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NEEA Heat Pump Water Heater Baseline Forecast Research

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Delphi Panel Results

Final Report

Prepared by Evergreen Economics for the Northwest Energy Efficiency Alliance

October 23, 2014

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Tami Rasmussen was the Evergreen Economics project director for this project, and Kevin Price was the project manager. Questions regarding this report should be directed to Mr. Price at price@evergreenecon.com.

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Executive Summary

Evergreen Economics was originally contracted by NEEA in the fall of 2012 to develop a forecast of naturally occurring baseline for its Heat Pump Water Heater Initiative. The term "baseline" refers to the percentage of the target market that has adopted, and is likely to adopt these units over a 20-year time horizon in the absence of a NEEA initiative, or local utility program influence. NEEA uses the pre-initiative condition, to estimate a 20-year forecast of the market adoption of the efficient product, assuming no NEEA initiative, Bonneville Power Administration, Energy Trust of Oregon, or utility program exists. This report presents results from the forecast assessment.

Background

The Heat Pump Water Heater Market Test is sponsored by NEEA and consists of numerous trial interventions within the residential electric water heater market in the Northwest. In conjunction with new market transformation activities, NEEA typically conducts research to estimate baseline market conditions to establish pre-initiative conditions to allow for measurement of initiative impact and assess the investment prudency as part of NEEA's fiscal responsibility.

It is important to note that the forecast baseline cannot be measured but only estimated because it is a counter-factual – a reasoned speculation of what the regional market will look like in future years without the sponsor's intervention.

Research Objectives

The objective of the research is to forecast baseline heat pump water heater sales in the Northwest – Idaho, Montana, Oregon, and Washington. Specifically, we estimated the unit sales and installations of heat pump water heaters meeting the Tier 1 and Tier 2 Northern Climate Specification, above and below 55 gallons, *in absence of utility incentive programs*. The research also incorporated the potential impact of a waiver related to 2015 federal standards for residential water heaters.

Baseline estimates may be used by NEEA as inputs to its cost-effectiveness calculations and to inform program planners and implementers about current and future market conditions.

Data Collection and Analysis Methods

A Delphi panel is "a highly structured technique in which selected experts provide their assessment of likely future outcomes by responding to several rounds of questions."[1] The method is used by researchers tasked with estimating what will occur in the future, in

[1] Parsons Brinckerhoff Quade & Douglas, Inc., 2002. *The Use of Expert Panels in Analyzing Transportation and Land Use Alternatives*. Prepared for: American Association of Highway and Transportation Officials (AASHTO) Standing Committee on Planning. Portland, Oregon. April 2002.

fields such as urban planning, market research, and sales forecasting. The Delphi panel is used to estimate future conditions because no data exists for what *will* occur. The Delphi panel approach is designed to provide best estimates to answer research questions about future conditions.

For this baseline assessment, two groups of panelists participated in the Delphi panel process sequentially. Panelists had the ability to inform the decisions of other panelists who participated during the same timeframe. Sequencing was required due to panelist attrition as well as recent developments in the market (the federal waiver for ETS[2] programs).

The ultimate goal of a Delphi panel is consensus among all panelists regarding future conditions. It is important to understand that consensus among panelists is never guaranteed through this process.

Summary of Results

The results of the heat pump water heater baseline Delphi panel forecast research are presented below for Panelists A – E in Figure 1 and for Panelists F – I in Figure 2.

We recommend adopting a baseline forecast based on panelists A – E. As shown for these panelists, baseline sales of the smaller HPWHs are expected to grow continuously over time (except between 2023 and 2026 for the Tier 1 HPWHs), but will make up a small share of the nearly 175,000 electric water heaters sold annually in the Northwest. The larger HPWHs will see most of their non-incented sales growth resulting from the impacts of the 2015 federal standards for residential water heaters.

The key factors that influenced our decision to recommend adopting the baseline forecast based on panelists A – E include:

Panelists A – E:

- Better accounted for unique market characteristics in the NW.
- Diverse approaches by panelists.
- Baseline sales of HPWHs never approach total electric water heater sales.
- Panelists assumed 2015 mandate the sole standard during the forecast period.
- Panelists assume low levels of compliance with federal mandates in absence of incentives.

Panelists F – I:

- Market forecasts based largely on national conditions.
- Largely homogenous approaches by panelists.

[2] "ETS" refers to the process of using off-peak energy to heat water, which is stored for use during both off- and on-peak hours. The purpose is to reduce peak demand.

- Baseline sales of HPWHs account for all electric water heater sales by 2040.
- Three out of four panelists assumed at least one additional standard update affecting small volume HPWHs.
- Panelists assume high levels of compliance with federal mandates in absence of incentives.

Figure 1: Panelists A – E, Blended Average Forecasts by Tank Size and Tier, and Overall

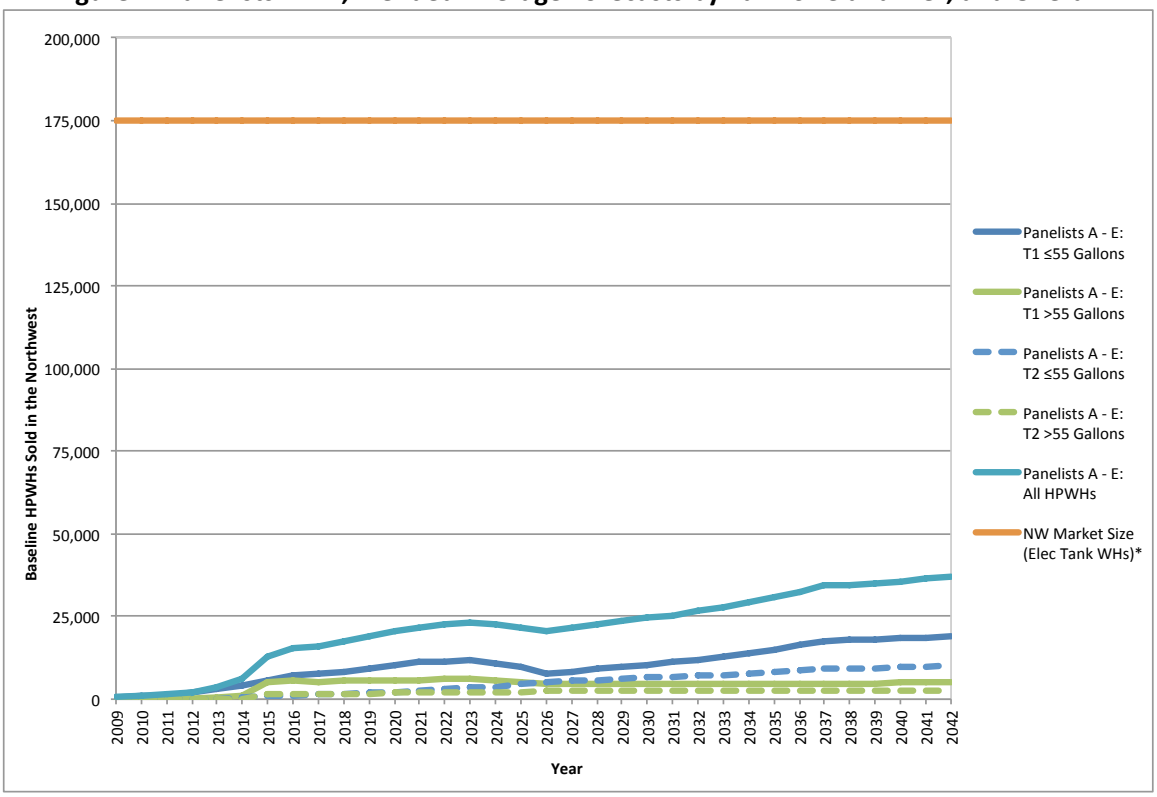
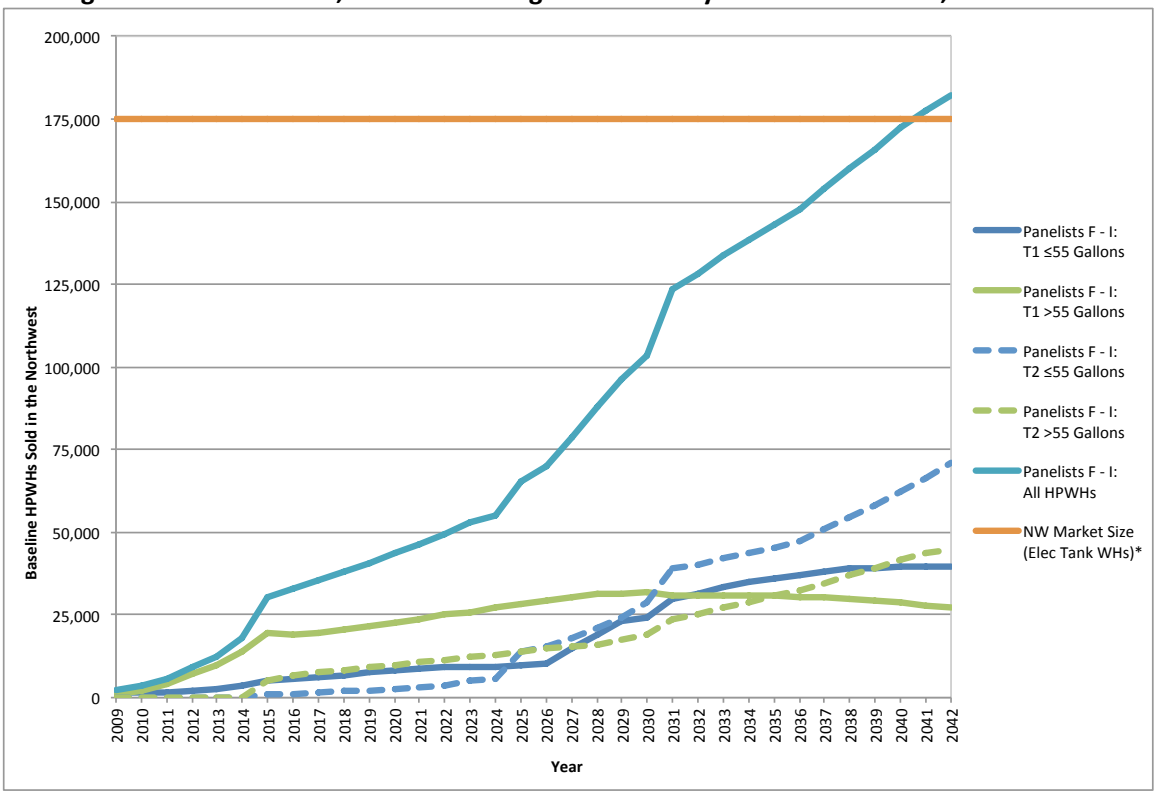


