Market Transformation Success Story: From Initial Specification to Federal Standards for Heat Pump Water Heaters

Meg Waltner, Energy 350
Emily Rosenbloom, Northwest Energy Efficiency Alliance

ABSTRACT

In the 2000s the Northwest[1] faced a huge energy efficiency opportunity and challenge: throughout the region, at least 3 million electric resistance water heaters were slated to be replaced by 2025. The Northwest Energy Efficiency Alliance (NEEA) identified this key opportunity: if all these water heaters were replaced with heat pump water heaters (HPWHs), the region could reduce electricity use by 335 aMW (KEMA Inc 2006).[2] The challenge: in the 2000's HPWHs were a nascent technology with <1% market share. This paper examines the water heater market transformation in the Northwest, starting with the development of the first ENERGY STAR ® specification, the NEEA qualified product list, and Northern Climate Specification in the 2000s to the launch of the Hot Water Solutions Program[3] in 2013, to the U.S. Department of Energy (DOE) final rule in 2024 that will shift the majority of the national electric water heater market to HPWHs. These milestones were complimented by countless technical and market research initiatives and years of developing relationships with manufacturers. During this time, HPWH market share in the Northwest has grown from <1% to 17+%, consumer awareness has reached over 50%, and installer awareness has reached almost 100%. DOE estimates that its final rule will shift 61 percent of electric water heaters nationwide to HPWHs by 2030. What were the key elements to this market transformation success story? What were the biggest challenges and unforeseen hurdles and could these have been avoided? With 20/20 hindsight, could the market have been transitioned faster? What work remains to be done and what lessons are there for future market transformation efforts?

Introduction

The road to significant heat pump water heater (HPWH) adoption in the Northwest has been long and winding. HPWHs were identified as a potential resource in the first Northwest Power Plan in 1983—when the technology existed but was far from commercialization—and have been included in all but one power plan since (Rehley 2024). Many decades of experience with early HPWH models culminated in the development of the first ENERGY STAR ® specification for electric water heaters in 2008, sparking a major transition in the product's history.

[1] For the purpose of this paper, the Northwest is used to describe the four-state region served by the Northwest Energy Efficiency Alliance (NEEA): Oregon, Washington, Idaho, and Montana.
[2] Later studies included even higher potential energy savings, with the 6th Northwest Power Plan published in 2010 estimating an available 490 aMW available by 2030 (NWPCC 2010).
[3] Originally known as the "Smart Water Heater" program.

In 2006, the Northwest Energy Efficiency Alliance (NEEA)[4] saw this major market opportunity in the Northwest: 64 percent of housing units at the time used electric resistance water heaters and 3 million existing electric water heaters were due to be replaced by 2025, representing 335 aMW of energy efficiency resource (KEMA 2006). This paper tells the stories of NEEA's efforts to transform the electric water heater market in the Northwest from electric resistance to HPWHs. While far from done, the market impact has been huge: market share of HPWHs in the Northwest has grown from less than one to approximately 17 percent of the electric storage water heater market, while national market share of HPWHs has grown to around 3 percent (NEEA 2024). In 2024, the U.S. Department of Energy (DOE) issued an updated energy conservation standard that will require electric storage water heaters over 35 gallons (as well as smaller water heaters with high draw patterns) to be HPWHs, which is projected to shift an estimated 63 percent of electric water heater shipments to HPWHs nationwide by 2030 (DOE 2023; DOE 2024).

Through review of primary documents and interviews with key stakeholders, this paper retells the market transformation story for HPWHs in the Northwest. It briefly touches on activities prior to the introduction of the ENERGY STAR ® specification in 2008, but focuses on the time period since, during which the market share has grown significantly.

Pivotal Events in the Northwest's Water Heater Market Transformation

This section summarizes the pivotal events that occurred in the Northwest in the water heater transformation timeline: starting with the initial work on HPWHs in the 1980s through early 2000s up through DOE's final standard in 2024.

1980s to early 2000s Heat Pump Water Heater Research and Development

The first Northwest Power Plan adopted in 1983 identified the potential energy savings from HPWHs, anticipating that 5 aMW could be achieved by Bonneville by 1988 from solar and HPWHs (NWPC 1983). At the time, HPWH models were in the early stages of development and had an average lifespan of about three years (Harris 2024). One of the first robust HPWH models was manufactured by Therma-Stor, a division of the Dairy Equipment Corporation (DEC) International of Wisconsin. Northwest stakeholders worked with DEC International to figure out the key elements of HPWH design that would make them sturdy and allow them to function long term (Harris 2024, Gehring 1986). Ultimately, DEC International developed a product with a COP of 3.1 to 3.5 (based on the DOE test procedure at the time) and sold 11,000 units per year (in a total water heating market of 6 million water heaters per year). As reported in an ACEEE Summer Study 1986 paper describing their experience, DEC International found significant barriers in commercializing this unit including high first cost and lack of economies of scale. They found that consumers were unaware of how much their water heating energy bills cost so

[4] NEEA is a non-profit organization founded in 1996 that works to encourage the development and adoption of energy-efficient products, practices, and services. Funded by the regional utilities, NEEA is a collaboration of 140 utilities and efficiency organizations working together to advance energy efficiency in the Northwest on behalf of more than 13 million consumers.

the first cost premium didn't seem worth it. Consumers were also concerned about where the heat came from in the winter to serve as the heat source (Gehring 1986).

