generally not a concern when units are installed in garages, mechanical rooms, or unfinished basements, and may not be an issue when the unit is separated from living space by a solid wall.



3.4.1 Manufacturer perspective

Manufacturers considered noise a bigger issue than cold air, reflecting the portion of homes with electric resistance tanks installed in living space. According to interviewed manufacturers, as the units have become more quiet the complaints they field about noise reflect awareness of unit cycling on and off, as opposed to the volume of noise. Cycling noise tends to disturb people when they are sleeping or concentrating. To avoid negative perceptions of their products, some manufacturers do not recommend installing HPWH too close to bedrooms or other areas of the home where quiet is expected.

According to manufacturers, the cold air generated by HPWH operation was not a major concern, as it is generally addressable with venting and not an issue at all when installed in garages, utility rooms, or unfinished basements. In some scenarios (humid climates, damp basements) the cold air is perceived as a benefit, adding cooling and acting as a defector humidifier.

3.4.2 Installer perspective

Installers in the focus group noted that newer HPWH models had lower operating noise levels, and that this had decreased their overall concern about noise complaints. These installers discussed addressing noise in conditioned spaced by installing insulation or using ductwork to direct the noise away from living spaces in customers' homes.

In the focus group, issues associated with noise and cold air were frequently discussed in tandem, and installers briefly discussed options for ducting out cold air when HPWHs are installed in spaces where cold air could affect occupant comfort. Installers mentioned that manufacturers could provide more solutions to address issues related to space, noise and cold air by providing options for split systems, where the heat pump or condensing unit is installed outside the home.

Prevalence

The survey reflects the overall experience of the installer market. The research team did not ask installers to rate only newer models, which means that their responses include experience with older models (which may have been noisier) as well as the newer, quieter models. In the survey installers estimated the percentage of homes in their area likely to have issues associated with mitigation to avoid occupant complaints associated with both noise and cold air. Reflecting the focus group discussion, the two issues have similar prevalence, with noise slightly more problematic than cold air. Table 3-8 provides installer estimates of the portion of homes in their area likely to have each concern. Responses ranged from zero to 100% and are provided in categories below. The average value is calculated from all responses.

Table 3-8. Installer estimates: Portion of homes likely to have occupant concerns (n=52)

Challenge	Percentage of homes likely to have issue			Average
	Less than 25%	25-49%	More than 50%	
Potential for occupant concern about noise	25%	21%	54%	47%
Potential for occupant concern about cold air	25%	25%	50%	43%

Because these occupant experience issues are directly related to installation location, installers were asked to rate specific locations on a scale of difficulty, where 1=not at all difficult and 5=extremely difficult. Table 3-9 reflects how installer perception of these issues is affected by the location of the existing water heater. Ninety-two percent of installers do not see garage installations as having challenges in this domain, while 81% of installers think these issues will be challenging when a water heater is installed in a closet in the main house.

Table 3-9: Installer rated difficulty of solving noise or cold air concerns by location (n=52)

Location	Portion indicating difficult to solve (rating a "4" or "5")			
	Basement	Utility room	Garage	Closet in main house
Potential for occupant concern about noise/cold air	23%	37%	8%	81%

Solutions

The survey separated the solutions for noise and those for cold air (although some of the solutions are the same) and asked installers to rate the likelihood that they would recommend several common solutions for each concern. They also had an opportunity to offer other solutions. Other solutions offered to mitigate concerns about noise included adding flexible ducting or switching the unit to electric resistance mode. Seven installers offered other solutions offered to mitigate concerns about cold air, including two who would recommend a different water heater, and four that recommended adding baffles, doors, ducting or even heaters to the space.

The distribution of installer responses by solution set is presented in Figure 3-4 .

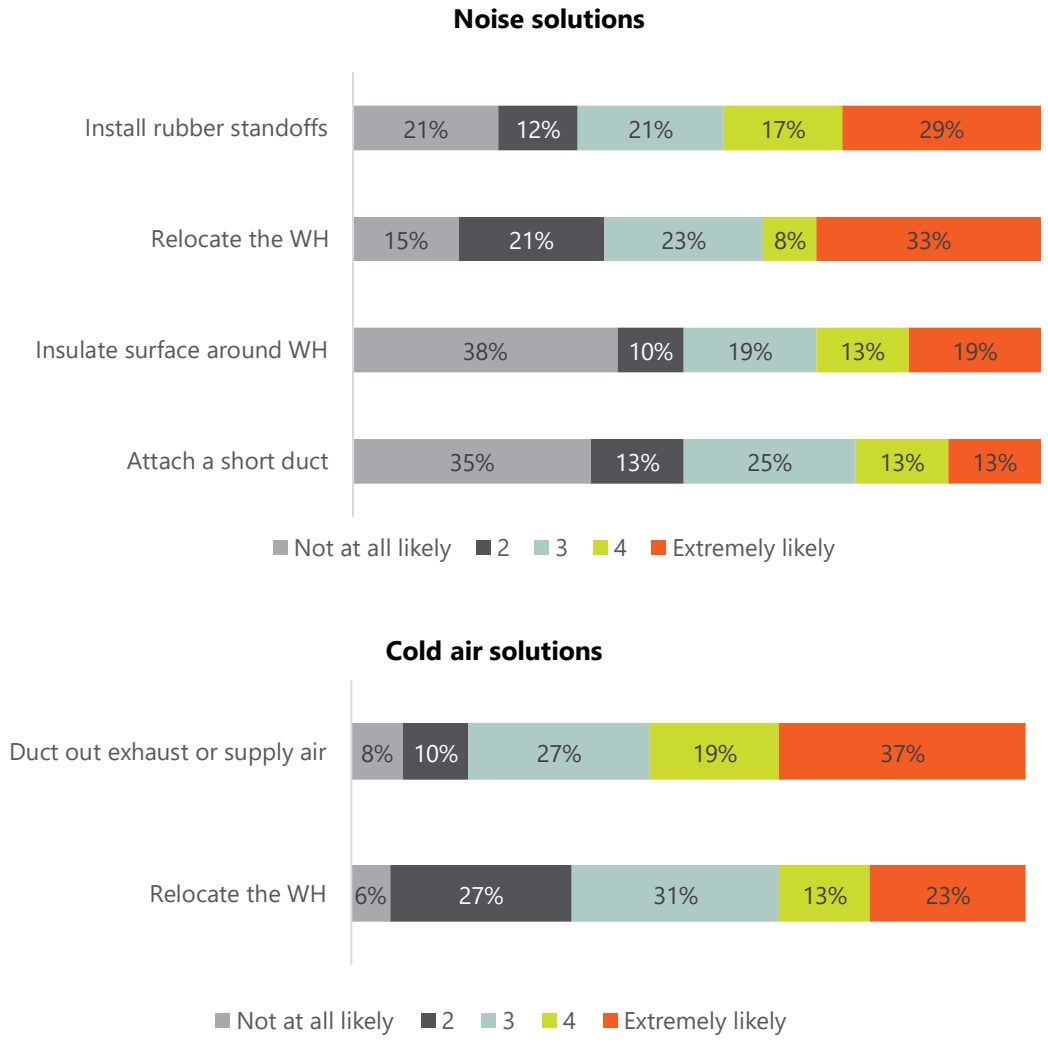


Figure 3-4: Likelihood of choosing solutions to mitigate concerns about noise or cold air (n=52)

Those reporting they were likely (offering "4" or "5" on a five-point scale) to recommend any of the proposed solutions provided an estimate of the additional hours required (Table 3-9, Table 3-10).

Table 3-10: Estimated hours associated with noise mitigation

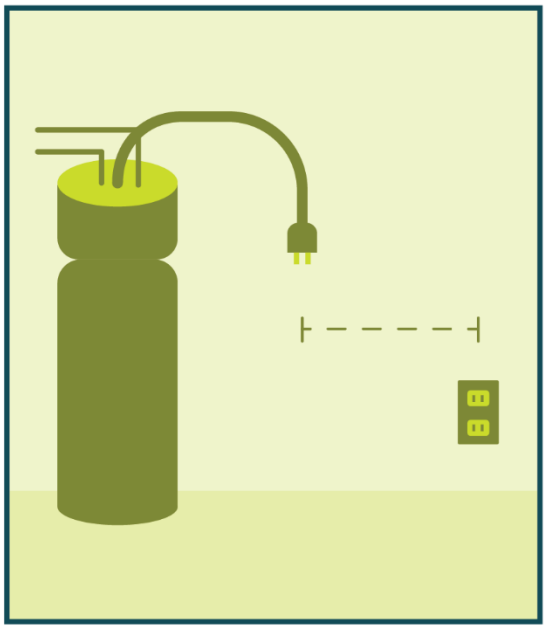
Solution	Installer "likely" to choose		Average additional hours required
Concerns about noise	Count	Percent	
Install rubber standoffs (n=52)	24	46%	1.2
Insulate surface around WH (n=52)	17	33%	2.2
Relocate the water heater (n=52)	21	40%	5.8
Attach a short duct to redirect noise (n=52)	14	27%	1.9

Table 3-11. Estimated hours associated with cold air mitigation

Solution	Installer "likely" to choose		Average additional hours required
Mitigating concerns about cold air	Count	Percent	
Duct out exhaust or supply air (n=52)	29	56%	3.3
Relocate the water heater (n=52)	20	38%	5.2

3.5 Existing Plumbing or Wiring

When replacing electric resistance with HPWH in the same location, it is likely that the existing electrical service and connections are sufficient to enable straightforward connection of the HPWH. However, all kinds of issues emerge when working in existing homes, so NEEA's challenging installation framework included the potential for adjustments to existing wiring or plumbing. These aspects can emerge in a variety of retrofit scenarios and are not unique to HPWHs. For example, if the wiring pigtail on the new unit is shorter than the existing one, or if the new unit is installed in a slightly different location in the same room (at request of the homeowner or on plumber recommendation), the existing wiring may not be sufficient.[10]



Similarly, it is common to have to adjust existing plumbing to match new equipment. Most HPWHs are configured differently from electric resistance, instead of a top mounted inlet and output, the plumbing connections are on the side of the unit to avoid plumbing through the mechanical equipment. As these units are typically installed by plumbers, minor adjustments to plumbing are not generally perceived as challenges.

3.5.1 Manufacturer perspective

According to manufacturers, adapting existing plumbing and wiring to HPWH connections is not considered a major barrier to HPWH installations. Manufacturers described two scenarios in which wiring and plumbing can create challenges:

- Lack of electrical access or even sufficient electrical service to a home built with a full suite of gas appliances can create challenges for fuel switching. This is more of an issue in states like California, where there are a lot of gas water heaters and policy pressure to decarbonize.

[10] In fuel switching scenarios, where the previous unit was propane or natural gas fired, access to sufficient electrical supply may be an issue. These scenarios are not explored in this research.

- Having to add piping to access side inlet/outlets can aggravate space requirements as it can increase the dimension required by the HPWH. Manufacturers noted that plumbers are not intimidated by adding pipes; the bigger issue was space.

3.5.2 Installer perspective

Installers participating in the focus group noted that HPWHs generally require some level of work to match existing pipes to the plumbing configuration required. The extent of this work will reflect the idiosyncrasies of the model and the condition and placement of existing plumbing. None of the installers described specific challenges related to plumbing, noting they expect some pipe installation work in every job.

In the focus group discussion installers noted that electrical supply and connections are typically sufficient when replacing a standard water heater. On occasion, wiring will need to be reconfigured to accommodate the HPWH. When replacing any water heater, installers may find that the wire gauge is inadequate, or the wiring needs to be extended to run to the main electric panel. One installer said that while HPWHs may need around a 30-amp circuit, some water heaters can get by with a smaller wire size and a smaller breaker: *"in a perfect world, I'm sure that every single one of us would like to see 10-gauge wire plus for this stuff."* Installers described running additional wire during a HPWH install as simple but requiring additional labor hours.

Prevalence

Surveyed installers estimated the percentage of homes in their area likely to have issues associated with existing plumbing or wiring. Respondents then rated the perceived difficulty of overcoming each challenge (Table 3-12). Challenges with existing wiring are more common than those associated with existing plumbing, however neither are perceived as difficult to overcome.

Table 3-12: Prevalence and perceived difficulty of existing wiring and plumbing

Challenge	Percentage of homes likely to have issue				% Respondents rating challenge as difficult[11]
	<25%	25-49%	50%+	Average	
Existing wiring insufficient	42%	8%	50%	44%	10%
Existing plumbing requires modification	67%	13%	19%	24%	12%

Solutions

The survey separated the solutions for addressing wiring and plumbing challenges and asked installers to rate the likelihood that they would recommend common solutions for each concern. They also had an opportunity to offer other solutions. Nine respondents offered other solutions for overcoming existing wiring challenges, including three suggestions to install a new or dedicated circuit, two suggestions to run new wiring, and two recommendations to call an electrician. None of the suggestions offered for plumbing challenges were substantially different from pre-programmed solutions, although one

[11] Rated "4" or "5" on a five-point scale.

suggested hiring a plumber as a subcontractor, indicating that not all HPWHs are being installed by plumbers.