Figure 2: Panelists F – I, Blended Average Forecasts by Tank Size and Tier, and Overall



1 Introduction

The Northwest Energy Efficiency Alliances (NEEA) engaged Evergreen Economics to conduct heat pump water heater baseline and baseline forecast research in the fall of 2012.

This report documents the results of the baseline research, and provides recommendations for baseline forecasts to be used by NEEA as inputs to its cost-effectiveness calculations and to inform program planners and implementers about current and future market conditions. The study period includes assessments of naturally occurring baseline from 2009 through 2012, and forecast naturally occurring baseline from 2013 through 2042.

1.1 Heat Pump Water Heater Market Context

This section provides the context of the heat pump water heater market in the Northwest, as well as information regarding U.S. Department of Energy (DOE) electric water heater standards set to become effective in 2015. We also present a potential waiver to the standard, for manufacturers producing electric resistance water heaters for specific demand response utility rebate programs.

1.1.1 ENERGY STAR® Residential Water Heater Criteria 2008

On April 1, 2008, the DOE released a "Final Criteria Announcement" for residential water heaters. The first certified heat pump water heater products became available in 2009. Following the release of the ENERGY STAR® specification, manufacturers began to approach the utility companies in the Northwest to discuss rebate programs for ENERGY STAR water heaters. The utilities directed the manufacturers to NEEA in the beginning of 2009.

When manufacturers approached NEEA, NEEA expressed concern that heat pump water heaters meeting the ENERGY STAR® specification would not necessarily suit climatic conditions in the Northwest.

1.1.2 Northern Climate Specification

Later in 2009, NEEA began developing a set of performance criteria for HPWHs, called the Northern Climate Specification. These criteria were created in response to the perceived shortcomings in the general ENERGY STAR® specification as they applied to northern climates, and included parameters to address the following:

- Acceptance and Market issues (e.g., noise, physical size, warranty)
- Ventilation issues
- Condensation

The Northern Climate Specification was first presented in the spring of 2009 at the American Council for an Energy-Efficient Economy (ACEEE) Hot Water Forum. Following the presentation, NEEA reached out to agencies in the Northeast and Midwest regarding the Northern Climate Specification in order to solicit their opinions and garner support.

NEEA and the other agencies then released to U.S. manufacturers a set of proposed specifications during a public forum.

The Northern Climate Specification includes three tiers. Currently there are products that meet the Tier 1 and Tier 2 requirements, but not the Tier 3 requirements. Below, in Table 1, is a description of the three tiers.

Table 1: Northern Climate Specification – Tier Descriptions[3]

Tier	Minimum Northern Climate EF*	Minimum "Northern Climate" Features	Minimum supported installation locations	Sound levels*
Tier 1	1.8	• ENERGY STAR® compliance	• Semi-conditioned • Unconditioned	dBA < 65
Tier 2	2.0	Tier 1 plus: • Minimal use of electric heating elements • Freeze protection • Exhaust ducting option • Compressor shut-down/notification • 10 year Warranty • Condensate Management	• Conditioned • Semi-conditioned • Unconditioned	dBA < 60
Tier 3	2.4	Tier 2 plus: • Intake ducting option • Air Filter Management	• Conditioned • Semi-conditioned • Unconditioned	dBA < 55

* details for how these metrics are calculated can be found here: http//neea.org/northernclimatespec

1.1.3 Heat Pump Water Heater Market Test Description

The Heat Pump Water Heater Market Test was sponsored by NEEA, and rebates for end-users were launched in mid-2012. The Market Test provided a limited number of incentives for Tier 2 HPWHs. The market test was similar to a pilot program – a smaller "test" version of a full-fledged initiative or rebate program.

In addition, 17 utilities in the Northwest have provided incentives for HPWH purchases. Some of these rebates were specific to Tier 2 products, while others promoted both Tier 1 and Tier 2 water heaters (some are technology neutral, requiring qualifying water heaters to meet an Energy Factor threshold as opposed to promoting specific technologies).

1.1.4 U.S. DOE Standards and Likely Waiver for ETS

The U.S. DOE released a set of standards for residential water heaters in April 2010. These standards, effective starting in 2015, set a minimum efficiency for electric storage water heaters above 55 gallons unreachable by standard electric resistance storage water heaters. While alternative actions are available to residential customers replacing their

[3] Source: http://neea.org/northernclimatespec

larger electric storage water heaters – including fuel switching, electric on-demand water heaters, and purchasing two 55 gallon or below water heaters – electric heat pump water heaters already meet the efficiency requirements.

One concern with the 2015 standard is that electric thermal storage (ETS) programs would be less viable for residential customers. From the DOE proposed waiver[4]:

> *ETS programs typically allow the utility to control the appliance remotely to allow operation of the appliance only during off-peak hours. During off-peak operation, the electricity consumed is stored by the appliance as thermal energy for use during peak hours when it is not allowed to operate. Large-volume electric storage water heaters are a key component of utility ETS programs that target electric water heaters because these larger-volume products allow for the storage of enough hot water to meet consumer usage during peak demand times when the water heater would not be allowed to turn on…*

The debate is focused on the ability of HPWHs to supply the same ETS potential, as well as the acceptance of higher-cost HPWH technology among consumers who would otherwise be amenable to participation in an ETS program.