Building on this early experience, DOE and Oak Ridge National Laboratory (ORNL) conducted a series of research projects in the 1990's and early 2000's looking at how you would build a lower cost, durable HPWH at scale. While these efforts improved upon the DEC design, the results were ultimately licensed to a boiler manufacturer and did not become a commercialized product—at the time none of the major water heater manufacturers were entering the HPWH market (Harris 2024). A handful of utility rebates were also run during this time for add-on units (HPWH modules that retrofit on to an existing electric resistance tank). For example, in 2002 Northeast Utilities in Connecticut ran a promotion that incentivized about 3,000 to 4,000 add-on units and in 2003 NYSERDA offered a $300 rebate for add-on HPWH modules that had an energy factor of 2.4 or better (KEMA 2006).

Despite these early efforts, it became clear that the market would not grow on its own. A 2006 residential water heater market assessment conducted by NEEA found significant barriers to entry across the supply chain due to higher upfront costs (and consumers unwillingness to pay these costs), lack of installer knowledge, and poor perceptions of performance based on early products. Jim Lutz from Lawrence Berkeley National Laboratories (LBNL) at the time was interviewed as part of this 2006 market assessment and said, "I do not believe that the market will grow just from retail sales. I believe that there must be organized programs by electric utilities or similar entities, to move large numbers of heat pump water heaters. This is necessary to bring manufacturing costs down. I firmly believe that this market has to grow from local successes — the local 'sponsor' has to find one plumber who is 'sold' on the product and support him intensely until he saturates his market (KEMA 2006)." It was clear that the market would not move without significant intervention.

2007 to 2009 – First ENERGY STAR ® Specification Launched

That needed intervention came in 2007 with the announcement of the development of the first ENERGY STAR ® specification for residential electric water heaters. At the time, the ENERGY STAR ® specification for gas water heaters was already a major force in the market, but no specification existed for electric water heaters as there was no gradation in efficiency amongst the commercially available products. It was clear that an ENERGY STAR ® specification was needed to generate manufacturer interest. Jeff Harris, Chief Transformation Officer at NEEA, recounted a visit to a major manufacturer in 2005 where they asked what it would take to get that manufacturer interested in HPWH. The answer? An ENERGY STAR ® specification for electric water heaters (Harris 2024). This was their opportunity to differentiate a product where there had been no differentiation before and got the major manufacturers interested (Rehley 2024).

In April 2008, the final ENERGY STAR ® specification criteria announcement for residential electric water heaters was released (Evergreen Economics 2014). By 2009, multiple major manufacturers had entered the market with ENERGY STAR ® qualified products including Rheem and GE (DOE 2013).

2009 – Development of First Northern Climate Specification

While the ENERGY STAR ® specification was an important step towards motivating major manufacturers to commercialize HPWHs, NEEA and other Northwest stakeholders were concerned that as written it would not be sufficient to ensure performance in cold climates based on their decades of experience with early HPWH models (Harris 2024). The response to this was the development of what was then called the Northern Climate Specification (NCS). The first version of the specification was published in October 2009 and was the result of collaboration between over 60 regional utilities and efficiency partners, as well as additional partners throughout North America (NEEA 2011).

The NCS specification used the ENERGY STAR ® specification as a foundation and added details for calculating a Northern Climate Energy Factor (EF) which accounted for colder water and air temperatures than the DOE standard test conditions as well as requirements for condensate management, freeze protection, ducting, sound, and a minimum warranty – all things that NEEA had learned from its experience with previous generations of HPWHs in the Northwest as well as through other stakeholder's program efforts in the Northeast (Rehley 2024). The initial specification did not have tiers, but it was an early learning that tiers were necessary to allow manufacturers to be rewarded with utility incentives for bringing HPWHs to the market while still having a gold standard tier. The lower tiers were products that would not work for all applications and the higher tiers were meant to drive manufactures to develop products to meet a wider range of installation locations (Rehley 2024). Importantly, the tiers laid out a roadmap for manufacturers as to where NEEA was heading with its incentive programs (Wickes 2024).

2010 – Department of Energy Standard Finalized Setting Heat Pump Efficiency Levels for Electric Water Heaters >55 Gallons

In 2010, DOE finalized a rule for residential electric water heaters that required heat pump levels of efficiency (EF of 2.0) for all water heaters greater than 55 gallons in storage capacity starting in 2015. At the time, tanks larger than 55 gallons accounted for roughly 9 percent of the electric water heating shipments. NEEA alongside many other stakeholders participated in the rulemaking process, with NEEA sharing data from its testing of HPWHs in the Northwest (DOE 2010). The rule would not have been possible without the commercialization of products that met the ENERGY STAR ® specification a few years previously (Rehley 2024). It was an ambitious step forward at the time and was anticipated to result in significant cost-effective savings for consumers, resulting in the vast majority of the large electric tank market shifting to HPWHs (DOE 2010). As discussed in detail later, this market shift did not come to fruition, but this standard nonetheless played an important role in moving the HPWH market forward.

2010 to 2012 – Manufacturers Develop First NCS Tier 1 and Tier 2 Product Offerings

When the NCS was first published, NEEA sent it to the major water heater manufacturers and AirGenerate asking them to develop a product that met the specification. NEEA made it clear that if manufacturers developed a product that met the specification, NEEA would help test it and offer incentives to get it into houses in the Northwest (Harris 2024). NEEA and the

Bonneville Power Administration also worked with retailers to include point of purchase resources that would help them select between tier 1 and 2 products.