The distribution of installer responses by solution set is presented in Figure 3-5.

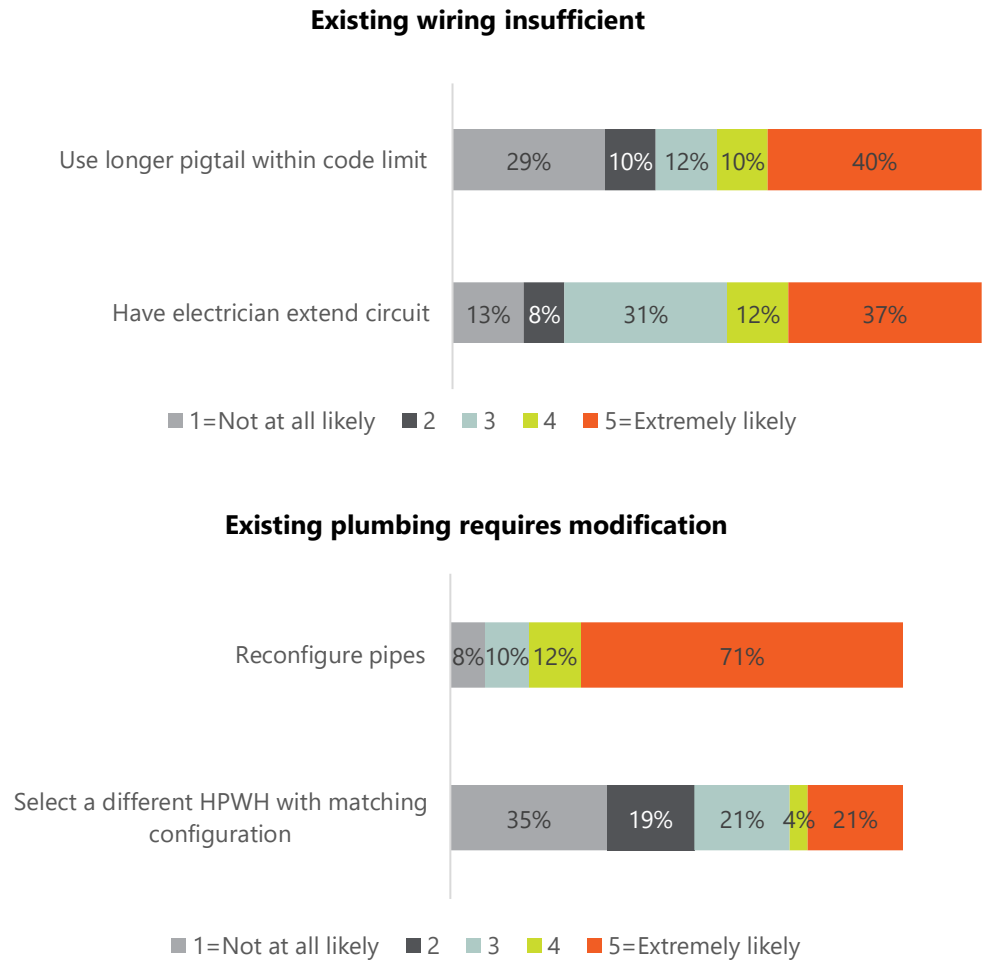


Figure 3-5: Likelihood of choosing solutions to address wiring or plumbing issues (n=52)

Those reporting they were likely to recommend any of the proposed solutions provided an estimate of the additional hours required.

Table 3-13. Estimated hours associated with adjustments to existing wiring or plumbing

Solution	Installer "likely" to choose		Average additional hours required
Existing wiring insufficient	Count	Percent	
Use longer pigtail within code limit (n=52)	26	50%	1.1
Have electrician extend circuit (n=52)	25	48%	1.8

Existing plumbing requires modification	Count	Percent	
Reconfigure pipes (n=52)	43	83%	1.8
Select a different HPWH with matching configuration (n=52)	13	25%	1.4

Note that 13 installers (25%) indicated they would be likely to select a different HPWH with a plumbing modification that matches the existing pipe configuration and estimated that this would add just over one additional hour. While the survey did not as for follow up explanations on each of the solutions, the research team believes that this could reflect the need to do additional research prior to scheduling the installation or finding that the expected model will not work and having to exchange the unit for a different version.

Section 4 Cross-cutting Findings

Cross-cutting challenge discussion

In every solution set, the survey included the option for the respondent to recommend against installing a HPWH. Because this solution was consistently offered, it is presented separately to enable comparison across challenges. Ultimately, if installers decide to recommend against a HPWH in the face of specific challenging scenarios it is unlikely their customers will pursue a HPWH. While half of installers indicated they would consider another product when faced with insufficient space, approximately 60-90% of installers would stick with a HPWH in the other scenarios. Challenges associated with condensate and existing wiring and plumbing do not appear to result in plumbers recommending against HPWHs.

Table 4-1: Portion likely to recommend against HPWH, by challenge

Challenge	Installers likely to recommend against HPWH when encountering…	
	Count	Percent
Insufficient space (n=52)	26	50%
Insufficient air flow (n=52)	22	42%
Concerns about noise (n=52)	21	40%
Concerns about cold air (n=52)	21	40%
Drainage location (n=52)	8	15%
Wiring issue (n=52)	6	12%
Plumbing issue (n=52)	6	12%
Condensate freezing or becoming blocked (n=37)	3	8%

In an open-ended question, installers described the most challenging issue to overcome based on their experience. The results reflect the challenges associated with small spaces as almost half of the survey respondents named limited space as the most challenging issue.

Table 4-2: Most challenging issue to overcome in HPWH installation (Multiple Responses Allowed)

Greatest type of challenge	Count	Percent
Space constraints (fit or airflow requirements)	24	46%
Concerns about noise or cold air	12	23%
Condensate drainage issues	8	15%
Plumbing or wiring	8	15%
Ducting or venting	5	10%
Relocating water heater	3	6%

This response is consistent with the sentiment in the focus group: insufficient space for the HPWH to fit or work properly can stop an installer from recommending or continuing with a HPWH installation.

Labor hour estimates

It is important to note that the average installation time for a HPWH includes all the idiosyncratic adjustments installers make in the field and reflects their experience "all in." Installations can be quicker, or substantially longer if complex modifications or relocation is indicated. To appropriately understand the average time required per solution in the discussions below, we recommend adding the incremental hours to the time required for a "typical" water heater installation (presented previously in Table 3-3), not the average HPWH installation time.

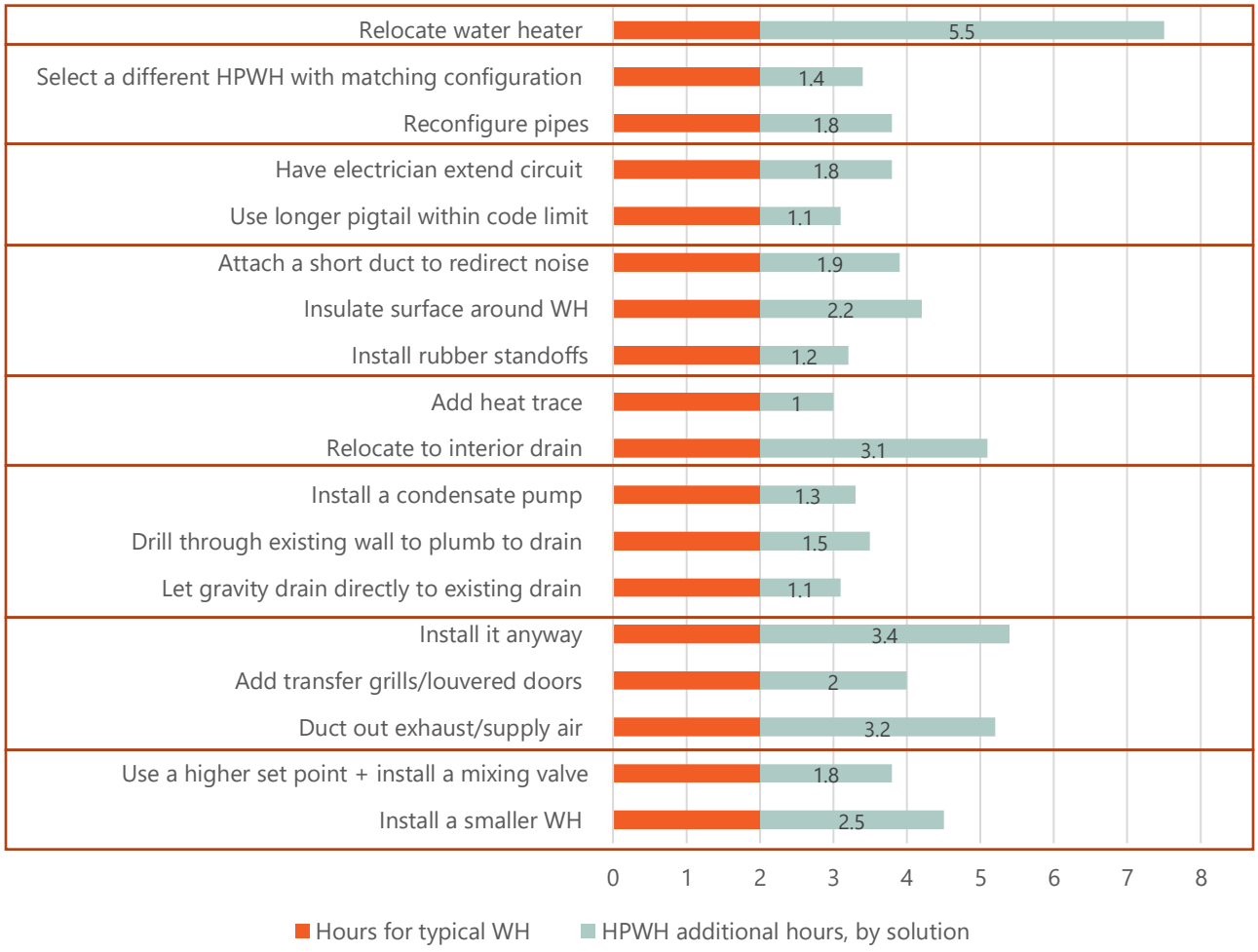


Figure 4-1. Total hours estimated for HPWH installation, by solution

In Figure 4-1, the additional hours estimated by installers for each solution are added to the hours for a "typical" water heater installation. Most solutions are very close to the four-hour HPWH installation estimate calculated from installer responses, however relocating the water heater is likely to take more than seven hours to complete.

4.1 Tracking product feedback

As part of understanding how information on installation challenges flows upstream to manufacturers, who are in the best position to alter product requirements, we asked manufacturer contacts about how they track feedback on their products. Manufacturers described a variety of mechanisms for collecting feedback from the market on product features or components affecting installers. The most common mechanism is using their national sales organization (including manufacturers' representatives, internal sales teams, and wholesalers) to reach deep into the contractor population and enable communication. Another common approach is to collect information on technical support calls, logging them and digging into issues emerging from those calls. Calls can come from the distribution network and directly from installers—in both scenarios, manufacturers have access to information on the specific issues faced by installers. Less common approaches included collecting reviews and feedback on products through their own websites and those of retail partners, contracting data and research firms to conduct surveys, and using in-person trainings to give installers hands-on experience.

While approaches to technical support hotlines varied, manufacturers universally expect that installers will reach out to them with questions or concerns about their products, acknowledging that their units are different and may have unique guidelines for installation. In the focus group discussion with installers, attendees discussed the varying quality of the manufacturer technical support provided, with some contacts avoiding products that do not have sufficient support. For their part, manufacturers noted that they provide installation guidelines that, if followed, should avoid customer complaints and product performance issues. Specific recommendations for room size, exhortations to avoid certain locations, and instructions for condensate likely affect the product options provided by installers to their customers very early in the decision-making process.

4.2 Sources of Information

Another cross-cutting topic explored in manufacturer interviews and the installer survey centered on sources of advice or information available to guide installers when they face installation challenges. Prior research indicated that installers consider distributors trusted sources of information and think of them as the conduit for information from manufacturers and support when questions arise during installation.[12]

Manufacturers universally expect that installers will reach out to them with questions or concerns about their products, acknowledging that the units have different best practice guidelines for installation. Installers confirmed their inclination to turn to manufacturers in the survey, as 85% indicated they would be likely to access manufacturer technical support (Table 4-3).