And thus, the proposed waiver provides:

> *… an alternative approach to energy conservation standards for certain, limited electric water heaters appears to be warranted in order to ensure the viability of these programs […] The proposed process would allow any manufacturer of electric water heaters, any electric utility company, or a combination of the two, to request a waiver granting exemption from the energy conservation standards […] for certain electric water heaters with rated storage volumes greater than 55 gallons. Each waiver granted by the U.S. Department of Energy (DOE), would allow, for a one-year period, manufacturers to produce limited numbers of electric water heaters with rated storage volumes above 55 gallons exclusively for the purpose of installation in residences enrolled in a specific utility company ETS program. Parties would be allowed to apply for additional one-year waivers in subsequent years. This proposed rule, if adopted, or the granting of a waiver under this rule, would not amend the energy conservation standard otherwise applicable to electric water heaters with rated storage volumes above 55 gallons.[5]*

It remains unclear whether the waiver will become effective in 2015.

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[4] Source: http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0022-0158

[5] *Ibid.*

1.2 Research Approach

The Delphi panel method is commonly used to estimate or predict future conditions. The method relies on expert opinion, as no concrete data source exists for what has yet to occur. In this particular case, the purpose of the research is to estimate future annual sales of heat pump water heaters in the Northwest in the absence of a NEEA-sponsored Initiative or similar utility-sponsored programs. The expert panelists were tasked with forecasting sales based on existing data sources, professional opinion, and any number of reasoned assumptions. The Delphi panel approach includes anonymously sharing these results among the panelists to allow panelists the opportunity to revise their analysis after reviewing the methods and results of other experts.

For this baseline assessment, two groups of panelists participated in the Delphi panel process sequentially. Panelists had the ability to affect the decisions of other panelists who participated during the same timeframe. Sequencing was required due to panelist attrition and due to recent developments in the market (the federal waiver for ETS programs).

The ultimate goal of a Delphi panel is consensus among all panelists regarding future conditions. It is important to understand that consensus among panelists is never guaranteed through this process.

The Delphi panel employed for this project included eight steps. Below we describe each step in sequence.

Step 1: Evergreen Provides Background Data/Preliminary Findings to Panelists

As a starting point for the Delphi panel, Evergreen Economics prepared a summary of national heat pump water heater forecasts from an independent market research firm and the U.S. Department of Energy (DOE). In addition, Evergreen supplied panelists with a spreadsheet tool for documenting analysis and results and the following additional background reports:

- "A Specification for Residential Heat Pump Water Heaters Installed in Northern Climates Version 4.0" (NEEA, November 7, 2011)
- "2011 Water Heater Market Update" prepared for NEEA (Verinnovation Inc., January 16, 2012)
- "ENERGY STAR Water Heater Market Profile" prepared for U.S. Department of Energy (D&R International, September 2010)

The spreadsheet template was developed by Evergreen to ensure a standard presentation of results among panelists. The spreadsheet contained tabs for documenting analysis, assumptions and caveats, and results.

Step 2: One-on-One Project Kick-off Meeting

The second step of the Delphi panel was a one-on-one meeting between the panelist and the Evergreen Delphi panel project manager. The purposes of these meetings were to discuss the materials mentioned above and to go over the entire Delphi panel process.

Step 3: Panelists Conduct Analysis and Report to Evergreen

Delphi panelists were given approximately three weeks to conduct their analysis, adding their own data and developing their own assumptions. The output of this analysis was a completed results spreadsheet, which was provided directly to the Evergreen Delphi project manager.

Step 4: Evergreen Analyzes Panelist Methods/Conclusions

Evergreen staff reviewed the panelists' methods and conclusions, and summarized them in an interim results report. Evergreen included descriptions of the methodologies – including data sources and assumptions – as well as results.

Step 5: Evergreen Provides Anonymous Interim Results to Panel

Evergreen provided the interim results report (mentioned above) to all panelists for review. All methods and results were kept anonymous so that all panelists understand the variety of methods, but cannot attribute any particular estimate to a specific panelist.

Step 6: Panelists Revise their Analysis

Panelists were allowed the opportunity to revise their analysis, incorporating what they had learned from other panelists. They were encouraged to adopt assumptions or data sources from other panelists if they perceived them more reliable or accurate.

Again, the output of this analysis was a completed results spreadsheet, which was provided directly to the Evergreen Delphi project manager.

Step 7: Evergreen Analyzes Revised Panelist Methods/Conclusions

Evergreen staff reviewed all of the panelists' revised methods and conclusions. Evergreen compiled this information into one spreadsheet for analysis and reporting.

Step 8: Develop Recommended Forecast Baselines

Panelists did not reach strong consensus in their ultimate baseline forecasts. Our method for providing recommended forecast baselines in absence of strong consensus among panelists is to utilize a blended average approach.[6] The blended averages are calculated for each year based on all panelist estimates. The calculation for blended average for each year is:

[6] Parsons Brinckerhoff Quade & Douglas, Inc., 2002. *The Use of Expert Panels in Analyzing Transportation and Land Use Alternatives*. Prepared for: American Association of Highway and Transportation Officials (AASHTO) Standing Committee on Planning. Portland, Oregon. April 2002.

$$\frac{(Mean + Median)}{2}$$

We determined that the blended average approach is the most suitable for reconciling the forecasts of this panel because it retains outlier estimates, but discounts their overall impact on the forecast. A simple mean estimate approach would have allowed outliers to significantly alter the ultimate recommended baselines, whereas a simple median estimate approach would have discounted their work entirely.

1.3 Organization of Report

The remainder of this report consists of findings from Delphi panel. First, we present a detailed explanation of the panelists' methods and results. We then provide a comparison of the results for the four HPWH categories of interest.

Lastly, we provide a discussion of the results and our recommended baseline forecasts, including rationale for our recommendation.

2 Delphi Panel Analysis and Results, by Panelist

This section contains descriptions of the approach taken by each panelist, as well as the ultimate results of each panelist's analysis. Results are presented in chart and graph form.

None of the panelists believed that the potential 2015 waiver would have any significant effect on baseline or overall sales of HPWHs at any point in the study period, for any of the Tiers or tank sizes.

2.1 Panelist A

This section presents an in-depth account of the analysis conducted by expert Panelist A. Data sources used by this panelist include:

Table 2: Panelist A: Data, Data Sources, and Application of Data

Data/Input	Source
Household income, by state	U.S. Census
Population, by state	U.S. Census
Percent of NW households with electric water heaters	NEEA 2011 Water Heater Market Update
Average household electric and gas rates, by state	U.S. Energy Information Administration (EIA)
2009 HPWH sales, national	ENERGY STAR Water Heater Market Profile
2008 and 2010 HPWH sales, national	North American Heat Pump Market Overview – 2011 (Groff Associates)
Analysis of the United States Residential Water Heating Markets	Verify Markets