AirGenerate was the first manufacturer to take NEEA up on this offer, ultimately developing the first NCS tier 2 water heater, the ATI 66. AirGenerate had been making add-on heat pump water heaters that could be added to existing tanks and had sold on the order of 6,000 units as of the early 2010s (Rehley 2024). AirGenerate was able to raise money to come up with a new design for an integrated product. NEEA worked closely with AirGenerate providing support as they worked through production issues. NEEA also worked to make sure the AirGenerate product would be a quality unit, including meeting with investors, visiting AirGenerate's US headquarters (Houston Texas), and arranged for a local third-party to evaluate their production facility in China (Rehley 2024; NEEA 2013a).

Around the same time, multiple major manufacturers developed tier 1 products. These included AO Smith, GE, and Stiebel Eltron. The NEEA lab tested all of these early products, working with manufacturers to ensure their products complied with the NCS (Allan 2012). During this same time, BPA, Electric Power Research Institute, Pacific Gas and Electric, Gas Technology Institute, and other organizations also lab and field tested HPWHs. The data from these field tests were critical to understanding the true performance of these new products and to help NEEA consider different ways to test their performance in adverse conditions, such as low ambient temperature conditions.

2012 to 2023 – NEEA and Northwest Utility Incentive Programs

In addition to providing support directly to manufacturers through testing, NEEA and the Northwest utilities supported these tier 1 and tier 2 products with incentives throughout the region. From May 2012 to April 2013 NEEA ran what was known as the Market Test, which led to the installation of 954 HPWHs in the Northwest, 639 of which met NCS tier 1, with the remainder meeting tier 2. This market test found that customers were motivated by saving energy, lowering monthly costs, and by rebates. It also confirmed the presence of familiar barriers: first cost and low consumer awareness of HPWHs. While overall satisfaction was very high, with 95 percent of participants saying that the HPWH had met their expectations, some participants did raise issues with noise (Evergreen 2013). To quantify the influence this Market Test had in the region it is notable that the promotion increased GE's HPWH sales over the same period one year earlier by 350 percent, indicating that this early incentive program had a significant impact on sales (NEEA 2013a). Following this Market Test, NEEA formally launched its Hot Water Solutions (HWS) program in 2013.

After the Market Test, NEEA offered what was known as the Smart Water Heater "upstream market" incentive program which was a manufacturer markdown program and was complemented by additional incentives from the regional utilities. Together these resulted in the sales of 4,483 to 5,186[5] HPWH sales in the region between July 2013 and January 2015, with about 90 percent of these sales being tier 1 units (Evergreen Economics 2015).

NEEA and the regional utilities continued to offer incentives after these initial programs in the early 2010s. Once regional program incentive offerings were broadly available, NEEA

[5] The range in water heaters sold is due to the fact that there were upstream and downstream incentives some of which may have gone to the same unit.

stopped offering “upstream market” incentives directly in approximately 2016 and instead shifted funding towards removing other barriers such as consumer awareness, working with distributors, and installer training. The overall magnitude of the investment, combined with NEEA technical research, installer training, and market initiatives is captured in Figure 1.

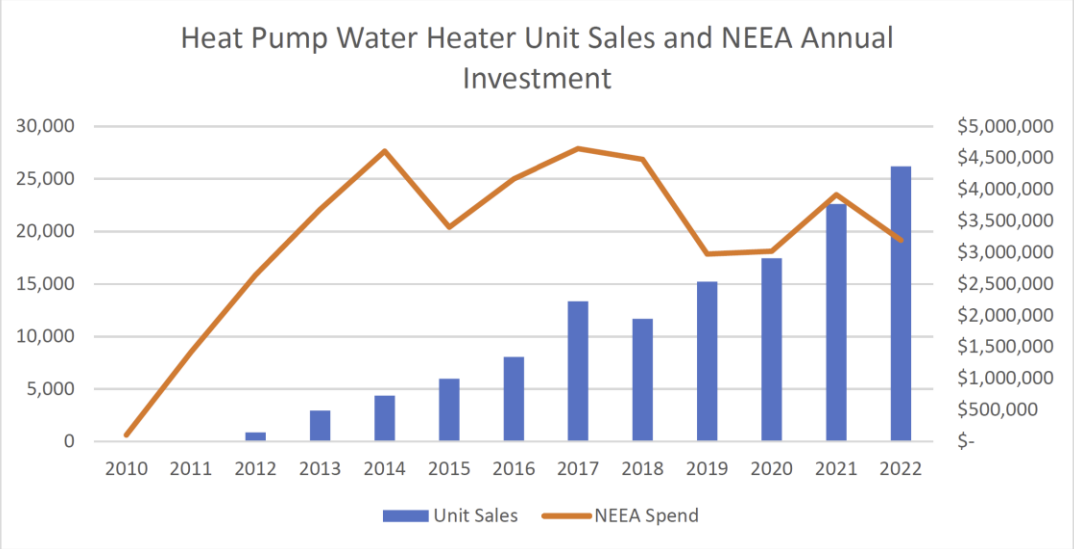

Figure 1: HPWH annual unit sales in the Northwest and NEEA HPWH program spending by year. (NEEA 2024)