Installers participating in the focus group mentioned turning to multiple sources for advice when they have questions. These installers confirmed reaching out to manufacturer tech support. They also reported looking up information on manufacturer websites, reading specification literature developed by manufacturers, talking to an expert at their wholesaler, accessing plumbing internet threads, or calling a contact at an organization like NEEA for advice. Installers sometimes find that manufacturer tech support representatives lack the expertise to answer their questions. One installer found that manufacturer literature about their HPWH models provides limited information and does not clearly differentiate

[12] Russell Research, 2018.

between different models: *"they spend millions of dollars in marketing, but the literature they put out is kind of lacking as far as details go sometimes."*

In the installer survey, contacts were asked where they turn for information or advice. Manufacturer technical support, colleagues and other experts, and distributors were the most common sources.

Table 4-3: Where installers turn for information or advice (Multiple Responses Allowed)

Information resource	Count	Percent
Manufacturer tech support	44	85%
Talk to a colleague	38	73%
Talk to experts in area	33	63%
Distributor expertise	32	62%
Online training video	28	54%
Manufacturer training video	26	50%
Internet threads	21	40%
Installation manuals	4	8%
Other	10	19%

4.3 Serviceability

Installer research sought to understand the supply of repair and maintenance service providers among plumber/installers. Manufacturers provide service guidelines and monitor performance issues among products under warranty. Manufacturers will often be involved when a product is under warranty and rely on qualified service technicians to resolve performance issues.

In the focus group, several installers reported that they service HPWHs under warranty by the manufacturers. A few installers found warranty work to be frustrating, noting that in many cases the repair issue is related to the unit being installed incorrectly. Installers mentioned seeing poor installation jobs most often in newly built homes. Several installers discussed developing company policies in which they only service HPWHs that their company installed: *"I won't warranty or even go out and do warranty work on one that wasn't installed by us. It's just not worth our time."* Installers sought to remove themselves from the middle of disputes between customers and manufacturers. Installers will charge the customer for the service call directly and have the customer take their receipt to the manufacturer to see what the warranty will cover. According to one installer, *"doing warranty work for manufacturers usually doesn't pay."*

During survey fielding, the research team made adjustments to reduce length and shortened the survey set focused on serviceability. For this reason, only 27 of the 52 respondents answered the question "Do HPWH require more, less, or about the equal maintenance to a standard water heater?" Of these, over 85% of respondents (23 of 27) reported that HPWH require more to maintain than standard water heaters, while nearly 15% said HPWHs require about the same as standard water heaters. No installers surveyed said that HPWHs require less to maintain than standard water heaters.

About half (27 of 52, or 52%) of surveyed installers provide maintenance services for HPWHs. Most of those installers, (20 of 27, or 74%) will repair HPWHs installed by another company. Nineteen of these respondents estimated the percentage of maintenance or service jobs that were under warranty, repairs related to an installation issue, or repairs where they recommended replacing the water heater equipment (Table 4-4).

Table 4-4. Characteristic of repair or maintenance calls (n=19)

Repair type	% of HPWH repair jobs
Under warranty	29%
Reflected an installation issue	26%
Recommended replacing the equipment	24%

Respondents described their primary reasons for service calls. Service call issues ranged from issues with controls or equipment failure (e.g., thermistor or anode rod failure), to complaints about hot water supply, dirty air filters, and compressor or fan noise (verbatim responses can be found in Table A-13)

Section 5 Conclusions and Opportunities

This project focused specifically on understanding how common different challenging installation scenarios are, how installers typically overcome them, the additional labor costs associated with common solutions, and where installers turn for information. This section provides a brief summary of conclusions and presents opportunities for the NEEA HPWH team to further encourage installations in existing homes.

The prevalence of challenging scenarios in the regional housing stock.

Regional stock data indicates that approximately 40% of water heaters are installed in rooms smaller than 1,000 cubic feet or with less than eight feet of vertical space. Manufacturer guidelines are more generous than this, allowing units to be installed in rooms as small as 700 cubic feet and requiring only seven feet of vertical space. Installer estimates of homes likely to have issues with limited space for a HPWH installation are close to the RBSA estimate at 38% of homes on average.

The likelihood of an installer recommending a HPWH is directly related to the location of the existing water heater. Installers indicated that they were most likely to recommend HPWH for installation in garages and basements (79% and 48% respectively). Across the Northwest, these locations represent just under half of the existing water heaters, and garage locations are far more common in Oregon and Washington than in Idaho or Montana.

The frequency with which installers encounter each scenario.

This question is closely related to prevalence overall, as the frequency of a given challenge will reflect its prevalence in the local housing stock. Installers provided a percent estimate for portion of homes they would expect to run into each scenario. Challenges do not appear evenly distributed. The average portion of homes expected to have each challenge is a reasonable proxy for the frequency with which the region's installers encounter each scenario.

Table 5-1. Expected prevalence by challenge, reported by installers (n=52)

Challenge	Portion of homes expected to have each challenge*
Occupant concerns about noise	47%
Condensate drainage issues	46%
Wiring issue	44%
Occupant concerns about cold air	43%
Insufficient space	38%
Insufficient thermal resources (cold air build up in small space affecting performance)	38%
Plumbing work	24%

**Average value calculated from distribution of installer reported percentage in local market.*

The level of intervention required to overcome scenarios and how installers adapt.

Prevalence is important to understand but does not tell the full story. The challenging scenarios investigated here are not equal. A common scenario that is easy to address is not truly a barrier to installation. Almost 70% of RBSA cataloged water heaters are not within four feet of a drain, which is a large portion. However, installers do not view this as a major challenge, and plumbers are able to adapt to a variety of drain configurations and plumb to drains much farther than four feet away.

The perceived difficulty of overcoming each of the challenges varies. The most difficult to overcome are issues associated with space constraints, both in simply fitting the HPWH and in ensuring that the airflow in the space will be sufficient to keep the unit functioning efficiently. Condensate management and wiring updates, while relatively common, were not viewed as difficult to solve.

Table 5-2: Expected difficulty of each challenging scenario, reported by installers

Challenge	Portion indicating difficult to solve.[13]
HPWH will not fit in existing space (n=52)	62%
Insufficient airflow in existing space (n=52)	52%
Issues associated with condensate drainage	Drain proximity 19% (n=52)
	Concerns about freezing/blockage 22% (n=37)
Existing wiring insufficient (n=52)	10%
Existing plumbing requires modification (n=52)	12%

As expected, installers indicated that the challenges they experience with HPWHs correspond to the location of the existing water heater. In particular, challenges associated with avoiding occupant complaints about noise or cold air are related to installation location: garages score low on difficulty (8%) while closets in the main house score higher, at 81%.

Each solution set included an option for installers to indicate they would recommend against a heat pump water heater. The portion of installers selecting this option varied by the challenge, reflecting the perceived difficulty of each scenario. Insufficient space for the HPWH unit led 50% of installers to indicate they were likely to recommend against a HPWH and 52% indicated they would recommend relocating the water heater. However, for every other scenario approximately 60-90% of installers indicated they would not necessarily recommend against a HPWH.

Adjusting for condensate drainage, wiring upgrades, or plumbing repair were strikingly lower in their rated difficulty. In none of these challenges did more than 15% of installers report they would be likely to recommend against a HPWH.

HPWH take, on average, approximately four hours to install relative to two hours for a "typical" electric water heater. While installers estimated the time required to address specific challenges, the estimate of time required to install a HPWH encompasses the variety of scenarios encountered when working in a

[13] Installers rated difficulty on a 1-to-5 scale, where 1=not at all difficult and 5=extremely difficult. Portion displayed answered a "4" or a "5."

customer home. For this reason, the specific estimates should not be added to the average HPWH value, they should be added to the "typical" water heater installation time of two hours.

Several of the solution sets included an option for installers to consider relocating the water heater. This was a particularly important option for homes that would likely be perceived as inappropriate candidates for HPWH—those with space constraints or where occupant complaints about noise or cold air are likely. It is worth noting that plumbers encounter challenges working in tight spaces regularly and may recommend relocating the water heater for a variety of reasons, such as to facilitate maintenance, to free up closet space, or to enable tank or equipment upgrades. Across all responses, the average incremental time required to relocate a heat pump water heater is approximately 7.5 hours.

Where plumber/installers turn for information and solutions.

Manufacturers expect that installers will reach out to them with questions or concerns about their products, acknowledging that the units are different and may have different best practice guidelines for installation. In-person and virtual training opportunities are provided by manufacturers and designed to promote a suite of manufacturer-approved solutions. HPWH-specific technical support is provided by at least one manufacturer, acknowledging that the technical support required is more specific and involved than the rest of the product line. Installers confirmed their inclination to turn to manufacturer technical support, training videos, installation manuals. Turning to colleagues and local experts (which may be the same person for some installers) is also common and reflects shared problem solving and on-the-job training.

5.1 Other Opportunities

It is encouraging that challenging scenarios do not stop installers from recommending HPWH. Ultimately, widespread HPWH installations require installers who are confident they can overcome challenging installation scenarios. If specific scenarios are perceived as too difficult, or if HPWH are not considered appropriate for certain homes, installers will recommend against a HPWH. Homeowners are unlikely to seek out and install a technology not presented to them by the expert they are consulting. This research indicates that installers are willing to consider solutions, and that information resources and product improvements could help them do this better.

Information resources

Promote mixing valves to encourage smaller units. A surprisingly low portion of installers reported they would be likely to increase set point temperature and add a mixing valve as a potential solution for space constraints, as this could enable installation of smaller units. This could represent a familiarity or standard practice barrier, which could be overcome with training and information, particularly if it comes from the distributors and manufacturers installers turn to. This practice is common in Canada and in assisted living facilities that want to avoid scalding residents while addressing concerns about Legionella.

Track the room size requirements and investigate options for installations in small rooms. Clarifying and communicating the performance penalty associated with installing HPWH units in smaller rooms could assuage some fears about efficiency and product performance that prevent installers from considering small space installations. Manufacturers ship units with specific requirements for room volume, and installers could be proceeding cautiously to maintain warranty coverage. Additional research by the NEEA product team could document warranty requirements and clarify the efficiency penalty and

other operational effects associated with these scenarios to expand installation options for main house locations.

Build a solution tree. Consider opportunities to link communication with installers about solving common installation challenges with a realistic decision tree or screening tool that can walk installers through solutions they might not otherwise consider. Linking program-based subsidies to a specific challenge or installation requirement could offset the labor cost for the homeowner and help installers identify more permanent solutions, such as relocating a water heater to a more appropriate space. The most challenging scenario is insufficient space. Communication and solution screening should focus on that first, as it would increase the odds that HPWHs are considered a viable solution for a variety of home configurations.

Build on experience with natural gas units. Plumbers doing both gas and HPWH could be oriented to treat the HPWH requirements like those for natural gas. While most gas water heater owners stick with natural gas when they replace their units, the space and condensation management requirements for gas water heaters are similar to those required for HWHP.

Product development

Encourage manufacturers to focus on more diversity in size and configuration. This is likely to have the greatest impact in terms of expanding the viable market. The persistent challenges associated with product size and concerns about noise point to the need to focus on product-specific solutions for main house installation challenges. Manufacturers report that they are aware of the most common challenges installers encounter in the field and continue are focused on product developments that would streamline installation and result in satisfied homeowners.

Support product innovation efforts associated with noise reduction. Concerns about occupant perceptions of noise emerged as a close second to those about product fit in interviews with manufacturers, and installer survey results indicate that noise continues to be an issue. While the decibel levels associated with operational noise have declined in recent years, complaints continue to flow from consumers bothered by the cycling of the unit, according to manufacturers noise complaints are often about the specific pitch emitted by the equipment. This challenge is primarily an issue when the unit is installed near quiet spaces used for sleep or concentration. Manufacturers are aware of this and report working on product-level solutions.

Explore opportunities to expand product options. Emerging products are expected to help with some of the challenging scenarios, including space requirements and noise mitigation. Split systems avoid many of the main house installation challenges by radically changing the profile and installation requirements of the product by moving cold exhaust air, mechanical noise, and condensate outside. However, these systems are currently substantially higher in price and are not considered widely accessible.

Improve the detail in the RBSA

As NEEA prepares to launch the next round of residential stock data collection, consider opportunities to improve the specificity and detail associated with the "main house" water heater installation category. Utility or mechanical rooms that contain laundry or other household mechanical equipment are often located away from quiet spaces and have options for condensate management. Improving the detail of main house installations could shed light on the portion of these that are truly unsolvable without relocating the water heater.