2.1.1 Panelist A: Analysis / Methodology

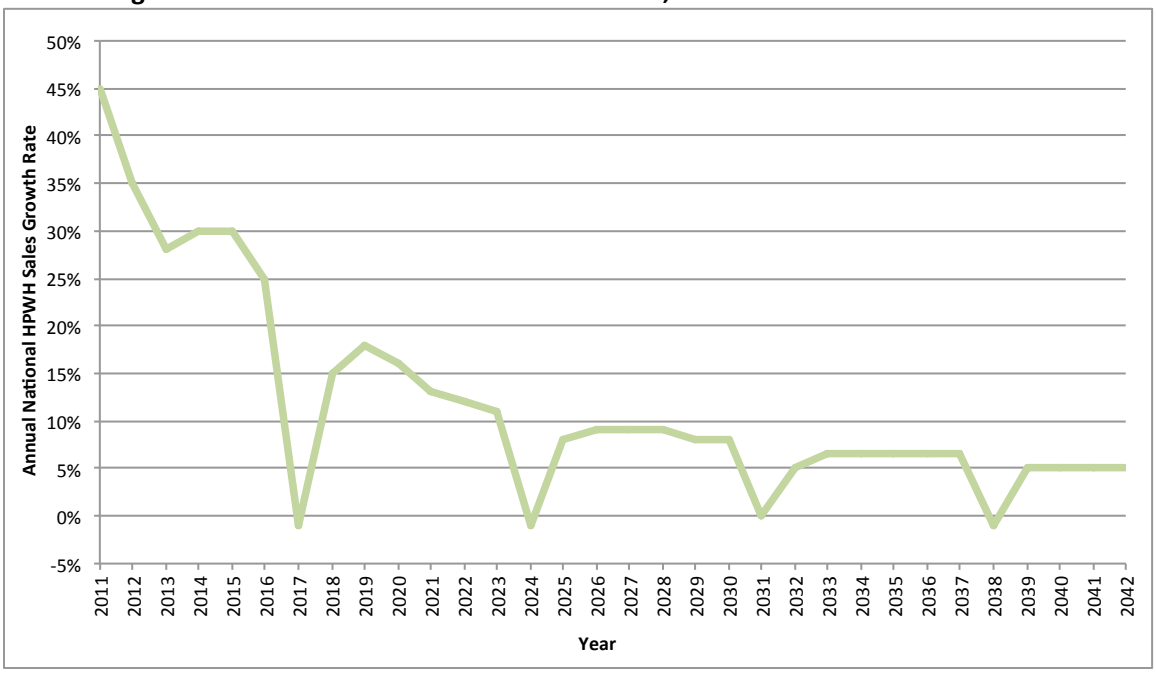
Panelist A relied on assumed 2010 national HPWH sales as a starting point for their analysis (for all types and sizes of HPWHs). Their other key assumption includes a declining rate of growth for national sales, including an "economic shock" every seven years that temporarily reduces the growth rate to between negative one and zero percent for that year.

***Assumption*:** 2010 national HPWH sales of 40,000 units.

Assumption: Growth rate from 2010 to 2011 of 45 percent.

The assumed annual national HPWH sales growth rates – in the absence of utility rebates (based on expert opinion) – are presented below in Figure 3.

Figure 3: Panelist A: Assumed Rate of Growth, National Baseline HPWH Sales

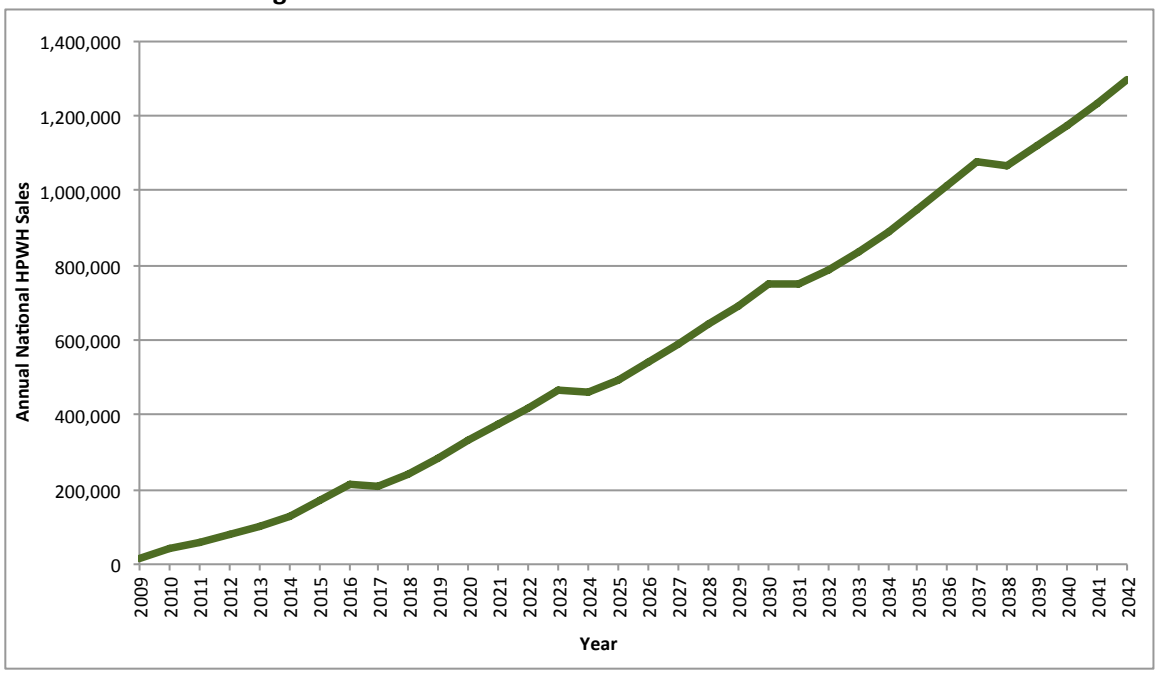


***Assumption*:** Declining annual growth rates of national baseline HPWH sales, as presented in Figure 3, above.

Assumption: "Economic shock" every seven years.

Starting with 2011, the assumed annual growth rates were applied to the baseline HPWH sales estimate from the year prior in order to estimate national baseline HPWH sales. The national sales estimates derived by Panelist A are presented next in Figure 4.

Figure 4: Panelist A: National Baseline Sales Estimates



In order to translate national HPWH sales to HPWH sales for the Northwest, Panelist A created the following four weighting factors for each of the four states in the region:

1) Economic Factor – based on overall economic conditions in the state;
2) Wealth Factor – based on the percent of "wealthier" households who would be most likely to invest in an expensive appliance (i.e., a HPWH without a rebate);
3) Favorable Utility Rates Factor – based on average electric and natural gas rates.
4) HPWH Interest Factor – based on climate / HPWH applicability and the relative "green-ness" of the population; and

The "Economic Factor" is consistent for each state over time, and is calculated using 2010 U.S. Census data. The "Economic Factor" is the ratio of a state's median annual income to the national median annual income.

The "Wealth Factor" decreases for each state over time, and is calculated using 2010 U.S. Census data. The "Wealth Factor" is the ratio of the proportion of homes in each state with household income above $100K, to the national proportion of homes with household income above $100K. The factor decreases over time as wealthier households change from being "likely adopters" to "adopters," and thus are removed from the population of likely households to adopt a HPWH.

The "HPWH Interest Factor" is consistent for each state over time. It is not a calculation, but rather an assumption about the relative interest or acceptance of HPWHs among the four states. It is based on reported Internet activity and perceived environmental interest, and is lowest for Montana (0.7) and Idaho (0.8), and highest for Oregon and Washington (1.3, each).

The "Favorable Utility Rates Factor" is a scaled factor that accounts for the relative difference in price within each state of electricity and gas. The theory is that where the ratio of $/therm to $/kWh is the highest, the market will naturally favor electric water heaters (as opposed to gas water heaters.

This panelist then weighted national HPWH sales estimates to the Northwest, by state, based on the percent of the national population (from the U.S. Census, 2010). The factors discussed above are then applied to the analysis to adjust for local conditions that are assumed to make some states more favorable than others in regards to HPWH adoption in absence of utility rebates.

The expert split the resulting overall baseline forecast HPWH sales by Tier and tank size using their expert judgment. Tier 1 sales are estimated to drop to zero in 2025 as Tier 2 sales increase and take over market share.

> ***Assumption*:** Natural evolution from Tier 1 HPWHs to Tier 2 HPWHs over time.
>
> ***Assumption:*** Long term market trend of an increase in penetration of smaller water heaters, due to reduced loads (resulting from improved showerheads and reduced water consumption of appliances).

2.1.2 Panelist A: Results

This section presents the results of the analysis and estimation described above.

Panelist A's forecast baseline estimate for Tier 1 HPWHs are shown below in Table 3, and graphically in Figure 5. As shown, Panelist A predicts no Tier 1 sales after 2025, with a peak in non-rebated sales for the smaller Tier 1 units in 2021 (10,146 HPWHs) and a peak in non-rebated sales for the larger Tier 1 units in 2023 (5,238 HPWHs).

Table 4 and Figure 6 show the forecast baseline estimates for Tier 2 HPWHs. While baseline sales of all Tier 2 HPWHs is expected to remain low in the near future, this panelist believes that baseline sales of HPWHs with tanks of 55 gallons or lower will increase to nearly 70,000 units per year by 2042. However, as mentioned above, the sales of the larger tanks are not expected to be as high, due to increased demand for smaller tanks resulting from reductions in demand for hot water.