2015 – Launch of Tier 3 and 4 Products, Exit of AirGenerate from the Market

While the incentive programs had been accelerating the deployment of NCS tier 1 and 2 products into the marketplace through 2014, there was not yet a tier 3 product on the market. At the time, GE had a tier 1 unit, which was limited to installations in garages, basements, and unconditioned crawlspaces in the Northwest’s warmer climate zone under the incentive programs (Harris 2024). NEEA worked closely with GE to encourage the development of a tier 3 product, including providing an upstream incentive to the manufacturer that resulted in the launch of the tier 3 GE GeoSpring in March 2015 (NEEA 2014). NEEA also learned that AO Smith had been developing a tier 3 product, which soon entered production as well (Harris 2024).

Around this same time, AirGenerate, which originally had been viewed as the program’s leading-edge manufacturer that had demonstrated the viability and value of the features documented in the NCS, closed production after a series of manufacturing issues led to product defects. However, this left room in the market for the newly developed tier 3 products from GE and AO Smith (Evergreen Economics 2016). Rheem soon followed with the introduction of the first tier 4 product, creating a major shift as now three of the four major manufacturers had high performance HPWH offerings (Harris 2024).

2015 – Implementation and Reality of DOE Standard for >55 Gallon Products

In 2015, the DOE standard which required large electric water heaters to be HPWHs took effect. At the time, it was expected that the 9 percent of water heater shipments above 55 gallons

would all shift to HPWHs and that there would be a spillover effect to smaller product sizes (Harris 2024; DOE 2010). These shifts did not materialize; instead, the market found workarounds. By 2017, only 20 percent of large tank replacements were HPWHs, with the most common scenario being downsizing (Cadeo Group 2017). This meant that fewer large tanks were sold overall with the market share of tanks above 55 gallons dropping significantly. This persisted in 2019: 40 percent of installers trained by NEEA's HWS program said that their typical replacement for a large water heater was a HPWH, which is likely a higher percentage than the general population of installers. Instead, the market was installing two 50-gallon electric resistance tanks, a single large commercial water heater, or a 50-gallon electric resistance tank set at a higher temperature with a mixing valve (NMR Group 2019).

GE had invested heavily in being ready to supply large HPWHs that met the new standard. Instead, they were left with a glut of stock and limited demand for larger tanks. This, combined with the sale of GE Appliances to Haier led to the ultimate closure of the GE water heating production line, which was ultimately purchased by Bradford White (Harris 2024; Wickes 2024). While this turn of events was unfortunate for GE, it was significant in that the result was that all major water heater manufacturers had high performance HPWH models (up until that point Bradford White private labeled the GE product under the "Aerotherm" brand). GE had also demonstrated that an excellently designed HPWH could be sold for a reasonable price. This was instrumental in convincing utilities, regulators, and other manufacturers that HPWHs were the future of storage electric water heaters.

2011-2023 – Evolution of NEEA Cold Climate Specification

Throughout this entire time period, the NEEA cold climate specification continued to evolve. It eventually changed in name to the Advanced Water Heating Specification (AWHS) and added additional requirements and product categories, such as the addition of split systems[6] in 2017, specifications for 120-volt products and gas HPWHs in 2019, and commercial, multifamily, and industrial systems in versions 8.0, which was released in 2022.[7] The current specification for residential integrated products is shown in Figure 2. The evolution of the AWHS was partly driven because manufacturers continually demonstrated the ability to improve efficiency without degrading performance. Specifically, while early ENERGY STAR ® products barely met the 2.0 energy factor requirement, products available today have uniform energy factors as high as 4.

2024 – DOE Final Rule that Will Shift Majority of Market to HPWHs

From the beginning, the ultimate goal of NEEA's HPWH program was a federal standard that would require the vast majority of electric water heaters to be HPWHs. DOE first released a request for information in 2020, that indicated a standard requiring HPWHs for most water heaters would likely be found to be cost-effective. In 2022, a "coalition of the willing" including manufacturers and energy efficiency advocates came together to discuss what a standard might

[6] A split system HPWH has the compressor and storage tank as separate components, similar to a split system air conditioner or space heating heat pump.
[7] Version 8.1 is currently under development.

look like that would shift the vast majority of the market to HPWHs while avoiding negative market consequences and workarounds (as was seen with the 2015 standard). This ultimately concluded with a joint comment from manufacturers and efficiency advocates recommending heat pump level standards for electric water heaters greater than 35 gallons in storage volume as well as smaller water heaters with high draw patterns (ASAP 2022). DOE finalized a rule largely aligned with this joint comment in May 2024 that requires all electric storage water heaters to be HPWHs except those under 36 gallons and with first hour ratings less than 51 gallons. This updated standard is expected to shift 61 percent of the electric storage water heater market to HPWHs by 2030 (DOE 2024).