Appendix A: Additional Survey Frequencies

Experience/Firm

Table A-1: Tenure Installing Water Heaters (n=52)

Tenure	Count	Percent
less than 10 years	4	7.7
10 to less than 20 years	12	23.1
20 to less than 30 years	11	21.2
30 years or longer	25	48.1

*Table A-2: State (n=52)**

State	Count	Percent
Washington	27	52
Oregon	19	37
Idaho	4	8
Montana	2	4

**May not total to 100% due to rounding*

Table A-3: Number of water heater installations per year, by company (n=52)

Number of water heaters per year	Count	Percent
less than 50	20	38.5
50 to less than 100	10	19.2
100 to less than 200	8	15.4
200 to less than 300	4	7.7
300 or more	10	19.2

Table A-4: Experience with HPWH (n=52)

# of HPWH installed in past two years	Count	Percent
less than 10	18	34.6
10 to less than 20	14	26.9
20 to less than 30	4	7.7
30 or more	16	30.8

Table A-5: Portion of total water heater installs that are HPWH (n=52)

Portion of installs that are HPWH	Count	Percent
0%	1	1.9
1%	9	17.3
2%	11	21.2
3%	3	5.8
4%	1	1.9
5%	6	11.5
10%	6	11.5
15%	5	9.6
20%	2	3.8
30%	2	3.8
40%	1	1.9
50%	2	3.8
60%	3	5.8

Average: 12.1% of all water heater installations are HPWH.

Table A-6: How many hours required on average to install typical water heater (n=52)

Hours to install typical water heater	Count	Percent
One	6	11.5
Two	22	42.3
Three	14	26.9
Four	8	15.4
Five	1	1.9
Six	1	1.9

Average: 2.6 hours, median 2 hours to install typical water heater.

Table A-7: How many hours required on average to install HPWH (n=52)

Hours to install HPWH heater	Count	Percent
One	2	3.8
Two	6	11.5
Three	12	23.1
Four	14	26.9
Five	7	13.5

Six	6	11.5
Seven	2	3.8
Eight	2	3.8
Twelve	1	1.9

Average: 4.2 hours, median 4 hours to install HPWH.

Prevalence and Difficulty Ratings

Table A-8. Portion of local homes with each challenge, binned (n=52)

Challenge	Respondent estimate of local homes with challenge					
	Fewer than 25%		25-49%		More than 50%	
	Count	%	Count	%	Count	%
Existing wiring insufficient	22	42%	4	8%	26	50%
Existing plumbing requires modification	35	67%	7	13%	10	19%
HPWH will not fit in existing space	17	33%	11	21%	24	46%
Insufficient airflow in existing space	21	40%	10	19%	21	40%
Issues associated with condensate drainage	13	25%	11	21%	28	54%
Potential for occupant concern about noise	13	25%	13	25%	26	50%
Potential for occupant concern about cold air	18	35%	8	15%	26	50%

Table A-9. Relative Challenge: Portion of local homes and rated difficulty (n=52)

Challenge	Percentage of local homes, range	Percentage of local homes, average	Portion indicating difficult to solve.[14]
Existing wiring insufficient	1-100%	44%	10%
Existing plumbing requires modification	0-100%	24%	12%
HPWH will not fit in existing space	1-85%	38%	62%
Insufficient airflow in existing space	0-100%	38%	52%
Issues associated with condensate drainage	0-100%	46%	Drain proximity 19% Concerns about freezing/blockage 22%*

[14] Installers rated difficulty on a 1-to-5 scale, where 1=not at all difficult and 5=extremely difficult.

Potential for occupant concern about noise	0-100%	47%	Varies by location
Potential for occupant concern about cold air	0-100%	43%	

*Only those with experience plumbing condensate to the exterior of a home rated this challenge (n=37)

Table A-10. Concerns about noise/cold air (Occupant Experience) by installation location

Location	Portion indicating difficult to solve			
	Basement	Utility room	Garage	Closet in main house
Potential for occupant concern about noise/cold air (n=52)	23%	37%	8%	81%

Solutions

Tight spaces

Table A-11. "Other solutions" for challenges

Other solutions for HPWH not fitting:	
Unlikely to use ("3" or lower)	Likely to use ("4" or "5")
Reconfigure piping of other appliances near the water heater	Direct replacement of water heater that's already there – not HPWH (recommend against HPWH)
Supplemental venting	Remove some walls, do carpentry work
Modify the room	Enlarge the space
Use a tankless water heater	Install a small electric heater instead
Look for a different brand with another size height, length or width	Pick a different water heater, like tankless
	Call a contractor and make more room
	Use another water heater
Other solutions for condensate challenges	
Proximity to drain	
Unlikely to use ("3" or lower)	Likely to use ("4" or "5")
Just draining it to the outside	Add a drain and reconfigure existing plumbing for adding a gravity floor drain
Drain to the outside	Install a hub drain or a floor drain to catch the condensate
	If there is a washing machine or utility sink, plumb to it via an air break
Concerns about condensate freezing or becoming blocked	

Unlikely to use (“3” or lower)	Likely to use (“4” or “5”)
In direct draining; plumb it so that if it freezes it will drip inside the garage	It doesn’t get very cold in Western Washington, so this usually isn’t an issue
Insulate the condensate line	Route condensate pipe in insulated space
Insulate the pipe	Put an air break in the drain line
	Make sure the drainage is properly sloped—no bellies, no sags, no areas where condensate can collect
	Install condensate pump and pump it up into a ¾ inch pipe, which will not allow the water to run back into the space. We run it uphill and back down again, through the ¾ inch pipe and then run out to exterior
	Insulate the pipe
	Insulate the drain
	Insulate and drain into pea gravel below grade
Other solutions for noise or cold air concerns	
Mitigate for noise	
Unlikely to use (“3” or lower)	Likely to use (“4” or “5”)
Insulate the walls in the space that the water heater is in	Use flexible ducting
	Install rubber or foam standoffs
	Switch to a regular water heater that doesn’t make noise, or a hybrid switched to electric mode
Mitigate for cold air	
Unlikely to use (“3” or lower)	Likely to use (“4” or “5”)
Install a door to the utility room	Insulate the surface between the house and the water heater
Baffle it up or baffle it down	If it’s in a garage, we can put a heater in there
Use a different water heater	Install a regular water heater
Ducting, with a fan, not just ducts	
Other solutions for wiring or plumbing	
Wiring	
Unlikely to use (“3” or lower)	Likely to use (“4” or “5”)
Install new circuit	Tell the customer to hire an electrician
Install entirely new circuits	Run a whole new wire to the heat pump

When the existing wiring is aluminum, install new copper wiring	Adding a dedicated circuit
Call an electrician	Whatever is required by code
I'd do it myself	
Plumbing	
Unlikely to use ("3" or lower)	Likely to use ("4" or "5")
Reroute the pipe or re-plumb	Change piping
	Hire plumber as subcontractor
	Add expansion or run T and P line to outside
	Put in a condensate pump

Table A-12: Additional time required to implement each solution (asked of those likely to use).

Solution	Additional hours, range	Additional hours, average
HPWH will not fit in existing space		
Install smaller water heater (n=21)	1-4 additional hours	2.5
Use higher set point and mixing valve (n=15)	1-4 additional hours	1.8
Relocate the water heater (n=28)	1-6 additional hours	5.4
Insufficient airflow for HPWH in existing space		
Add transfer grills, louvered doors or similar (n=21)	1-6 additional hours	2
Duct out exhaust or supply air (n=31)	1-8 additional hours	3.2
Install it anyway, as planned (n=10)	1-8 additional hours	3.4
Relocate the water heater (n=21)	1-8 additional hours	4.9
Proximity to drain		
Let gravity drain directly to existing drain in same space (n=35)	1-2 additional hours	1.1
Install a condensate pump (n=31)	1-3 additional hours	1.3
Drill through existing wall to plumb to drain (n=31)	1-3 additional hours	1.5
Concerns about freezing or blockage when condensate drained to exterior		
Add a heat trace (n=8)	1 additional hour	1
Relocate to an interior drain (n=16)	1-11 additional hours	3.1
Existing wiring insufficient		

Use longer pigtail within code limit (n=23)	1-2 additional hours	1.1
Have electrician extend circuit (n=20)	1-3 additional hours	1.8
Existing plumbing requires modification		
Reconfigure pipes (n=42)	1-5 additional hours	1.8
Select a different HPWH with matching configuration (n=11)	1-3 additional hours	1.4
Mitigating concerns about noise		
Install rubber standoffs (n=23)	1-4 additional hours	1.2
Insulate surfaces around water heater (n=18)	1-6 additional hours	2.2
Attach a short duct to redirect noise (n=14)	1-4 additional hours	1.9
Relocate water heater (n=21)	1-16 additional hours	5.8
Mitigating concerns about cold air		
Duct out exhaust or supply air? (n=28)	1-8 additional hours	3.3
Relocate water heater (n=20)	1-8 additional hours	5.2

Service and Maintenance

Table A-13. Q29 Open ended responses: reason for service calls

Q29. Open-ended response: reason for service calls (n=19)
THERMISTOR MALFUNCTION, ANODE RODS GOING BAD, ELEMENTS GOING BAD
EQUIPMENT FAILURE (EXP) IT'S USUALLY THE HEAT PUMP HEADS, THE NON-WATER HEATER PARTS.
I HAVEN'T HAD ANY SERVICE ISSUES. OR CALLBACKS ON SERVICING HEAT PUMP WATER HEATERS.
ONE IS NO HOT WATER. TWO IS LEAKING WATER. AND THREE IS NOT ENOUGH HOT WATER. AND FOUR IS NOT HOT ENOUGH WATER. (EXP LEAKING) USUALLY IT'S A CONNECTION.
NOT ENOUGH HOT WATER (W/E) NO, GENERALLY IT'S PROBABLY NOT WORKING RIGHT IN NOT GIVING HOT WATER
TOO COLD AT INTAKE: LINE NOT SUITABLE TO RUN HEAT PUMP ONLY INTAKE AIR
NO HEAT, WATER LEAKING, AND ERRATIC BEHAVIOR(W/M) INTERMITTENT PERFORMANCE, LIKE AT CERTAIN TIMES HAVING NO HEAT.
HARD WATER DESTROYING THE ELEMENT. PROBLEMS NOT ASSOCIATED WITH NOT HAVING A WATER SOFTENER.
NO HEAT, THE FILTERS HAVE TO BE CLEANED ON THE INTAKE, AND PEOPLE DON'T TAKE CARE OF IT, THEY NEED BACKUP ELECTRIC, OR IT FALLS OUT OF CODE.
CONTROL VALVES NOT WORKING.

CONDENSATE LINES, DIRTY FILTERS
WHEN IT'S LOCATED IN TOO SMALL OF AN AREA; THE AGE OF THE HEAT PUMP; LACK OF MAINTANENCE; WRONG WIRING WAS USED SUCH AS WIRING USED WAS TOO SMALL TO ACCOMMODATE THE EQUIPMENT.
NOISE -- INDUCER MOTOR NOISE, COMPRESSOR NOISE. (W/E) LEAKING (EXP) FITTINGS (W/E) NO
BAD INSTALLATION
NEEDS TO BE FLUSHED, THE GLYCOL NEEDS TO BE FLUSHED. NO ISOLATION VALVE ON THE BOTTOMS OF THE HEATER TO ISOLATE THE PATH, THE DIRECTION OF THE GLYCOL, AND REPLACE THE ISOLATION VALVE.
DIRTY AIR FILTER PLUGGED UP.
COMPRESSOR ISSUES AND FAN NOISE
THE ONE THAT I'VE SEEN THE MOST IS A FAN FAILURE
ELECTRIC ELEMENT GOING BAD, THERMISTERS GOING BAD, ANODE ROD GOING BAD, ALSO HEAT PUMP FAILURE DUE TO LACK OF MAINTENANCE AND ISSUES WITH PC BOARDS.