Table 3: Panelist A: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

TIER 1 Heat Pump Water Heaters						
Year	≤55 gallons	>55 gallons		Year	≤55 gallons	>55 gallons
2009	939	506		2026	0	0
2010	2,296	765		2027	0	0
2011	3,308	1,059		2028	0	0
2012	4,141	887		2029	0	0
2013	4,890	1,129		2030	0	0
2014	4,858	2,915		2031	0	0
2015	5,646	3,764		2032	0	0
2016	6,855	4,518		2033	0	0
2017	6,741	4,137		2034	0	0
2018	7,350	4,375		2035	0	0
2019	8,467	4,750		2036	0	0
2020	9,517	4,996		2037	0	0
2021	10,146	4,806		2038	0	0
2022	10,098	5,049		2039	0	0
2023	9,821	5,238		2040	0	0
2024	7,724	4,506		2041	0	0
2025	5,522	3,797		2042	0	0

Figure 5: Panelist A: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

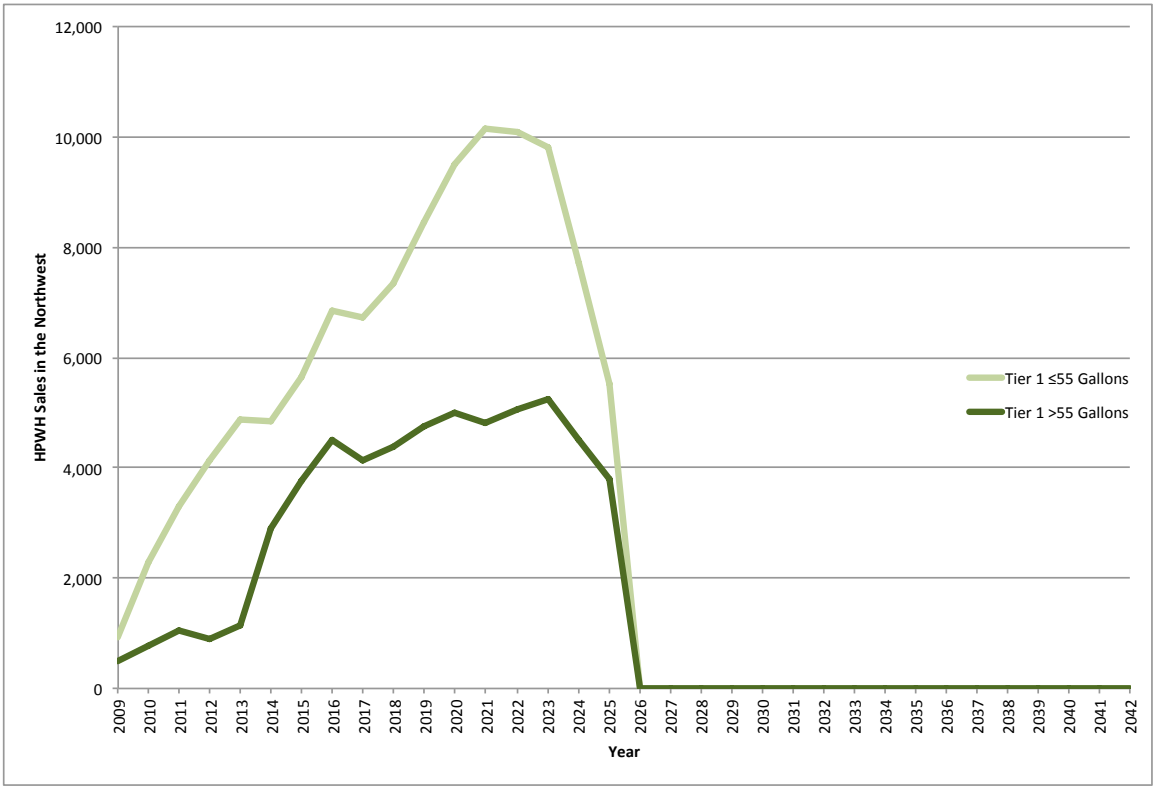
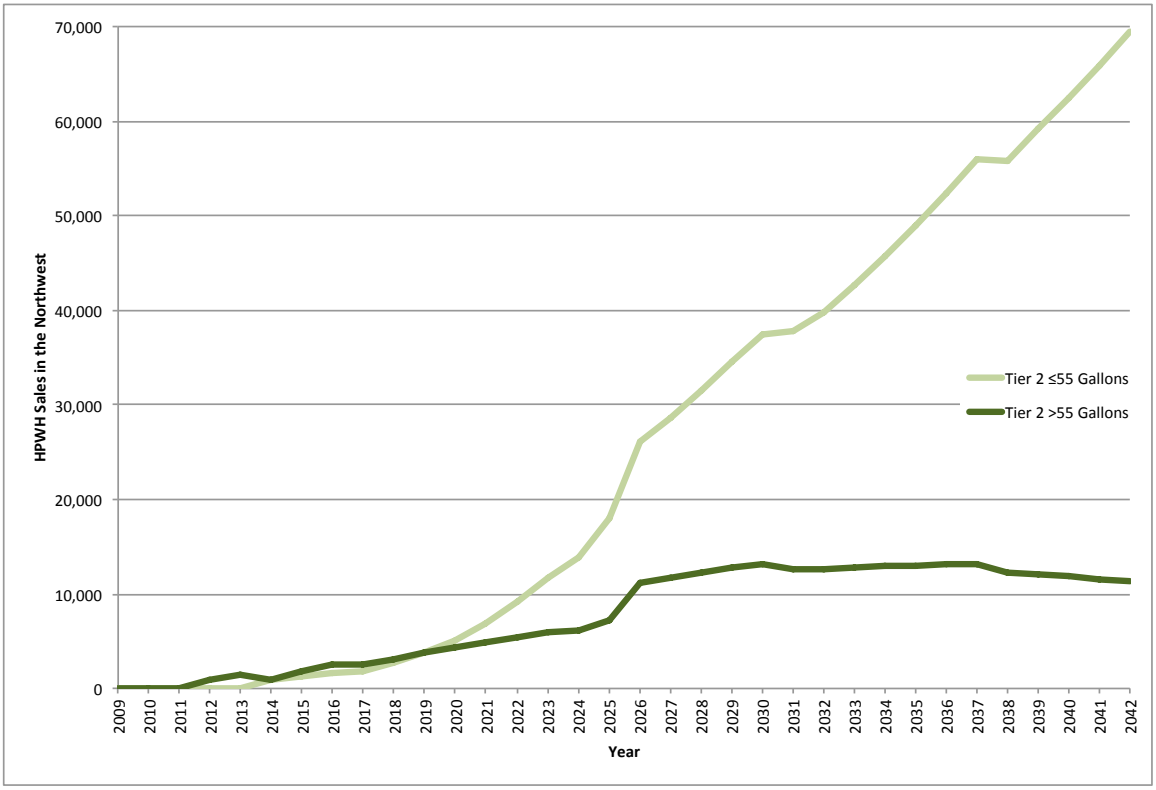


Table 4: Panelist A: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size

TIER 2 Heat Pump Water Heaters					
Year	≤55 gallons	>55 gallons	Year	≤55 gallons	>55 gallons
2009	0	0	2026	26,148	11,206
2010	0	0	2027	28,702	11,723
2011	0	44	2028	31,498	12,249
2012	0	887	2029	34,490	12,757
2013	0	1,505	2030	37,486	13,171
2014	972	972	2031	37,716	12,572
2015	1,255	1,882	2032	39,835	12,580
2016	1,714	2,493	2033	42,665	12,744
2017	1,839	2,605	2034	45,685	12,886
2018	2,625	3,150	2035	48,909	13,001
2019	3,717	3,717	2036	52,348	13,087
2020	4,996	4,282	2037	56,018	13,140
2021	6,942	4,806	2038	55,711	12,229
2022	9,207	5,346	2039	59,210	12,127
2023	11,785	5,893	2040	62,433	11,892
2024	13,839	6,115	2041	65,817	11,615
2025	17,947	7,248	2042	69,372	11,293

Figure 6: Panelist A: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size



2.2 Panelist B

This section presents an in-depth account of the analysis conducted by expert Panelist B. Data sources used by this panelist include:

Table 5: Panelist B: Data, Data Sources, and Application of Data

Data/Input	Source
Baseline forecast expert opinion; market barriers	Installers
Baseline forecast expert opinion; market barriers	Suppliers
Market barriers; acceptable cost; product history	Consumers

2.2.1 Panelist B: Analysis / Methodology

Panelist B relied on key assumptions to develop a baseline forecast for small and large Tier 1 and Tier 2 HPWHs. The panelist determined their forecast through consideration of market forces, product costs, barriers to adoption, product reliability and acceptance, and an assessment of the current economy.