	Minimum Cool Climate Efficiency (CCE)*	Minimum Features	Sound Levels**	Demand Response-Enabled?
Tier 1.0	2.0	• ENERGY STAR compliance • Freeze protection	dBA < 65	Optional
Tier 2.0	2.3	Tier 1 plus: • Minimal use of resistance heating elements (see Section 2.5.1) • Compressor shut-down/notification • 10 year warranty • Condensate management	dBA < 60	Optional
Tier 3.0	2.6	Tier 2 plus: • Simultaneous intake and exhaust ducting capabilities • Air filter management • Override and default mode behavior as per Section 2.6.1	dBA < 55	Required
Tier 4.0	3.0	Tier 3 plus: • Physical design or default controls that limit resistance element heating to less than upper 50% of tank	dBA < 50	Required
Tier 5.0	3.5	Tier 4 plus: • No resistance element usage in default	dBA < 50	Required

** See Appendix B.1.2 for details on Cool Climate Efficiency definition and calculation method.*
*** See Appendix D for details on Sound Level definition and calculation method.*

Figure 2: Integrated HPWH criteria in Advanced Water Heater Specification version 8.0 (AWHS 8.0)

Key Elements of Success

The results of this decade plus of effort was a significant increase in market share and awareness of HPWHs throughout the Northwest region. As shown in Figure 3, market share has grown steadily since the launch of the first Market Test incentive program in 2012. Consumer and installer awareness has also increased significantly throughout the history of the program. Homeowner awareness doubled between 2016 and 2021, with 57 percent of homeowners surveyed in 2021 saying they were aware of HPWHs (NMR Group 2022). Installer awareness has also become the norm, with 96 percent of installers saying they were aware of HPWHs in 2022 and about half considering themselves very familiar with HPWHs (NMR Group 2023).

Year	Pre-2012	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Market Share	0%	1%	2%	3%	4%	5%	9%	8%	10%	12%	15%	17%	17+%

Figure 3: Market share of HPWH in the Northwest as a percentage of total electric water heater installs (NEEA 2024)

The following section outlines the key elements that led to this increase in market share and laid the groundwork for DOE to propose a standard in 2023 that would shift the majority of the electric storage water heater market to HPWHs.

Importance of Efficiency Specifications and Qualified Product List

Early efficiency specifications, including ENERGY STAR ® and the NCS (including the corresponding qualified product list) were a critical element to the program's success. These two specifications were complementary and together drove the market towards high efficiency, high performing products. ENERGY STAR ® was critical for brand recognition and driving manufacturer interest in developing HPWHs initially. The NCS built on decades of experience and product testing and outlined the key criteria for products to function at high efficiency in the Northwest. The tiered structure of the specification was also important as it provided clear direction of where products needed to go that manufacturers could look to as a roadmap (Wickes 2024).

It was also important that the initial NCS was a collaborative effort that was signed on to by dozens of stakeholders both inside and outside of the region. This increased the market weight of the specification and established something that could be used in other states and programs, leading to important complementary efforts outside of the Northwest region, such as mid-stream incentive programs run by Efficiency Maine and Vermont Energy Investment Corporation (VEIC), as well as in California's building code, Title 24 (Harris 2024; Wickes 2024).

Working Closely with Manufacturers from Early On

Another key part of NEEA's strategy was working closely with manufacturers from the beginning to develop long-term relationships that could be leveraged to encourage the development of more efficient products over time. NEEA worked to establish itself as a valuable resource to manufacturers by showing its technical credibility, testing resources, and commitment to incentive funding through the region (Wickes 2024; Rehley 2024). These manufacturer relationships ended up being key at every stage – from encouraging the development of higher tier products in the mid-2010s to the formation of the "coalition of the willing" in 2022 that recommended DOE set HPWH-level standards for most products in its joint comment agreement (Rehley 2024).

NEEA Technical and Market Research

Part of NEEA's credibility with manufacturers came from its extensive testing and research into the performance of HPWHs. This included early research to better understand draw patterns and how to develop an appropriate test method for HPWHs as well as the performance testing of essentially all the early HPWH models in its contract laboratory (Allan 2012). More recently, NEEA's research has focused on installation practices (such as the effects of ventilation and room size on performance, cold climate performance, and challenging installation scenarios), new product categories (such as 120-V products and split systems), and market research (such as understanding optimal pricing) (Larson Energy Research 2022a; Larson Energy Research 2022b;

Cadeo Group and Larson Energy Research 2023; Illume Advising 2024; Illume Advising 2022; NEEA 2022). This ongoing research has informed the continued evolution of the performance specification, NEEA's programs efforts, has been leveraged by extra-regional stakeholders, and has strengthened NEEA's credibility with manufacturers.

NEEA's research complemented testing and market research done by partner organizations throughout the US. This research by partner organizations has been critical to the success of the NEEA program and to the evolution of the market.

New Construction as Major Driver of Installations

The new construction market was identified as an opportunity for HPWH installations in 2015, given the lack of installation barriers as compared to retrofits (Evergreen Economics 2015).[8] In new construction, it is relatively easy and low-cost to plan for the needed space and drainage configurations for HPWHs in advance. By 2018, new construction made up the vast majority of HPWH installs, representing 70-90 percent of distributor sales. This was driven by a combination of manufacturer incentives, special pricing arrangements, and code requirements that enabled builders to easily get compliance points for installing HPWHs, often making them the least cost code compliance path (Cadeo Group 2018). NEEA helped influence the point system by participating in the code development process and sharing research and learning from the region. By 2019, the motivation posed by these building code points became clearer: only 38 percent of HPWHs installed in new homes received incentives, compared to 81 percent of retrofit installations (NMR Group 2019). The effects of this motivation are significant. By 2021, 67 percent of electric water heaters installed in new homes in the Northwest were HPWHs as shown in Figure 4 (NMR Group 2023). Furthermore, a compliance study of homes permitted in Washington between February 2021 through January 2022 found that 84 percent of homes installed a HPWH for compliance (with 96 percent of homes choosing either a gas or electric high efficiency water heating measure) (TRC 2023).