Wrap up

Table A-14. Most challenging aspect

Q31. Open-ended response: Most challenging aspect
SPACE
EXISTING PLUMBING AND WIRING
IT'S SPACE, THE LOCATION TO BE INSTALLED.
ISSUES WITH EXISTING PIPING.
TIGHT SPACES
TIGHT SPACES, CLOSETS AND CONDITIONED BASEMENTS
EXISTING TANK IS IN CLOSET INSIDE HOME
CUSTOMER PERCEPTION OF COLD AND NOISE
TOO TIGHT A SPACE
MOST OF THE TIME IT'S THE SPACE FOR THEM TO BREATHE PROPERLY, TO DO WHAT IT NEEDS TO DO TO GET FRESH AIR BACK & FORTH. THEY'RE PUT IN ALL KINDS OF SPACES THAT ARE NOT NECESSARILY SET UP FOR A HEAT PUMP.
ISSUE WITH TIGHT SPACES
GETTING AN ELECTRICIAN, VENTING TO OUTSIDE, SIZE/WEIGHT
TIGHT SPACES, INSIDE LIVING SPACE OF HOME.
IT'S PROBABLY BECAUSE THEY'RE TALLER AND YOU HAVE TO REPLUMB THE SERVICE VALVE.
NOISE ISSUES

COLD AIR & NOISE
I THINK THE BIGGEST ISSUE WE FACE IS THE TIGHT SPACES.
RELOCATING PLUMBING
COLD AIR & NOISE
TIGHT SPACES
FROM MY EXPERIENCE, THE #1 ISSUE IS NOISE BECAUSE MOST PEOPLE DON'T WANT TO HEAR IT IN THE MIDDLE OF THE NIGHT.
3) ISSUES WITH COLD AIR AND NOISE
GETTING THEM IN A VERTICAL POSITION. BUT I'D SAY WARM & COLD AIR SPACES.
ISSUES WITH TIGHT SPACES.
PROBABLY PLUMBING
ISSUES WITH TIGHT SPACES.
ISSUES WITH TIGHT SPACES
TIGHT SPACES
THE SIZE OF THE WATER HEATER, IN PARTICULAR THE HEIGHT OF THE WATER HEATER.
WIRING
PLACEMENT
THE VENTING FOR THE HEAT EXHAUST
CONDENSATE DRAINS, NOISE
TIGHT SPACES
COLD AIR AND NOISE.
TIGHT SPACES.
TIGHT SPACE
DUCTING
DUCTING
TIGHT SPACES
DUCTING THE EXHAUST TO THE EXTERIOR OF THE HOME
2) TIGHT SPACES, AND 4) CONDENSATE DRAINAGE.
CONDENSATE DRAINAGE IS ALWAYS A BIT OF A CHALLENGE. BECAUSE MOST OF THESE WATER HEATERS DONT HAVE A CONDENSATE DRAIN ON THEM.
CONDINSATE DRAINAGE ISSUES.
CONDENSATE LINE
LOCATION -- RELOCATING
CONDENSATE DRAINAGE

TIGHT SPACES.
EXISTING PLUMBING
ISSUES WITH COLD AIR AND NOISE
ALL OF THEM, HAS A ROLE IN THE LEVEL OF DIFFICULTY.
CONDENSATE ISSUES

Table A-15. Sources of information

Q32. Other specify: Sources of information or advice (n=11)	Pre-coded category
ASK MY COWORKERS	TALK TO A COLLEAGUE
IN-PERSON FACTORY TRAINING	
FACTORY REP, OR FACTORY TECH SUPPORT.	MANUFACTURER
INSTALLATION MANUAL FOR THE HEAT PUMP WATER HEATER	
PLUMBING SUPPLIER	DISTRIBUTOR
MANUFACTURER REPS	MANUFACTURER
READ THE BOOK THAT COMES WITH IT	
DO A GOOGLE SEARCH.	INTERNET THREADS
MYSELF, BECAUSE I'VE DONE THIS FOR SO LONG. IF I AM EVER STUMPED, I WOULD USE THE INTERNET TO FIND THE ANSWER.	INTERNET THREADS
INSTALLATION MANUAL	
MY WHOLESALER, THEY USUALLY HAVE A GOOD IDEA.	DISTRIBUTOR
LOOK AT THE INSTALLATION MANUALS.	
MY SUPPLIER, THE COMPANIES WE BUY IT FROM	DISTRIBUTOR

Appendix B. Survey Disposition

Working with NEEA staff, the Cadeo team developed a survey instrument to estimate the prevalence of and solutions to the challenging installation scenarios provided to us by NEEA. In addition to understanding specific scenarios we sought to identify the labor hours associated with each solution and the likelihood that an installer would recommend the solution. The survey population was derived from two sources: a list of 635 plumbing, HVAC, and builder contacts provided by NEEA and a list of 2,052 plumbers purchased from Data Axle. We combined the two lists and removed duplicates for a final sample frame of 2,453 records.

The survey began with a soft launch in mid-October and revealed that the survey was too long as programmed and that we would experience challenges in reaching plumber installers by phone. We made programming adjustments to the survey, primarily resulting in plumbers estimating hours only for solutions they were "likely" to recommend. The shortened survey re-launched October 26th within the targeted 15-20 minute time to complete. The phone outreach continued to be a challenge and the response rate remained quite low. To encourage survey completion we made several adjustments:

- We converted the outreach script from a blind outreach to one that named NEEA as the sponsor.
- We increased the respondent incentive from $50 to $100.
- We appended our sample with email addresses and used email outreach to encourage in-bound calling.

These adjustments enabled us to complete the survey with 52 plumber installers before closing the survey on November 30 with a 3% response rate. The final survey disposition is presented in Table B-1.

Table B-1: Final Survey Disposition

Disposition	Count
Complete	52
Refusal	625
No answer/not reached	1322
Screened out/not qualified	156
List error/wrong number	298
Total	**2453**

Appendix C: Sources

Russell Research. *Water Heater Market Characterization Report*. Prepared for NEEA. April 3, 2018. https://neea.org/img/documents/water-heater-market-characterization-report.pdf

Cadeo Group. Northwest Heat Pump Water Heater Initiative Market Progress Evaluation Report #3. Prepared for NEEA. October 31, 2017. https://neea.org/resources/northwest-heat-pump-water-heater-initiative-market-progress-evaluation-report-3

NMR Group. Northwest Heat Pump Water Heater Initiative Market Progress Evaluation Report #5. Prepared for NEEA. November 4, 2019. https://neea.org/resources/northwest-heat-pump-water-heater-initiative-market-progress-evaluation-report-5

Owl Research Partners. Heat Pump Water Heaters: Market Research Synthesis. Prepared for NEEA. July 2019.

Cadmus Group. Residential Building Stock Assessment. Prepared for NEEA. Published 2018, updated April 2019. https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf

Appendix D: Survey Instrument

51618 NEEA - HPWH Challenging Install Research

Updated DRAFT Installer Survey 10/27/2020

Descriptor	This Instrument
Instrument Type	Phone/mixed mode survey
Estimated Time to Complete	20-30-minute survey
Population Description	Plumber/water heater installers
Contact List	NEEA provided + purchased sample
Completion target	60- 68 installers **[GLOBAL QUOTA]**
Type of Sampling	Regional sample, stratified by state based on population distribution Target sample distribution: **[SOFT QUOTA]** ID=8 MT=5 OR=20 WA=34
Contact Sought	At least two years installation experience and installed at least 5 heat pump water heaters.
Recruiting and Hosting Firm	Blackstone Group

5.2 Outreach & Screening

[PROG: PROGRAMMING STARTS HERE – WITH INTRO]

Thank you for talking with me today. I'm with the Blackstone Group, an independent research firm. We are conducting research to understand experiences related to installing residential water heaters. We are not selling anything, and your responses will be kept confidential. We are very interested in hearing installer perspectives on the challenges they face when installing water heaters, particularly heat pump water heaters. This survey should last about 20-25 minutes. We are offering a $50 Amazon gift card to those who complete the survey.

(INTERVIEWERS: IF NEEDED: YOUR PERSPECTIVE IS EXTREMELY VALUABLE TO OUR RESEARCH AND WILL HELP INFORM EFFECTIVE SOLUTIONS TO CHALLENGING INSTALLATIONS. [ALSO IF NEEDED, REPEAT: WE ARE NOT SELLING ANYTHING. YOUR RESPONSES WILL BE KEPT CONFIDENTIAL AND RESULTS AGGREGATED FOR REPORTING.])

FOR ANY INTERESTED PLUMBERS, SAY: Great! Let's make sure you are qualified to participate.

5.3 Screening Questions

This call may be monitored and/or recorded for quality or training purposes. With your permission may I record this call?

1. Yes
2. No

[CONTINUE TO C1]

C1: For safety reasons, have I reached you on a cell phone?
1. Yes **[ASK C2]**
2. No **[GO TO S1]**
99. REFUSED **[TERMINATE]**

[IF TERMINATED FOR CELL PHONE READ: Thank you for your time. This concludes the survey]

C2. Are you driving or doing anything else that requires your focused attention?

1. Yes [SET SOFT CALL BACK AND READ: Due to safety reasons, we will need to call you back at a more convenient time. Thank you.]
2. No **[GO TO S1]**
99. REFUSED **[TERMINATE]**

[IF TERMINATED FOR CELL PHONE READ: Thank you for your time. This concludes the survey]

S1. Do you install water heaters in existing residential homes in your current role at your company? **[REQUIRED: WATER HEATER INSTALLATION EXPERIENCE]**

a. Yes
b. No **[GO TO S0]**

S0. **[If QS1= B - the CONTACT IS NOT AN INSTALLER]** At this time we are interested in hearing from installers about their experiences. Can you refer me to someone at your firm who currently installs water heaters?

[INTERVIEWER: IF RESPONDENT ON PHONE DOES NOT QUALIFY/TERMINATES, BUT PROVIDES A REFERRAL, MAKE SURE TO CAREFULLY RECORD IN INTERVIEWER NOTES BOTH THE NAME OF "TERMINATED RESPONDENT" (SO THAT YOU KNOW WHO CANNOT BE TALKED TO AGAIN) AND THE "REFERRAL NAME/NUMBER" (TO KNOW WHO TO ASK FOR ON CALLBACK)]

1. **[IF RESPONDENT PROVIDES REFERRAL, COLLECT CONTACT INFORMATION THEN PROCEED TO "CALLBACK" SETUP SCREEN]**

2. **[NO REFERRAL GIVEN/REFUSES TO GIVE NAME: GO TO TERMINATE TEXT AS SHOWN HERE]**

   TERMINATE TEXT: Thank you for your time and have a great day!

S2. For how many years have you been involved in installing water heaters? _____ yrs **[MUST EQUAL 2 YEARS OR MORE, ELSE GO TO "SCREEN-OUT TEXT" SCREEN]**

[IF SCREEN-OUT]

We are sorry. Unfortunately, you do not qualify for this research project at this time. Do you know of anyone in your firm who would meet these qualifications (e.g., 2 years installation experience and at least 2 Heat Pump Water Heater installs in the last 5 years)? Would you mind sharing their contact information?

INTERVIEWER: IF RESPONDENT ON PHONE DOES NOT QUALIFY/TERMINATES, BUT PROVIDES A REFERRAL, MAKE SURE TO CAREFULLY RECORD IN INTERVIEWER NOTES BOTH THE NAME OF "TERMINATED RESPONDENT" (SO THAT YOU KNOW WHO CANNOT BE TALKED TO AGAIN) AND THE "REFERRAL NAME/NUMBER" (TO KNOW WHO TO ASK FOR ON CALLBACK)

1. **[IF RESPONDENT PROVIDES REFERRAL, COLLECT CONTACT INFORMATION: PROCEED TO "CALLBACK" SETUP SCREEN]**
2. **[NO REFERRAL GIVEN/REFUSES TO GIVE NAME: GO TO TERMINATE TEXT AS SHOWN HERE]**

   TERMINATE TEXT: Thank you for your time and have a great day!

S3. How many **heat pump water heaters**, specifically, have you installed, in total? _____ **[MUST HAVE INSTALLED AT LEAST 3 HPWHs ELSE TERMINATE: GO TO "SCREEN-OUT TEXT" SCREEN]**

[IF SCREEN-OUT]

We are sorry. Unfortunately, you do not qualify for this research project at this time. Do you know of anyone in your firm who would meet these qualifications (e.g., 2 years installation experience and at least 2 Heat Pump Water Heater installs in the last 5 years)? Would you mind sharing their contact information?

INTERVIEWER: IF RESPONDENT ON PHONE DOES NOT QUALIFY/TERMINATES, BUT PROVIDES A REFERRAL, MAKE SURE TO CAREFULLY RECORD IN INTERVIEWER NOTES BOTH THE NAME OF "TERMINATED RESPONDENT" (SO THAT YOU KNOW WHO CANNOT BE TALKED TO AGAIN) AND THE "REFERRAL NAME/NUMBER" (TO KNOW WHO TO ASK FOR ON CALLBACK)

1. **[IF RESPONDENT PROVIDES REFERRAL, COLLECT CONTACT INFORMATION THEN PROCEED TO "CALLBACK" SETUP SCREEN]**
2. **[NO REFERRAL GIVEN/REFUSES TO GIVE NAME: GO TO TERMINATE TEXT AS SHOWN HERE]**

   TERMINATE TEXT: Thank you for your time and have a great day!

[IF PASSED SCREEN]

It sounds like your experience makes you a good fit for our research. Let's move forward with the survey questions. This should take about 20 minutes; we will email you a 50-dollar electronic Amazon gift card after you complete the survey.

5.4 Survey

1. First, about how many hours does it take you on average to install a **typical water heater**? **[NUMERICAL OPEN TEXT]**

2. And how many hours does it take to install a **heat pump water heater**? **[NUMERICAL OPEN TEXT]**

Installers run into a variety of challenges when installing new water heaters in existing homes, and those challenges may be different when installing heat pump water heaters. We'd like to hear about your experience with and solutions for some of the challenges you have likely faced.