The key assumptions include:

***Assumption*:** The cost of the units will remain high, which keeps consumers from purchasing the product in the absence of utility rebates. This also limits the availability.

***Assumption*:** Lack of product "history" causes a negative impact with consumers.

***Assumption*:** Installers have limited knowledge of HVAC maintenance and HVAC contractors have limited ability to service plumbing. This leaves a gap for consumers with warranty issues. This is expected to improve over time as plumbers have more experience with the technology.

***Assumption*:** Consumers are concerned with the amount of noise and vibration coming from the units. There are other technological issues with some of the Tier 2 products available, as well. Design will improve over time.

***Assumption*:** HPWHs are practical and the energy efficiency is unmatched by other water heaters. The Tier 2 specification fits the needs of the Northwest market. The Tier 1 specified HPWHs lose efficiency in unconditioned spaces.

2.2.2 Panelist B: Results

As shown in Table 6 and Figure 7, below, Panelist B estimates sales of Tier 1 HPWHs at or below 55 gallons have decreased since 2010 in the absence of utility rebates, and will drop to one per year through 2042. Despite zero baseline sales of the larger Tier 1 HPWHs with tank sizes above 55 gallons for 2011, sales are estimated to remain consistent at five per year through 2042.

Table 7 and Figure 8 contain estimates for Tier 2 HPWHs. As shown, baseline sales of all Tier 2 HPWHs are expected to remain low, but rise steadily through 2042. The larger, above 55 gallon tanks are expected to outpace the smaller tanks, reaching baseline sales of 336 large HPWHs in 2042, compared to 21 HPWHs at or below 55 gallons.

Table 6: Panelist B: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

TIER 1 Heat Pump Water Heaters					
Year	≤55 gallons	>55 gallons	Year	≤55 gallons	>55 gallons
2009	30	5	2026	1	5
2010	30	5	2027	1	5
2011	15	0	2028	1	5
2012	1	5	2029	1	5
2013	1	5	2030	1	5
2014	1	5	2031	1	5
2015	1	5	2032	1	5
2016	1	5	2033	1	5
2017	1	5	2034	1	5
2018	1	5	2035	1	5
2019	1	5	2036	1	5
2020	1	5	2037	1	5
2021	1	5	2038	1	5
2022	1	5	2039	1	5
2023	1	5	2040	1	5
2024	1	5	2041	1	5
2025	1	5	2042	1	5

Figure 7: Panelist B: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

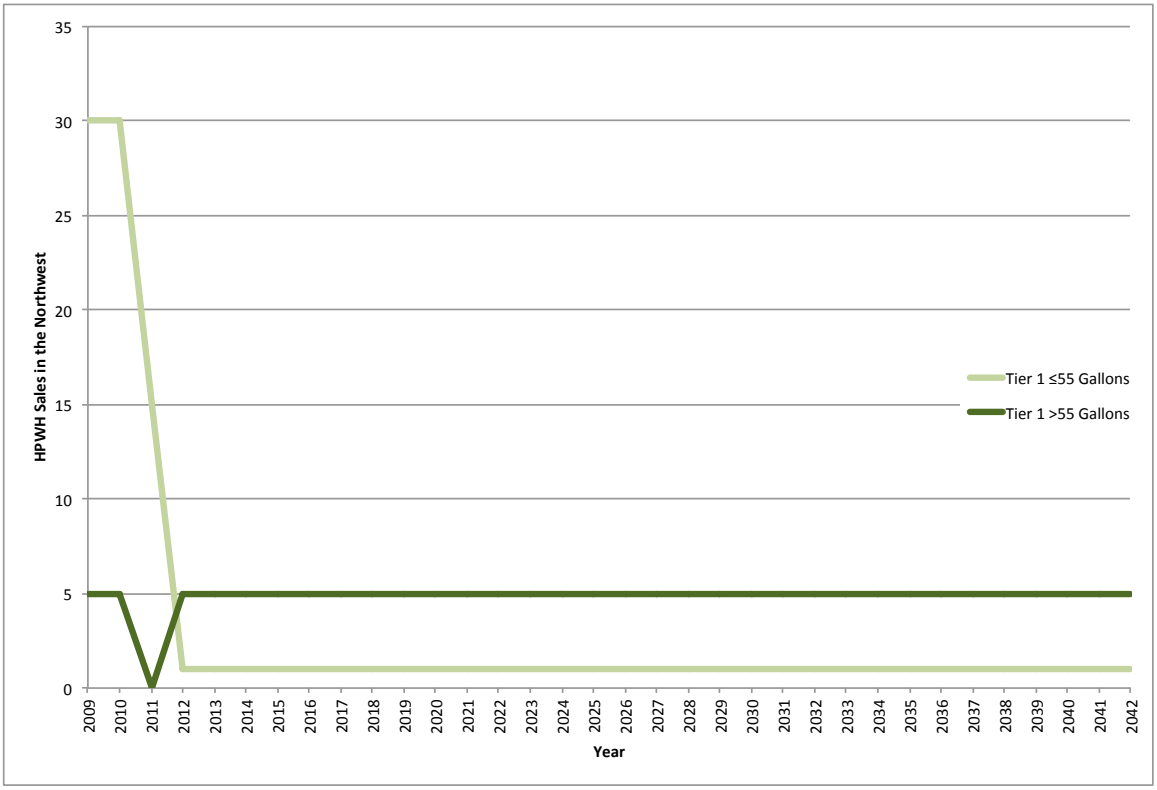
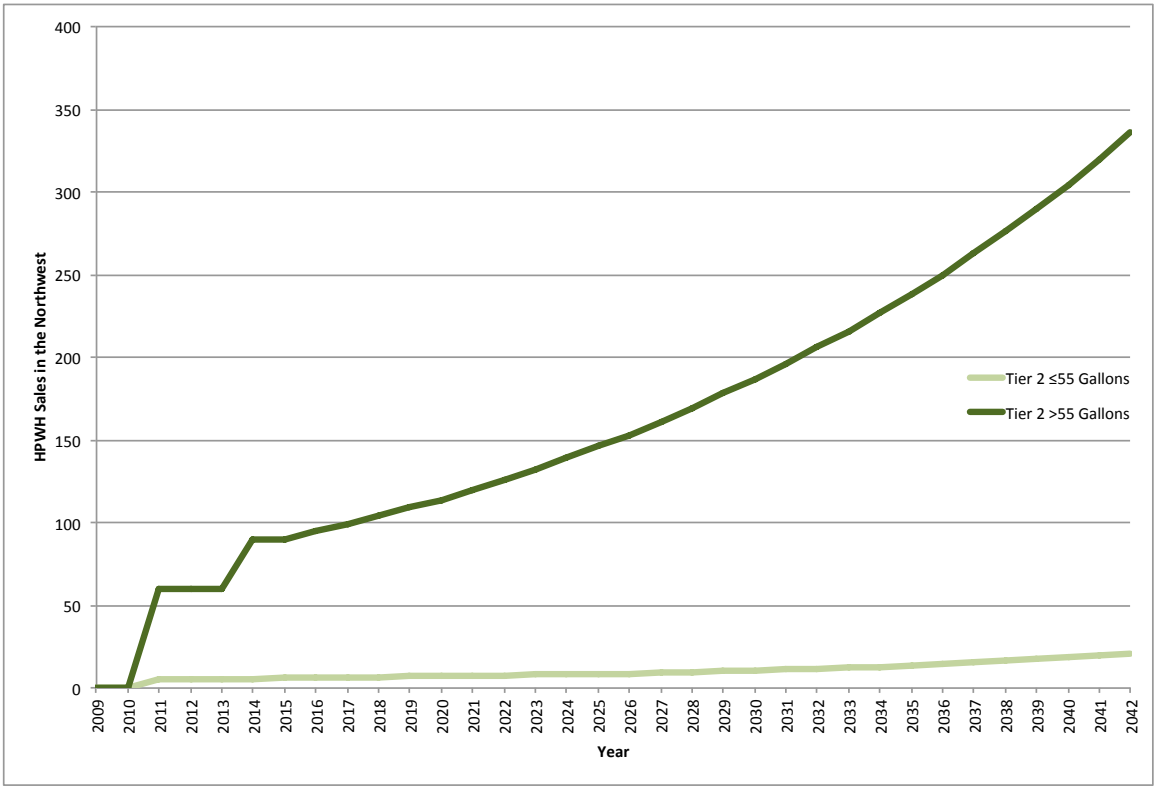