Install Type	2019 (MPER 6)				2020 (MPER 6)				2021 (MPER 7)			
	Electric Water Heater Market	HPWH Installs	Relative Market Share	Overall Market Share	Electric Water Heater Market	HPWH Installs	Relative Market Share	Overall Market Share	Electric Water Heater Market	HPWH Installs	Relative Market Share	Overall Market Share
Total	*148,700*	*15,217*	*10.2%*	*10.2%*	*150,200*	*17,442*	*11.6%*	*11.6%*	*155,100*	*22,598*	*14.6%*	*14.6%*
New	18,300	9,022	49.3%	6.1%	19,200	11,413	59.4%	7.6%	17,500	11,751	67.1%	7.6%
Existing	130,400	6,195	4.8%	4.2%	131,000	6,029	4.6%	4.0%	137,600	10,847	7.9%	7.0%
Planned replacements	*82,142*	*5,692*	*6.9%*	*3.8%*	*82,530*	*5,902*	*7.2%*	*3.9%*	*86,688*	*6,074*	*7.0%*	*3.9%*
Emergency replacements	*48,248*	*503*	*1.0%*	*0.3%*	*48,470*	*490*	*1.0%*	*0.3%*	*50,912*	*4,773*	*9.4%*	*3.1%*

Figure 4: Northwest HPWH water heater installations and market share broken out by new construction and existing buildings (NMR Group 2023).

[8] Since HPWH require appropriate ventilation and condensate drains, retrofit installations can pose additional challenges if the existing space is not configured for these features.

Installer Training

From the early stages of market engagement, NEEA has invested significantly in installer training, with trainings as early as 2013 (NEEA 2013b). This has led to an installer base that is knowledgeable in HPWHs. In total, NEEA has offered trainings to at least a thousand individual installers. While installer awareness and know-how continues to be a major program priority, installers that have been trained by the program consistently report higher levels of familiarity and comfort with HPWHs, as well as higher install and recommend rates. For example, in 2019, NEEA found that HWS trained installers installed HPWHs at nearly double the rate of overall market penetration. NEEA also found that nine in ten HWS-trained installers agreed that their technicians can easily install HPWHs correctly (89 percent) and that replacing an electric resistance water heater with a HPWH will lower a customer's energy bill (90 percent) (NMR Group 2019). In addition to trainings in the Pacific Northwest, NEEA supported manufacturers in extra regional training in 12 different states including Florida, California, Indiana, Michigan, Ohio, and Pennsylvania, among others (Wickes 2024).

Challenges

While the overall story is one of successful market transformation with the significant increase in market share, there have also been significant challenges, many of which remain today. These include lack of consumer awareness, high first cost, issues with performance, installer perceptions, and consumer acceptance, each of which is described below.

Lack of Consumer Awareness

While consumer awareness has increased significantly (to 57 percent in 2021 as described earlier) it is still low overall and is not leading to significant demand for HPWHs. NEEA research consistently shows that installer recommendations are key and installers, while familiar with HPWHs, are still unlikely to recommend them.

NEEA has more recently invested in general consumer awareness campaigns, such as the Family Meeting ad campaign in 2019[9] and the Boring but Efficient campaign in 2022.[10] Starting campaigns like these earlier in the process might have led to higher consumer awareness and demand for HPWHs (Wickes 2024).

First Cost

Incremental first cost has been one of the most significant barriers to HPWHs since the beginning. In 2006, when NEEA conducted its initial market survey the retail cost of a HPWH was 3 times that of a standard tank (KEMA 2006). That survey found that "as with manufacturers, the biggest barrier from the distributor, wholesaler, and retailer perspective is the initial cost of the heat pump water heater." It also found that most consumers are unwilling to pay a higher price for an energy efficient water heater (KEMA 2006). Despite the fact that

[9] https://www.youtube.com/watch?v=aHhRZ4vpN7U)
[10] https://www.boringbutefficient.com/

HPWHs are highly cost-effective and result in significant energy savings, incremental first cost continues to be a major barrier to broader market adoption of HPWHs today (NMR GROUP 2023).

While first costs continue to be high, there is reason to believe that costs will come down in the future, in particular with the implementation of the DOE standard. At its core, a HPWH is the combination of two appliances: an electric resistance water heater and a room air conditioner. This implies that at scale, the incremental cost of a HPWH compared to an electric resistance water heater should be similar to the cost of a room air conditioner which can be purchased for a few hundred dollars (Harris 2024). Additionally, to date HPWHs have been a race to the top – meeting the highest NEEA efficiency tiers to achieve the most energy savings and largest incentives. The proposed DOE standards would require more modest efficiency levels, allowing manufacturers to develop lower cost products that continue to deliver significant cost-effective savings to consumers.