3. Challenges in heat pump water heater installations can be affected by location. Using a 1-to-5 scale, where 1=not at all likely, and 5=extremely likely, how likely are you to recommend installing a heat pump water heater in a…..... **[INTERVIEWER DIRECTION: READ EACH ITEM AND CONFIRM CHOICE WHEN RESPONDENT ANSWERS.] [PROGRAMMER: RANDOMIZE RESPONSE OPTIONS; USE GRID.]**
    a. Basement **{Enter rating}**
    b. Utility Room **{Enter rating}**
    c. Garage **{Enter rating}**
    d. Closet in main house **{Enter rating}**
    e. Other **[OTHER SPECIFY] [ADD TEXT BOX] {Enter rating}**

5.4.1 [Existing plumbing or wiring]

Thinking about your installation experiences related to **existing plumbing or wiring…**

4. What percentage of homes in your area are likely to have issues associated with existing wiring during an installation of a heat pump water heater? ___**%** **[ALLOW 0-100; NO RANGES]**

5. What percentage of homes in your area are likely to have issues associated with existing plumbing during an installation of a heat pump water heater? ___**%** **[ALLOW 0-100; NO RANGES]**

6. Using a 1-to-5 scale, where 1=not at all difficult and 5=extremely difficult, typically, how difficult is it for you to overcome…. **[INTERVIEWER DIRECTION: READ EACH ITEM AND CONFIRM CHOICE WHEN RESPONDENT ANSWERS.]**
    a. Issues with existing wiring during an installation? **{Enter rating}**
    b. Issues with existing plumbing configuration? **{Enter rating}**

7. There are several options available to address issues with existing **wiring** On a 1-to-5 scale where 1=not at all likely and 5=extremely likely, how likely are you to choose each option? **[INTERVIEWER DIRECTION: READ EACH ITEM AND CONFIRM CHOICE WHEN RESPONDENT ANSWERS.] [PROGRAMMER: RANDOMIZE RESPONSE OPTIONS "A" AND "B"; "OTHER SPECIFY" OPTIONS SHOULD ALWAYS BE "NEXT TO LAST"; "RECOMMEND AGAINST" OPTION SHOULD ALWAYS "ANCHOR"/BE SHOWN LAST]**

   A1. Use longer pigtail that is still within code length limit **{Enter rating}**

   B1. Have electrician extend circuit **[{Enter rating}**

   C1. Any other solution? **(OTHER SPECIFY #1) [ADD TEXT BOX] {Enter rating}**

   D1. **[THERE IS NO "D" ATTRIBUTE]**

   E1. Recommend against installing a heat pump water heater **{Enter rating}**

   [PROG: IF RESPONSES TO A1-C1 = 4 OR 5, ASK THE FOLLOWING]

   How many hours does it take to do each of these, on average?

   A2. Use longer pigtail that is still within code length limit **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

   B2. Have electrician extend circuit **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

   C2. **(OTHER SPECIFY #1) [NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION] [WHEN SHOWING C2, PLEASE PIPE IN THE ACTUAL VERBATIM RESPONSE FROM C1 INSTEAD OF "ANY OTHER SOLUTION"]**

8. There are also options available to address issues with existing **plumbing** when installing a heat pump water heater. How likely are you to use the following solutions to overcome a plumbing issue? Please rate how likely you would be to choose each solution on a scale from 1 to 5, where 1=not at all likely and 5=extremely likely. **[INTERVIEWER DIRECTION: READ EACH ITEM AND CONFIRM CHOICE WHEN RESPONDENT ANSWERS.] [PROGRAMMER: RANDOMIZE RESPONSE OPTIONS "A" AND "B"; "OTHER SPECIFY" OPTIONS SHOULD ALWAYS BE "NEXT TO LAST"; "RECOMMEND AGAINST" OPTION SHOULD ALWAYS "ANCHOR"/BE SHOWN LAST]**

   A1. Reconfigure pipes to match new water heater connections **{Enter rating}**

   B1. Select a different heat pump water heater with matching pipe connections **{Enter rating}**

   C1. Any other solution? **(OTHER SPECIFY #1) [ADD TEXT BOX] {Enter rating}**

   D1. **[THERE IS NO "D" ATTRIBUTE]**

   E1. Recommend against installing a heat pump water heater **{Enter rating}**

[PROG: IF RESPONSES TO A1-C1 = 4 OR 5, ASK THE FOLLOWING]

How many hours does it take to do each of these, on average?

A2. Reconfigure pipes to match new water heater connections **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

B2. Select a different heat pump water heater with matching pipe connections **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

C2. **(OTHER SPECIFY #1) [ADD TEXT BOX] [NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION] [WHEN SHOWING C2, PLEASE PIPE IN THE ACTUAL VERBATIM RESPONSE FROM C1 INSTEAD OF "ANY OTHER SOLUTION"]**

5.4.2 [Tight Spaces]

My next set of questions are related to challenging heat pump water heater installations in **tight spaces**, for example, when a new heat pump water heater won't fit, the space is too small to work in, or the space might get too cold for a heat pump water heater to work properly.

9. What percentage of homes in your area are likely to have issues associated with insufficient space for a heat pump water heater? ___**%** **[ALLOW 0-100; NO RANGES]**

10. Using a 1-to-5 scale, where 1=not at all difficult and 5=extremely difficult, typically how difficult it is to solve issues that emerge when a heat pump water heater won't fit easily in the existing space?
    a. **{Record response}**

11. There are several options available to overcome challenges when **the heat pump water heater won't fit easily in existing space**. Please rate how likely you would be to choose each solution, using the 1-to-5 scale, where 1=not at all likely and 5=extremely likely**. [INTERVIEWER DIRECTION: READ EACH ITEM AND CONFIRM CHOICE WHEN RESPONDENT ANSWERS.] [PROGRAMMER: RANDOMIZE RESPONSE OPTIONS "A", "B" AND "C''; "OTHER SPECIFY" OPTIONS SHOULD ALWAYS BE "NEXT TO LAST"; "RECOMMEND AGAINST" OPTION SHOULD ALWAYS "ANCHOR"/BE SHOWN LAST]**

    A1. Install a smaller water heater? **{Enter rating}]**

    B1. Use a higher set point and install a mixing valve? **{Enter rating}**

    C1. Relocating the water heater? **{Enter rating}**

    D1. Any other solution? **(OTHER SPECIFY #1) [ADD TEXT BOX] {Enter rating}**

    E1. **[THERE IS NO "E" ATTRIBUTE]**

    F1. Recommend against installing a heat pump water heater? **{Enter rating}**

[PROG: IF RESPONSES TO A1-D1 = 4 OR 5, ASK THE FOLLOWING]

How many hours does it take to do each of these, on average?

A2. Install a smaller water heater? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

B2. Use a higher set point and install a mixing valve? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

C2. Relocating the water heater? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

D2. **(OTHER SPECIFY #1) [ADD TEXT BOX] [NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION] [WHEN SHOWING D2, PLEASE PIPE IN THE ACTUAL VERBATIM RESPONSE FROM D1 INSTEAD OF "ANY OTHER SOLUTION"**

12. Small, unventilated spaces can be a particular problem when installing **heat pump water heaters** because the accumulation of **cold air** can affect the performance of the equipment. Thinking about the homes in your area, what percentage are likely to have issues about cold air? __%

13. Using a 1-to-5 scale, where 1=not at all difficult and 5=extremely difficult, typically how difficult it is to address concerns that a space might get too cold for the heat pump water heater to work properly?
    a. **{Record response}**

14. There are options available to address issues with **cold air in a small space**. For each, I will your likelihood to choose that solution, using the 1-to-5 scale, where 1=not at all likely and 5=extremely likely**. [INTERVIEWER DIRECTION: READ EACH ITEM AND CONFIRM CHOICE WHEN RESPONDENT ANSWERS.] [PROGRAMMER: RANDOMIZE RESPONSE OPTIONS "A", "B", "C" AND "D''; "OTHER SPECIFY" OPTIONS SHOULD ALWAYS BE "NEXT TO LAST"; "RECOMMEND AGAINST" OPTION SHOULD ALWAYS "ANCHOR"/BE SHOWN LAST]**

    A1. Add transfer grills, or louvered doors or similar? **{Enter rating}**

    B1. Duct out exhaust or supply air? **{Enter rating}**

    C1. Relocate water heater? **{Enter rating}**

    D1. Install it anyway, as planned **{Enter rating}**

    E1. Another option? **(OTHER SPECIFY #1) [ADD TEXT BOX] {Enter rating}**

    F1. **[THERE IS NO "F" ATTRIBUTE]**

    G1. Recommend against installing a heat pump water heater? **{Enter rating}**

[PROG: IF RESPONSES TO A1-E1 = 4 OR 5, ASK THE FOLLOWING]

How many hours does it take to do each of these, on average?

A2. Add transfer grills, or louvered doors or similar? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

B2. Duct out exhaust or supply air? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

C2. Relocate water heater? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

D2. Install it anyway, as planned **(OTHER SPECIFY #1) [ADD TEXT BOX] [NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

E2. **(OTHER SPECIFY #1) [ADD TEXT BOX] [NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION] [WHEN SHOWING E2, PLEASE PIPE IN THE ACTUAL VERBATIM RESPONSE FROM E1 INSTEAD OF "ANY OTHER SOLUTION"]**

5.4.3 [Potential for poor occupant experience]

I'd like to ask specifically about **heat pump water heater installations** where the water heater might affect occupant comfort — primarily from exposure to noise or cold air.

15. Please rate the difficulty of each location using a 1 to 5 scale, where 1 = not at all difficult and 5 = extremely difficult. How difficult is it to address concerns about **noise or cold air** when the water heater needs to be installed in….. **[INTERVIEWER DIRECTION: READ EACH ITEM AND CONFIRM CHOICE(S) WHEN RESPONDENT ANSWERS.]**
    a. A basement? **{Enter rating}**
    b. A utility room? **{Enter rating}**
    c. A garage? **{Enter rating}**
    d. A closet in the main house? **{Enter rating}**

16. Thinking about the homes in your area, what percentage are likely to have issues associated with occupant concerns about noise? (Record percent) **[ALLOW 0-100; NO RANGES]**

17. There are several options available to address concerns about **noise.** For each, I will ask your likelihood to choose that solution, using the 1-to-5 scale, where 1=not at all likely and 5=extremely likely. **[INTERVIEWER DIRECTION: READ EACH ITEM AND CONFIRM CHOICE WHEN RESPONDENT ANSWERS.] [PROGRAMMER: RANDOMIZE RESPONSE OPTIONS "A", "B", "C" AND "D''; "OTHER SPECIFY" OPTIONS SHOULD ALWAYS BE "NEXT TO LAST"; "RECOMMEND AGAINST" OPTION SHOULD ALWAYS "ANCHOR"/BE SHOWN LAST]**

    A1. Install rubber standoffs to reduce noise when heater is strapped to a wall? **{Enter rating}**

    B1. Insulate surfaces around water heater for noise? **{Enter rating}**

    C1. Attach a short duct to redirect noise? **{Enter rating}**

D1. Relocate the water heater? **{Enter rating}**

E1. Another solution we didn't mention? **(OTHER SPECIFY #1) [ADD TEXT BOX] {Enter rating}**

F1. **[THERE IS NO "F" ATTRIBUTE]**

G1. Recommend against installing a heat pump water heater? **{Enter rating}**

[PROG: IF RESPONSES TO A1-E1 = 4 OR 5, ASK THE FOLLOWING]

How many hours does it take to do each of these, on average?

A2. Install rubber standoffs to reduce noise when heater is strapped to a wall? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

B2. Insulate surfaces around water heater for noise? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

C2. Attach a short duct to redirect noise? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

D2. Relocate the water heater? **(OTHER SPECIFY #1) [ADD TEXT BOX] [NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

E2. Another solution we didn't mention? **(OTHER SPECIFY #1) [ADD TEXT BOX] [NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION] [WHEN SHOWING E2, PLEASE PIPE IN THE ACTUAL VERBATIM RESPONSE FROM E1 INSTEAD OF "ANY OTHER SOLUTION"]**

[COLD AIR]

18. Thinking about the homes in your area, what percentage are likely to have issues associated with occupant concerns about cold air? (Record percent) **[ALLOW 0-100; NO RANGES]**

19. There are several options available to address concerns about **cold air.** For each, I will ask your likelihood to choose that solution, using the 1-to-5 scale, where 1=not at all likely and 5=extremely likely. **[INTERVIEWER DIRECTION: READ EACH ITEM AND CONFIRM CHOICE WHEN RESPONDENT ANSWERS.] [PROGRAMMER: RANDOMIZE RESPONSE OPTIONS "A" AND "B"; "OTHER SPECIFY" OPTIONS SHOULD ALWAYS BE "NEXT TO LAST"; "RECOMMEND AGAINST" OPTION SHOULD ALWAYS "ANCHOR"/BE SHOWN LAST]**

A1. Duct out exhaust or supply air? **{Enter rating}**

B1. Relocating the water heater? **{Enter rating}**

C1. Another solution we didn't mention? **(OTHER SPECIFY #1) [ADD TEXT BOX] {Enter rating}**

D1. **[THERE IS NO "D" ATTRIBUTE]**

E1. Recommending against installing a heat pump water heater? **{Enter rating}**

[PROG: IF RESPONSES TO A1-C1 = 4 OR 5, ASK THE FOLLOWING]

How many hours does it take to do each of these, on average?