Table 7: Panelist B: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size

TIER 2 Heat Pump Water Heaters						
Year	≤55 gallons	>55 gallons		Year	≤55 gallons	>55 gallons
2009	0	0		2026	8	153
2010	0	0		2027	9	161
2011	5	60		2028	9	169
2012	5	60		2029	10	178
2013	5	60		2030	10	187
2014	5	90		2031	11	196
2015	6	90		2032	12	206
2016	6	95		2033	13	216
2017	6	99		2034	13	227
2018	6	104		2035	14	238
2019	7	109		2036	15	250
2020	7	114		2037	16	263
2021	7	120		2038	17	276
2022	7	126		2039	18	290
2023	8	132		2040	19	304
2024	8	139		2041	20	320
2025	8	146		2042	21	336

Figure 8: Panelist B: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size



2.3 Panelist C

This section presents an in-depth account of the analysis conducted by expert Panelist C. Data sources used by this panelist include:

Table 8: Panelist C: Data, Data Sources, and Application of Data

Data/Input	Source
NW population and households forecast	U.S. Census
2011 national HPWH sales estimate	BSRIA
Total NW water heater market	NEEA 2011 Water Heater Market Update
Percent of total NW water heater market that are electric water heaters	NEEA 2011 Water Heater Market Update

2.3.1 Panelist C: Analysis / Methodology

Panelist C began their analysis with "best guess" baseline 2009 – 2012 HPWH sales for the Northwest. These were based on industry forecasts and include reductions related to rebate program sales. Panelist C does not believe there have been, or will be, any significant baseline sales of Tier 2 HPWHs at or below 55 gallons.

> ***Assumption*:** There will be no Tier 2 HPWHs below 55 gallons because the DOE draw profile will change, which in turn will reduce the rated performance of current 55 gallon (and smaller) units below the ENERGY STAR level.

The expert also based their analysis on a series of assumptions about the market. These include the following:

> ***Assumption*:** Ten percent of national HPWH sales are assumed to be in the Northwest, which is the starting point for the forecast analysis.

> ***Assumption*:** Heat pump water heater price will remain stable. This is in part due to material cost, and in part due to mature component technologies.

> ***Assumption*:** "Green Acceptance Factor" – HPWH technology will have a slightly higher acceptance in the Northwest because the population is more concerned about the environment than many other portions of the country.

> ***Assumption*:** Total Northwest electric water heaters above 55 gallons estimated at 20,021 units.

For 2013, the 2012 baseline sales are increased at the rate of population growth – assumed to be one percent per year for the Northwest.

> ***Assumption*:** The population of the Northwest grows at a rate of one percent per year during the forecast period.

Panelist C's analysis treats the large and small HPWHs independently after 2013. For 2014 the smaller Tier 1 HPWHs are anticipated to continue baseline sales growth in lockstep with population, but from 2015 and on, other factors are included in Panelist C's analysis.

Beginning in 2015, the baseline sales of the smaller Tier 1 HPWHs remain tied to population growth. However, between 2015 and 2020, Panelist C predicts that baseline sales growth will also be impacted by a halo effect, producing an additional five percent growth per year. From 2021 through 2042, the halo effect becomes stronger and is estimated to translate into eight percent growth, above the population-related growth in baseline sales. The halo effect is an increase of product demand due to increasing product familiarity. Panelist C believes that contractors, retailers and homeowners will become more knowledgeable and comfortable with HPWH technology as a result of the regulatory requirements for HPWHs over 55 gallons. This comfort level is estimated to have a positive impact on smaller water heater users as well.

> ***Assumption*:** Halo effect of five percent per year between 2015 and 2020. Halo effect of eight percent per year between 2021 and 2042. The halo effect only applies to the HPWHs at or below 55 gallons.

Panelist C relied on a slightly different set of calculations for forecasting baseline sales of Tier 1 and Tier 2 HPWHs above 55 gallons. Baseline sales for both product classes will increase in 2014, outpacing population growth as production ramps up in anticipation of the federal standards in 2015. Panelist C estimates that 75 percent of these sales will be of Tier 1 models and 25 percent will be Tier 2.

> ***Assumption*:** For 2014, among the HPWHs with tank sizes above 55 gallons, approximately 75 percent are Tier 1 HPWHs.

Starting in 2015, Panelist C forecasts that of the estimated 20,021 electric water heaters above 55 gallons sold annually in the Northwest, 75 percent will be HPWHs (the rest will be either another technology, such as solar, or households that replace a 55 gallon or larger tank with two less than 55 gallon tanks).

> ***Assumption*:** Of the 20,021 electric water heaters above 55 gallons in the Northwest, and due to the assumed building code change for 2015, 75 percent – approximately 15,016 – will switch to HPWHs.

Of all baseline sales of HPWHs above 55 gallons, 70 percent are assumed to be Tier 1, and 30 percent Tier 2.

> ***Assumption*:** For 2015 and beyond, approximately 70 percent of HPWHs above 55 gallons are Tier 1.

Increased demand over the forecast period is attributed to population growth in the Northwest, assumed to be one percent per year.

2.3.2 Panelist C: Results

Table 9 and Figure 9 show Panelist C's forecast estimates for Tier 1 HPWHs. As shown, baseline sales of the larger tanks increase significantly with the onset of the federal standards in 2015, and then continue to grow with population over the remainder of the forecast period (assumed to be one percent annual population growth). The smaller Tier 1 HPWHs growth starts around one percent, but increases over time due to the halo effect, discussed above.

Table 10 and Figure 10 show forecast estimates for Tier 2 HPWHs. As shown, Panelist C believes there will be no baseline sales of Tier 2 HPWHs at or below 55 gallons. Baseline sales of larger Tier 2 HPWHs are expected to grow with population, similar to the larger Tier 1 models.

Table 9: Panelist C: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

TIER 1 Heat Pump Water Heaters						
Year	≤55 gallons	>55 gallons		Year	≤55 gallons	>55 gallons
2009				2026	1,833	11,844
2010	600	200		2027	2,000	11,962
2011	700	200		2028	2,181	12,082
2012	750	150		2029	2,379	12,203
2013	758	152		2030	2,595	12,325
2014	765	1,730		2031	2,831	12,448
2015	811	10,616		2032	3,088	12,573
2016	860	10,722		2033	3,369	12,698
2017	913	10,829		2034	3,675	12,825
2018	968	10,938		2035	4,008	12,954
2019	1,026	11,047		2036	4,372	13,083
2020	1,088	11,158		2037	4,769	13,214
2021	1,187	11,269		2038	5,202	13,346
2022	1,295	11,382		2039	5,674	13,480
2023	1,413	11,496		2040	6,190	13,614
2024	1,541	11,611		2041	6,752	13,751
2025	1,681	11,727		2042	7,365	13,888