Performance, Installer Perceptions, and Consumer Acceptance

The other major challenge to the widespread deployment of HPWHs has been negative perceptions around performance, particularly as it comes to noise, reliability, cold air, and recovery time, even though consumer satisfaction rates have been consistently high throughout the course of the Hot Water Solutions program (NMR Group 2023). Compared to electric resistance water heaters, HPWHs are more complex products. They require proper installation to function properly, including adequate ventilation, condensate drainage, and consideration of potential noise and cold air concerns. While all of these considerations can be addressed during installation – and come with large societal and consumer cost benefits – they have led to some negative perceptions in the marketplace, particularly amongst installers. For example, in 2022, 23 percent of HPWH purchasers cited the need to address installation issues – most frequently pipe configuration or lack of a drain nearby for condensate. Installers in particular cited concerns about customer callbacks, even though reported customer satisfaction is high, with only 55 percent of installers who were aware of HPWHs saying that they are reliable (NMR Group 2023). Ensuring that installers are properly training and addressing these negative perceptions remains one of the major barriers as the market transitions to a HPWH standard. Additionally, similar to the long-term expectations on cost, NEEA anticipates that these performance challenges will lessen over time. A HPWH is essentially a refrigerator in reverse which are nearly silent today. Similar to how refrigerators have improved in noise and reliability, NEEA expects continued improvements in HPWH performance as the market scales up (Rehley 2024).

Additional Lessons Learned

Additional key lessons learned from NEEA's experience growing the market for HPWHs in the Northwest include:

- Focus on installers early: Consumer choices are heavily influenced by installer recommendations. It is therefore critical to get installers on board early to train them in

how to install HPWHs, and to have their buy in. While this has been a focus of the NEEA program from early on, in hindsight this is an area that could have used even more resources and will need resources going forward.

- "Pro-installer" approach – don't go wide too soon: NEEA went wide quickly training many installers across the region. An alternate approach that might have been more successful would have been to use a pro-installer approach, focusing deeply on a few installers that become experts in HPWH installation before broadening this approach to the rest of the industry (Wickes 2024).
- Effect of the 2015 Standard: It's unclear whether the 2015 standard was ultimately helpful or harmful in the market shift towards HPWHs. On the one hand, it encouraged significant manufacturer investment in new, high efficiency products. On the other, it created significant market uncertainty as the market shifted to work arounds, negatively impacting manufacturers. It also highlighted the ability of the market to find workarounds to a HPWH level standard, which heavily influenced the discussions surrounding the 2024 DOE standard. Time will tell whether the effort that went in to preventing workarounds in the 2024 DOE standard achieve the intended outcome.
- Focus on the standard from the beginning: From day one, NEEA's market transformation goal was clear: a federal standard that would shift the majority of the market to HPWHs by the mid-2020s (Allan 2012). NEEA's efforts have been focused on this from the start which is why the development of the specification, understanding of draw patterns, and test procedure development was such an important part of the process (Harris 2024).

Conclusion

While the Northwest has seen significant success in its implementation of HPWHs throughout the region, the market transformation story is by no means done. Significant work remains ahead in particular between now and 2029 to lay the groundwork for the standard. The focus over the next 5 years will include fostering increased public awareness (so that consumers are asking for HPWHs), continued outreach and training for installers (in particular to those who have negative perceptions of HPWHs currently), and working with manufacturers to continue to improve product performance, bring down first cost, and introduce new products in the market that serve unmet market needs (such as small water heaters in small homes and multifamily buildings that don't currently have a readily available HPWH solution and are exempted from the standard). All these key focus areas will be better accomplished by working across the U.S.; NEEA looks forward to working with extra regional partner organizations to scale up these efforts. The earlier these efforts can begin and the more resources they have to work with will help ensure the savings projected from the standard – an estimated 17.6 quadrillion Btu over the 30-year life of the rule – will be realized (DOE 2024).

As with all market transformation programs, the long-term goal is sustained market change such that HPWHs are the default technology for electric water heating. Achieving this goal will require HPWH installations to become the path of least resistance for industry. This will come in part through installer and consumer awareness and knowledge but may also come from the emergence of new products as the industry invests to meet the new standard. This could include new split system products, products with better performance (particularly sound,

condensate management), increased thermal storage volume through phase change materials or other technologies that improves recovery time, and/or the use of variable speed compressors which could improve temperature management. Eventually, NEEA anticipates that a fully transformed market would include a strong trained workforce and structure for continual learning, widespread consumer awareness and preference for HPWHs, quality products that meet diverse needs and are dependable, and codes and standards that have adapted key elements of AWHS. In the meantime, NEEA plans to continue to support the market to ensure a successful implementation of the DOE standard.

References

Allan, A. 2012 *Heat Pump Water Heater Presentation to EPA ENERGY STAR ®.* https://www.energystar.gov/sites/default/files/asset/document/NEEA-Allen.pdf

Appliance Standards Awareness Project (ASAP). 2022. *Stakeholders Recommend Major Boost to Water Heater Standards.* https://appliance-standards.org/blog/stakeholders-recommend-major-boost-water-heater-standards

Cadeo Group. 2017. *Northwest Heat Pump Water Heater Initiative Market Progress Evaluation Report #3.* Portland, OR: Northwest Energy Efficiency Alliance.

Cadeo Group. 2018. *Northwest Heat Pump Water Heater Initiative Market Progress Evaluation Report #4.* Portland, OR: Northwest Energy Efficiency Alliance.

Cadeo Group and Larson Energy Research. 2023. *Heat Pump Water Heater Market Research: Challenging Installations Scenarios.* Portland, OR: Northwest Energy Efficiency Alliance.