A2. Duct out exhaust or supply air? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

B2. Relocating the water heater? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

C2. **(OTHER SPECIFY #1) [ADD TEXT BOX] [NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION] [WHEN SHOWING C2, PLEASE PIPE IN THE ACTUAL VERBATIM RESPONSE FROM C1 INSTEAD OF "ANY OTHER SOLUTION"]**

5.4.4 [Condensate Drainage]

We are also interested in learning how you've overcome challenges associated with draining condensate from heat pump water heaters, including finding a place to drain the condensate or condensate freezing that may occur in cold months.

20. Approximately what percentage of the homes in your area are likely to have issues associated with condensate drainage? (Record percent) **[ALLOW 0-100; NO RANGES]**

21. Using a 1-to-5 scale, where 1=not at all difficult and 5=extremely difficult, typically how difficult it is to solve issues associated with limited access to drainage?
    a. **{Record response}**

22. There are several options when facing issues related to **the drain location.** I will your likelihood to choose that solution, using the 1-to-5 scale, where 1=not at all likely and 5=extremely likely. **[INTERVIEWER DIRECTION: READ EACH ITEM AND CONFIRM CHOICE WHEN RESPONDENT ANSWERS.] [PROGRAMMER: RANDOMIZE RESPONSE OPTIONS "A", "B" AND "C''; "OTHER SPECIFY" OPTIONS SHOULD ALWAYS BE "NEXT TO LAST"; "RECOMMEND AGAINST" OPTION SHOULD ALWAYS "ANCHOR"/BE SHOWN LAST]**

    A1. Let gravity drain directly to existing drain in same space? **{Enter rating}**

    B1. Install a condensate pump? **{Enter rating}**

    C1. Drill through existing wall to plumb to drain?

    D1. Another solution we didn't mention? **(OTHER SPECIFY #1) [ADD TEXT BOX] {Enter rating}**

    E1. **[THERE IS NO "F" ATTRIBUTE]**

    F1. Recommend against installing a heat pump water heater? **{Enter rating}**

[PROG: IF RESPONSES TO A1-D1 = 4 OR 5, ASK THE FOLLOWING]

How many hours does it take to do each of these, on average?

A2. Let gravity drain directly to existing drain in same space? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

B2. Install a condensate pump? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

C2. Drill through existing wall to plumb to drain? **(OTHER SPECIFY #1) [ADD TEXT BOX] [NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

D2. **(OTHER SPECIFY #1) [ADD TEXT BOX] [NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION] [WHEN SHOWING D2, PLEASE PIPE IN THE ACTUAL VERBATIM RESPONSE FROM D1 INSTEAD OF "ANY OTHER SOLUTION"]**

23. Have you ever piped condensate so that it drains to the exterior of a home?
    a. Yes
    b. No **[Skip to Q26]**
    c. Don't know **[Skip to Q26]**

24. **[If Q23 =A]** Using a 1-to-5 scale, where 1=not at all difficult and 5=extremely difficult, how difficult is it to address concerns about condensate freezing or getting blocked when drained to the exterior?
    a. {Record response}

25. **[ASK IF Q23 = A]** There are several options available to avoid **condensate freezing or becoming blocked** when drained to the exterior. I will ask your likelihood to choose that solution, using the 1-to-5 scale, where 1=not at all likely and 5=extremely likely. **[INTERVIEWER DIRECTION: READ EACH ITEM AND CONFIRM CHOICE WHEN RESPONDENT ANSWERS] [PROGRAMMER: RANDOMIZE RESPONSE OPTIONS "A" AND "B''; "OTHER SPECIFY" OPTIONS SHOULD ALWAYS BE "NEXT TO LAST"; "RECOMMEND AGAINST" OPTION SHOULD ALWAYS "ANCHOR"/BE SHOWN LAST]**

A1. Add heat trace? **{Enter rating}**

B1. Relocate to interior drain? **{Enter rating}**

C1. Another solution we didn't mention? **(OTHER SPECIFY #1) [ADD TEXT BOX] {Enter rating}**

D1. **[THERE IS NO "D" ATTRIBUTE]**

E1. Recommend against installing a heat pump water heater? **{Enter rating}**

[PROG: IF RESPONSES TO A1-C1 = 4 OR 5, ASK THE FOLLOWING]

How many hours does it take to do each of these, on average?

A2. Add heat trace **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

B2. Relocate to interior drain? **[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION]**

C2. **(OTHER SPECIFY #1) [ADD TEXT BOX] [NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES; ALSO OFFER "DON'T KNOW" OPTION] [WHEN SHOWING C2, PLEASE PIPE IN THE ACTUAL VERBATIM RESPONSE FROM C1 INSTEAD OF "ANY OTHER SOLUTION"]**

5.4.5 [Serviceability]

26. Do you offer maintenance services for heat pump water heaters?
    a. Yes
    b. No **[Skip to Q31]**
    c. Not sure **[Skip to Q31]**

27. Do you repair heat pump water heaters that you or your company did **NOT** originally install?
    a. Yes
    b. No
    c. Not sure

28. Thinking about the heat pump water heater repairs that you've worked on…
    a. What percentage have been under warranty? **___% [ALLOW 0-100; NO RANGES]**
    b. What percentage reflect an installation issue? **___% [ALLOW 0-100; NO RANGES]**
    c. And what portion of the time do you recommend replacing the equipment? **___% [ALLOW 0-100; NO RANGES]**

29. What are the primary reasons for service calls on heat pump water heaters? **[OPEN END TEXT BOX]**

30. Do heat pump water heaters require more, less or about equal maintenance to a standard water heater?
    a. More maintenance
    b. Equal maintenance
    c. Less maintenance

5.4.6 [Wrap-up]

31. Thinking about the challenges discussed previously, which is the hardest to overcome when installing heat pump water heaters? **[OPEN END TEXT BOX] [Interviewer direction: if needed, remind respondent of challenges discussed including (1) existing plumbing and wiring, (2) issues with tight spaces, (3) issues with cold air and noise, (4) condensate drainage issues]**

32. Where do you personally go when you need advice on installation solutions for heat pump water heaters? **[INTERVIEWERS: READ ATTRIBUTES]** **[PROG: MULTI-PUNCH QUESTION; GRID FORMAT WITH "YES/NO" RESPONSE OPTIONS FOR EACH ATTRIBUTE]**
    a. Manufacturer tech support
    b. Manufacturer training video
    c. Distributor expertise
    d. Internet threads (e.g., Reddit, blogs, chatrooms)
    e. Online training videos (e.g., YouTube)
    f. Talk to a colleague
    g. Talk to experts in area
    h. Other **[SPECIFY] [ADD TEXT BOX]**

5.4.7 [Firmographics]

To wrap-up I have a few questions about your firm.

33. What is the 5-digit zip code for your location where you work? _ _ _ _ _ **[NUMERICAL OPEN TEXT]** **[Interviewer Direction: May also accept City and State if zip code not available]** **[PROG: MAIN RESPONSE OPTION SHOULD BE ZIP CODE TEXT BOX, BUT ALSO ADD RESPONSE OPTION TEXT BOX FOR "CITY & STATE"] [PROG: DO NOT FORCE RESPONSE OPTIONS]**

34. Including yourself, how many employees work at your location? ____**[NUMERICAL OPEN TEXT; ALLOW 1-999; NO RANGES]**

35. Roughly, how many water heater installations does your firm do a year? _____ installations **[NUMERICAL OPEN TEXT; ALLOW 1-9999; NO RANGES]** **[INTERVIEWER DIRECTION: IF FIRM HAS MULTIPLE LOCATIONS, ASK ONLY ABOUT THE LOCATION THEY WORK AT]**

36. What percentage of these installations are heat pump water heaters? ____% **[NUMERICAL/PERCENTAGE OPEN TEXT; ALLOW 0-100; NO RANGES]**

5.4.8 Closing

37. Are you willing to be re-contacted for additional research about your experience? You would be compensated for your time.
    a. Yes
    b. No

Those are all the questions I have for you today. What is the best email address to send your $50 Amazon gift card?

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REPORT #E23-461

OTS Appendix: Heat Pump Water Heater Market Research - Challenging Installation Scenarios

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Contents

1 Introduction

Heat pump water heaters (HPWHs) present a significant opportunity for energy savings for US households given their superior energy efficiency over electric resistance and gas-fired units. Higher first costs, however, have thus far presented a barrier for widespread adoption for many consumers. In addition, HPWHs often present additional challenges to installation compared to conventional electric resistance water heater replacements.

In 2010, the U.S. Department of Energy (DOE) issued a rulemaking on water heating products that went into effect in 2015 (10 CFR 430, 2010). The rule sought to consider the wide-ranging impacts of different efficiency standards on consumers, manufacturers, utilities and the US economy. DOE's technical support documents for this rulemaking assessed the various lifetime costs of HPWHs, including first costs and operational costs throughout the product lifetime. First costs include both the cost of the HPWH itself as well as the labor to install it, which can include a range of challenges the installer must overcome.

DOE's previous analysis made several assumptions about the likelihood and expense of potential installation challenges. Many of these assumptions were approximate and not based on nationwide data collection efforts; nevertheless, basis exists in expert opinions and experiences. Determining realistic installation costs for HPWHs is important since these first costs have a significant impact on lifetime cost-effectiveness.

To address this critical knowledge gap in the HPWH market, the Northwest Energy Efficiency Alliance (NEEA) commissioned a study in 2020 to evaluate challenging installation scenarios for HPWHs. After working with installers and water heating experts to characterize specific installation challenges and solutions, a mixed-mode market survey was conducted with over 100 experienced installers in the Northwest and Southeast regions of the United States. The responses from the survey provide insights into installers' perspectives on challenges, their preferred solutions, and the time required to resolve them. The survey results have previously been used for NEEA program purposes and only recently have been analyzed in the context of understanding challenges in a broader, national market. In general, the findings support DOE's original assumptions and suggest possible regional variations in the types and frequency of installation challenges. The key findings from NEEA's study compared to DOE's assumptions are summarized herein.

2 Background

Cadeo Group conducted the NEEA-commissioned research on challenging installations for HPWHs in 2020 and finalized it in Spring 2021[1,2]. The goal of this study was to identify challenges faced by HPWH installers, the prevalence of those challenges and possible solutions for future implementation.

Cadeo initiated its research by conducting a review of existing data, a virtual focus group of installers, and interviews with four HPWH manufacturers.

Following the initial data review and interviews, Cadeo's research next focused on conducting a survey of over 100 plumbers familiar with HPWH installation in the Northwest and Southeast regions of the US. A total of 52 survey respondents participated in the Northwest (Oregon, Washington, Montana and Idaho) with an additional 52 participants in the Southeast (Florida and Georgia). Of the survey respondents in the Northwest region, 66% reported having installed at least 10 HPWHs in the last two years, with 31% having installed 30 or more. In the Southeast region, 73% of respondents had installed at least 10 HPWHs and 42% had installed more than 30 in the last two years. This report is a synthesis of Cadeo's survey results intended to highlight key measures of HPWH installation challenges and present them in context with assumptions made by DOE in water heater rulemakings.

Surveys of this type are by no means a perfect tool for making precise estimates about the prevalence and severity of challenges in a complex installation process. The need for brevity in conducting the survey, classification of problems and solutions into fixed categories, and the tendency to estimate likelihood and labor using "round numbers" will lead to approximations that do not necessarily reflect the exact experience of installing every individual HPWH. Nevertheless, the survey results provide useful, actionable findings to fill a significant gap in understanding the HPWH market.

[1] Moran, D., Starkey, A., & Suzuki, J. (2021a). *Heat Pump Water Heater Market Research: Challenging Installations Scenarios*. Cadeo Group.
[2] Moran, D., Starkey, A., & Suzuki, J. (2021b). *Heat Pump Water Heater Market Research: Challenging Installations Scenarios: Southeast States Survey Results*. Cadeo Group.