Department of Energy (DOE). 2010. *Energy Conservation Program: Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters. Final Rule*. 75 Federal Register 20112.

Department of Energy (DOE). 2013. *Hot Showers, Fresh Laundry, Clean Dishes*. https://www.energy.gov/eere/buildings/articles/hot-showers-fresh-laundry-clean-dishes

Department of Energy (DOE). 2023. *Energy Conservation Program: Energy Conservation Standards for Consumer Water Heaters. Notice of Proposed Rulemaking*. 88 Federal Register 49058.

Department of Energy (DOE). 2024. *Energy Conservation Program: Energy Conservation Standards for Consumer Water Heaters. Final Rule*. 89 Federal Register 37779.

Evergreen Economics. 2013. *Northwest Heat Pump Water Heater Market Test Assessment*. Berkeley, CA: Northwest Energy Efficiency Alliance.

Evergreen Economics. 2014. *Heat Pump Water Heater Baseline Forecast Research.* Portland, OR: Northwest Energy Efficiency Alliance.

Evergreen Economics. 2015. *NEEA Northwest Heat Pump Water Heater Initiative Market Progress Evaluation Report #1.* Portland, OR.

Evergreen Economics. 2016. *NEEA Northwest Heat Pump Water Heater Initiative Market Progress Evaluation Report #2.* Portland, OR.

Harris, J. 2024. *Interview with Jeff Harris conducted February 21, 2024 by Meg Waltner.*

Fluid Market Strategies. 2013. *NEEA Heat Pump Water Heater Field Study Report.* Portland, OR: Northwest Energy Efficiency Alliance.

Gehring, K. 1986. *The Evolution of Ventilating Heat Pump Water Heater.* In *Proceedings of the 1986 ACEEE Summer Study on Energy Efficiency.* https://www.aceee.org/files/proceedings/1986/data/papers/SS86_Panel1_Paper_06.pdf

Illume Advising. 2022. *Pricing Research for Efficient Water Heaters.* Portland, OR: Northwest Energy Efficiency Alliance.

Illume Advising. 2024. *Cold Climate Demonstration & Water Heater Installer Focus Group Research.* Portland, OR: Northwest Energy Efficiency Alliance.

KEMA Inc. 2006. *Assessment of the Residential Water Market in the Northwest*. Portland, OR: Northwest Energy Efficiency Alliance. https://neea.org/resources/residential-water-heater-market-2006

Rehley, M. 2024. *Interview with Mark Rehley conducted February 22, 2024 by Meg Waltner*

Larson Energy Research. 2022a. *Heat Pump Water Heater in Small Spaces Lab Testing: "The Amazing Shrinking Room."* Portland, OR: Northwest Energy Efficiency Alliance.

Larson Energy Research. 2022b. *Plug-in Heat Pump Water Heaters: An Early Look to 120-Volt Products.* Portland, OR: Northwest Energy Efficiency Alliance.

NMR Group. 2019. *NEEA Northwest Heat Pump Water Heater Initiative Market Progress Evaluation Report #5.* Somerville, MA.

NMR Group. 2022. *NEEA Northwest Heat Pump Water Heater Initiative Market Progress Evaluation Report #6.* Somerville, MA.

NMR Group. 2023. *NEEA Northwest Heat Pump Water Heater Initiative Market Progress Evaluation Report #7.* Somerville, MA.

Northwest Energy Efficiency Alliance (NEEA). 2011. *NEEA Updates Northern Climate Specification for Heat Pump Water Heaters.* PR Newswire. https://www.prnewswire.com/news-releases/neea-updates-northern-climate-specification-for-heat-pump-water-heaters-134059733.html

Northwest Energy Efficiency Alliance (NEEA). 2013a. *NEEA Q2 2013 Quarterly Performance Report.* Portland, OR.

Northwest Energy Efficiency Alliance (NEEA). 2013b. *NEEA Q4 2013 Quarterly Performance Report.* Portland, OR.

Northwest Energy Efficiency Alliance (NEEA). 2014. *NEEA Q4 2014 Quarterly Performance Report.* Portland, OR.

Northwest Energy Efficiency Alliance (NEEA). 2022. *NEEA Q4 2022 Market Research & Evaluation Quarterly Newsletter.* Portland, OR.

Northwest Energy Efficiency Alliance (NEEA). 2024. *NEEA Market Tracking Data.* Unpublished.

Northwest Power Planning and Conservation Council (NWPCC). 1983. *Northwest Conservation and Electric Power Plan.* Portland: Oregon. https://www.nwcouncil.org/media/filer_public/7a/3e/7a3e18f9-929a-4f7d-866f-8b456cd5b6ef/1983Plan.PDF

Northwest Power Planning and Conservation Council (NWPCC). 2010. *Sixth Northwest Conservation and Electric Power Plan.* Portland: Oregon. https://www.nwcouncil.org/sites/default/files/SixthPowerPlan_Ch4_2.pdf

TRC. 2023. *Washington Residential Code Evaluation.* Portland, OR: Northwest Energy Efficiency Alliance.

Verinnovation Inc. 2011. *2011 Water Heater Market Update.* Portland, OR: Northwest Energy Efficiency Alliance.

Wickes, G. 2024. *Interview with Geoff Wickes conducted February 20, 2024 by Meg Waltner.*