3 Installation Challenges

DOE's recent preliminary technical support document for the proposed consumer water heater rulemaking makes assumptions about installation challenges that are essentially the same as in the 2010 rulemaking.[3] These include:

1. An average of one hour of labor is added to HPWH installations relative to conventional electric resistance installations.
2. 25% of HPWHs will require a condensate pump.
3. 40% of homes will have space constraints.
    a. Half (20%) will select a smaller water heater with a higher setpoint and mixing valve;
    b. Half (20%) will require door jamb removal and replacement with a louvered door (Due to the HPWH's increased insulation and/or need for air exchange).
4. One-third (33%) of installations are estimated to experience significant indoor cooling and require venting.[4]

3.1 Installation Time

Survey respondents confirmed that on average, a HPWH requires more time to install than a "typical" electric resistance product. Table 1 shows the mean and median installation times for the Northwest and Southeast regions of typical water heater replacements compared to a HPWH. These results are consistent among respondents and across regions with little variability, as Figure 1 shows.

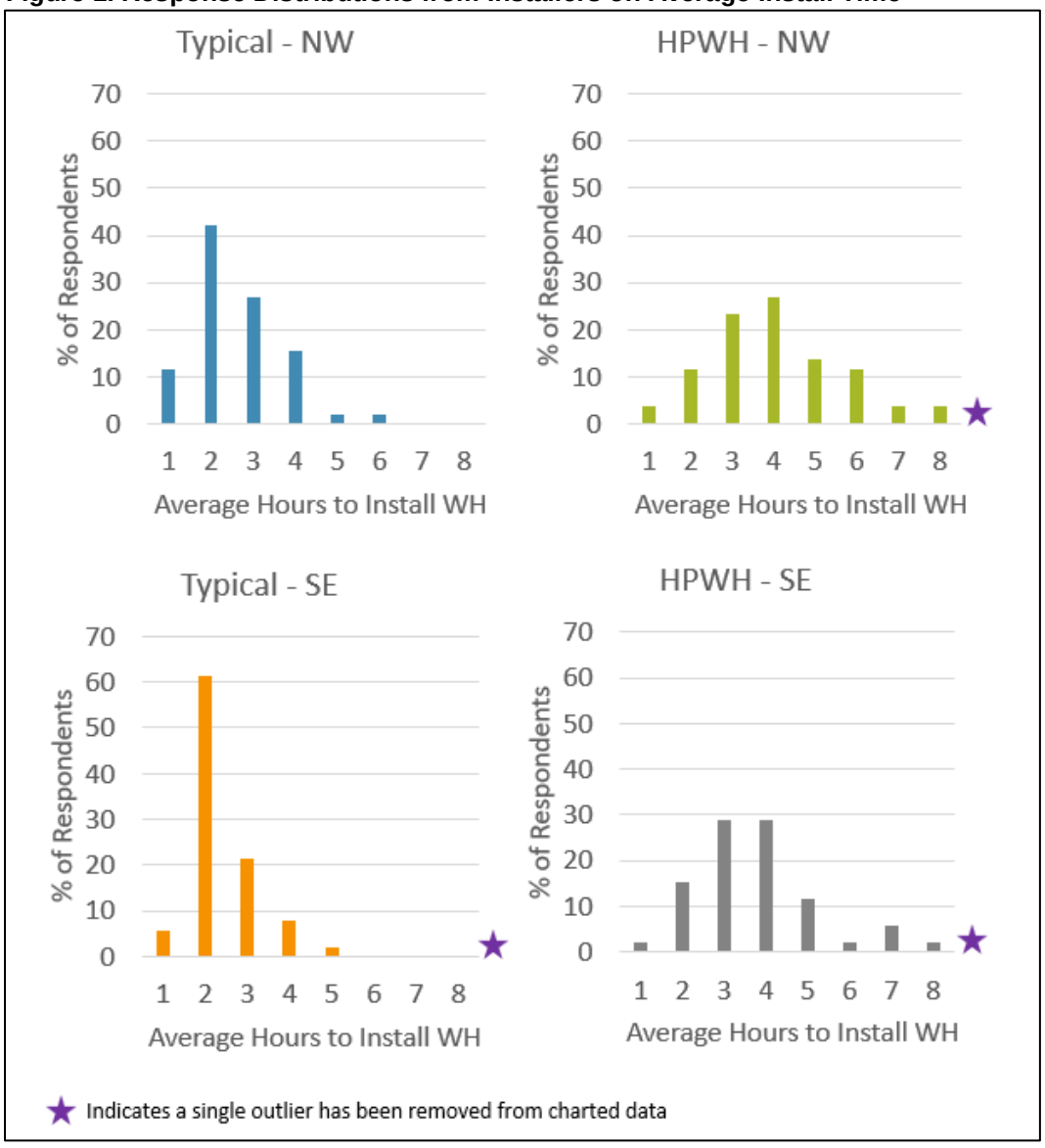
Table 1. Average Installation Time (hrs) for Typical Electric Resistance Water Heater Replacements vs. HPWHs [12]

	Northwest		Southeast	
Water Heater Type	Mean	Median	Mean	Median
Typical Replacement (hrs)	2.6	2.0	2.6	2.0
HPWH (hrs)	4.2	4.0	3.9	4.0

[3] U.S. DOE. 2022. *Preliminary Analysis Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Consumer Water Heaters.* 7 March 2022. Docket # EERE-2017-BT-STD-0019. https://www.regulations.gov/document/EERE-2017-BT-STD-0019-0018.

[4] Note that this is a higher value than DOE's 2010 rulemaking, which considered only homes where cooling loads exceeded 10% of the home's heating load (about 14% of installs).

Figure 1. Response Distributions from Installers on Average Install Time



This result -indicates that HPWHs require more labor than conventional electric resistance products due to a variety of installation challenges, but that the difference is only two hours or less on average. This finding appears well-aligned with DOE's assumption that a HPWH requires one additional hour of labor, and in some cases additional labor for installation challenges.

A "typical" installation is considered a like-for-like replacement, but a HPWH installation is necessarily different from the existing conventional water heater and sometimes requires changes in installation configuration. This is a one-time challenge; once a HPWH is installed, future replacements should require installation time closer to "typical" installation time because they will also represent a like-for-like replacement.

The new configuration with HPWHs introduces a higher likelihood of encountering installation challenges. Because integrated HPWHs are larger in size, may have different plumbing tap locations, require sufficient airflow to the evaporator, and have the potential to produce noise, cold air and condensate, they may require additional measures to facilitate installation in place of an existing electric resistance water heater.

3.2 Condensate Pump

HPWHs use a vapor compression system to operate, generating condensate on the evaporator, which should be drained away from the unit. HPWHs may be installed in basements, garages or mechanical closets that may or may not have direct access to a water drain or other appropriate outlet for condensate water. As such, a condensate pump or a longer drain line may be required to move the collected water away from the unit for proper disposal. As noted above, DOE assumed that one in every four HPWH installations (25%) would require a condensate pump.

Surveyed installers noted that condensate could be an issue in a variety of locations; however, the majority of condensate issues can often be addressed by drilling a hole through an existing wall to run a drain line and/or to let gravity drain directly to an existing drain. Installers agree that a condensate pump is required in some cases. While DOE assumed that 25% of homes would require a condensate pump, installers in the Southeast and Northeast estimated respective averages of 26% and 46% of homes would have *some* issue with condensate, a smaller proportion of which might require a condensate pump; many others could be resolved more easily with a gravity drain. For cases in which a condensate pump is required, respondents estimated average labor time between 1.3–1.8 hours.

Table 2. DOE Assumptions and Survey Responses Regarding Condensate Drainage Installation Challenges[123]

	DOE Assumption	Northwest Survey	Southeast Survey	Survey Average
% of Installs Having Condensate Challenges*	25%	46%	26%	36%
Condensate Pump Installation Time (hrs)	0.67	1.3	1.8	1.6

**Note*—DOE's estimate is for condensate pumps only, while survey respondents ranked the likelihood of *any* measure needed to address a condensate issue.

3.3 Space Constraint

HPWHs are often larger than conventional electric resistance water heaters primarily because of the heat pump equipment included on top of the tank (compressor, evaporator, fans, controls, etc.). This can create an installation challenge when the physical space cannot accommodate the HPWH or when inadequate airflow is available to supply the evaporator. DOE estimated these space constraints exist in 40% of homes and noted they can be rectified by two possible solutions: 1) some homeowners will choose a smaller water heater with a higher setpoint and mixing valve; and 2) other homeowners will remove the door jamb to install the HPWH and then provide a louvered door replacement.

In the case of the first installation solution, DOE assumed 0.4 hours of labor to install a tempering valve in 20% of homes. Survey respondents estimated this task to require 1.8 hours on average, which is seemingly much longer than the actual time required to install a mixing valve. This suggests that participants' responses may have included time spent evaluating the space constraint, retrieving parts and/or struggling with a tight installation space.

For the second installation solution, DOE assumed three hours of labor to remove door jambs and install a louvered door in 20% of homes. Survey respondents estimated that installing a new louvered door would require 1.9 hours on average. Importantly, most consumer HPWH products are sized to fit through standard door frames and the need to remove door jambs is thought to be very rare, according to experts NEEA consulted.[5] These responses are summarized in Table 3.

In addition, survey respondents indicated that relocating the water heater entirely was also a feasible solution to space constraints. While this may initially seem like an extreme option, survey respondents estimated it would take an average of 3.8 (SE) or 5.3 (NW) hours. In some instances, relocation could potentially eliminate the additional installation time and cost of other solutions to constrained spaces. Nevertheless, the estimated average number of hours to relocate demonstrates it is a viable option.

Table 3. DOE Assumptions and Survey Responses Regarding Space Constraint Installation Challenges[123]

Challenge	DOE Assumption	Northwest Survey	Southeast Survey	Survey Average
% of Installs Having Space Constraint Installation Challenges	40%	38%	29%	34%
Tempering Valve Installation Time (hrs)	0.4	1.8	1.8	1.8
Louvered Door Installation Time* (hrs)	3.0	2.0	1.7	1.9

**Note*—DOE refers to removing door jambs and installing a louvered door while survey respondents refer to installing a louvered door or transfer grille.

3.4 Indoor Cooling Requiring Venting

A HPWH works by extracting heat from its surrounding environment and transferring that heat into the water tank. This has the effect of cooling the surrounding interior space. During the cooling season, this effect may be desired, but in the heating season, it may generate unwanted additional load and potentially uncomfortable conditions. DOE assumed that one in three installations (33%) would experience significant indoor cooling effects. To eliminate the negative effects of this condition, DOE assumes the system is vented to exchange air with the outside. DOE assumed venting a HPWH would require 2.2 hours of labor. Respondents in the Southeast and Northwest estimated this task at 2.3 and 3.3 hours, respectively.

[5] Typical diameters for 50- and 80-gallon tanks are 22¼ and 24¼ inches respectively.

Installers in the Northwest responded that negative cooling impacts would occur for 43% of installations while installers in the Southeast, where more cooling is needed and may not be considered undesirable, indicated that venting would be required for only 12% of installations. These responses are summarized in Table 4. Respondents again indicated that another feasible solution to undesired cooling would be to relocate the water heater entirely.

Table 4. DOE Assumptions and Survey Responses Regarding Indoor Cooling Venting Installation Challenges[123]

Challenge	DOE Assumption	Northwest Survey	Southeast Survey	Survey Average
% of Installs Having Indoor Cooling Installation Challenges	33%	43%	12%	28%
Vent Installation Time (hrs)	2.2	3.3	2.3	2.8

4 Conclusions

NEEA's research into HPWH installation challenges provides new insights into the issues faced by installers and the variety of solutions available to overcome them. It demonstrates installers understand the challenges associated with HPWH installation and are prepared to employ a range of solutions to overcome them. Their responses offer valuable insights into the labor costs of solutions to installation challenges that can be weighed against HPWH energy savings to assess their economic viability. The conclusions from this work should not be interpreted as absolute figures showing the exact likelihood and labor cost of installation challenges, but instead provide a useful reference point for understanding the approximate probability and severity of challenges encountered in the HPWH installation process.

Further, different regions within the US have varying sensitivities to each challenge due to their differing climates and building stock. A more comprehensive set of estimates could be determined through additional data collection in other US regions. The existing data gathered, however, provides confirmation that DOE's assumptions for the occurrences of HPWH installation challenges are within reason. Table 5 summarizes the assumptions and estimates for the four main challenges described in this report.

Table 5. Summary of DOE Assumptions vs. Survey Results

Installation Challenge	DOE Assumption	Survey Average
General Additional Installation Time Required for HPWHs	1 hour	2 hours
% of Installs Having Condensate Issues	25%	36%
% of Installs Having Space Constraint Issues	40%	34%
% of Installs Having Indoor Cooling Issues	33%	28%