Figure 9: Panelist C: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

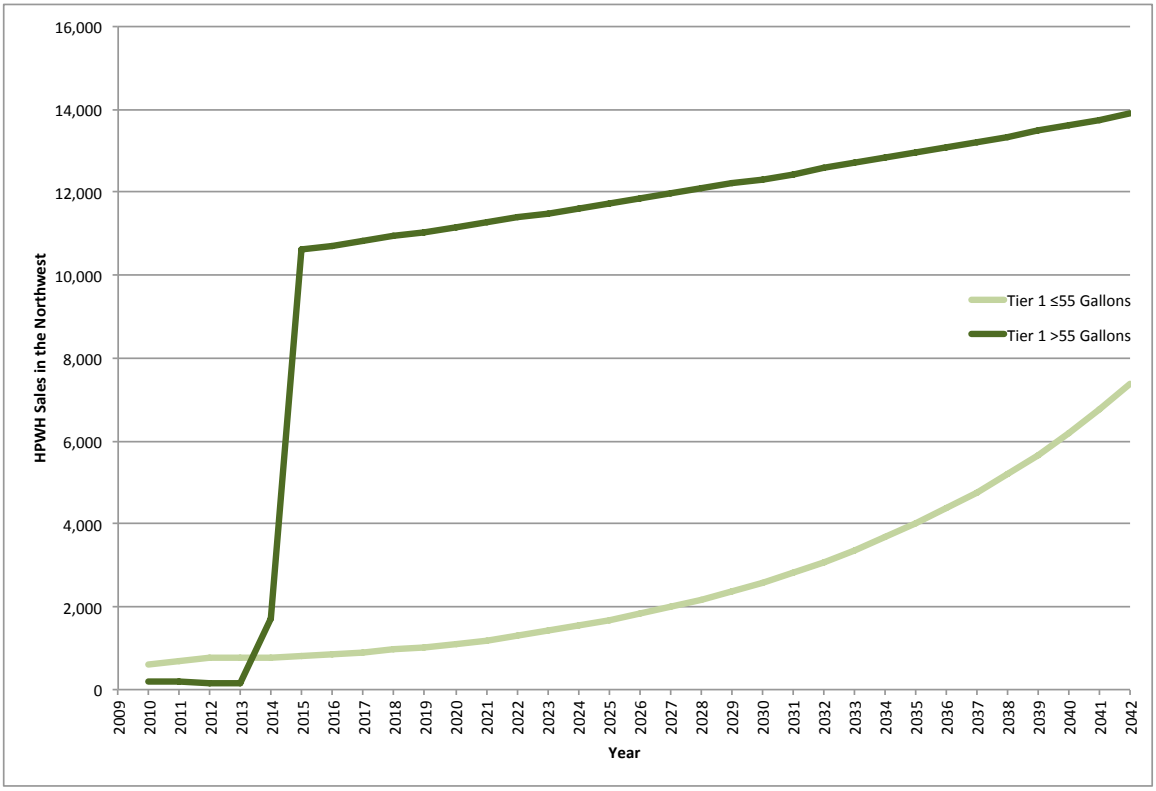
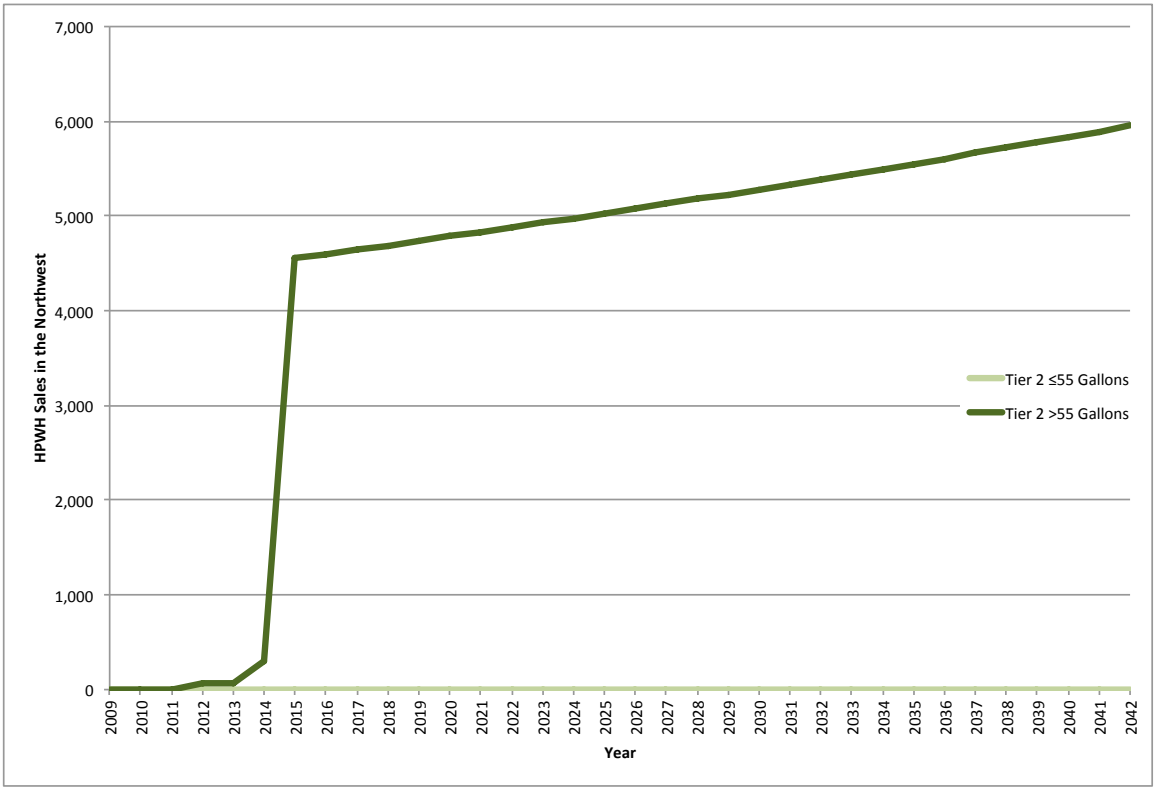


Table 10: Panelist C: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size

TIER 2 Heat Pump Water Heaters					
Year	≤55 gallons	>55 gallons	Year	≤55 gallons	>55 gallons
2009	0	0	2026	0	5,076
2010	0	0	2027	0	5,127
2011	0	0	2028	0	5,178
2012	0	75	2029	0	5,230
2013	0	76	2030	0	5,282
2014	0	302	2031	0	5,335
2015	0	4,550	2032	0	5,389
2016	0	4,596	2033	0	5,443
2017	0	4,642	2034	0	5,497
2018	0	4,688	2035	0	5,552
2019	0	4,735	2036	0	5,607
2020	0	4,782	2037	0	5,664
2021	0	4,830	2038	0	5,720
2022	0	4,878	2039	0	5,777
2023	0	4,927	2040	0	5,835
2024	0	4,976	2041	0	5,893
2025	0	5,026	2042	0	5,952

Figure 10: Panelist C: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size



2.4 Panelist D

This section presents an in-depth account of the analysis conducted by expert Panelist D. Data sources used by this panelist include:

Table 11: Panelist D: Data, Data Sources, and Application of Data

Data/Input	Source
Annual NW water heater sales (all types)	NEEA 2011 Water Heater Market Update
Percent of NW households with electric water heaters	NEEA 2011 Water Heater Market Update
Preliminary national forecasts	Verify Markets
HPWH shipment estimates	U.S. EPA

2.4.1 Panelist D: Analysis / Methodology

This expert relied on the general assumption that due to lower electric rates it is likely that HPWH sales in the Northwest will lag behind other areas of the country with higher electric rates (assuming no incentives, or marketing efforts by program sponsors). Lower electric rates lead to a longer payback period for HPWHs in the Northwest than in other regions.

> ***Assumption*:** Lower electric rates in the Northwest lead to a payback period of about five years (compared to three years or less in other areas of the country).

Panelist D started their analysis with the estimate that one percent of the electric water heater market in the Northwest is comprised of baseline Tier 1 HPWH sales, with 95 percent of Tier 1 HPWHs having tank sizes of 55 gallons or less. The other five percent of Tier 1 HPWH sales are of tanks above 55 gallons. This expert estimates that Tier 2 baseline sales are one-tenth of the sales of Tier 1 units, for both tank sizes.

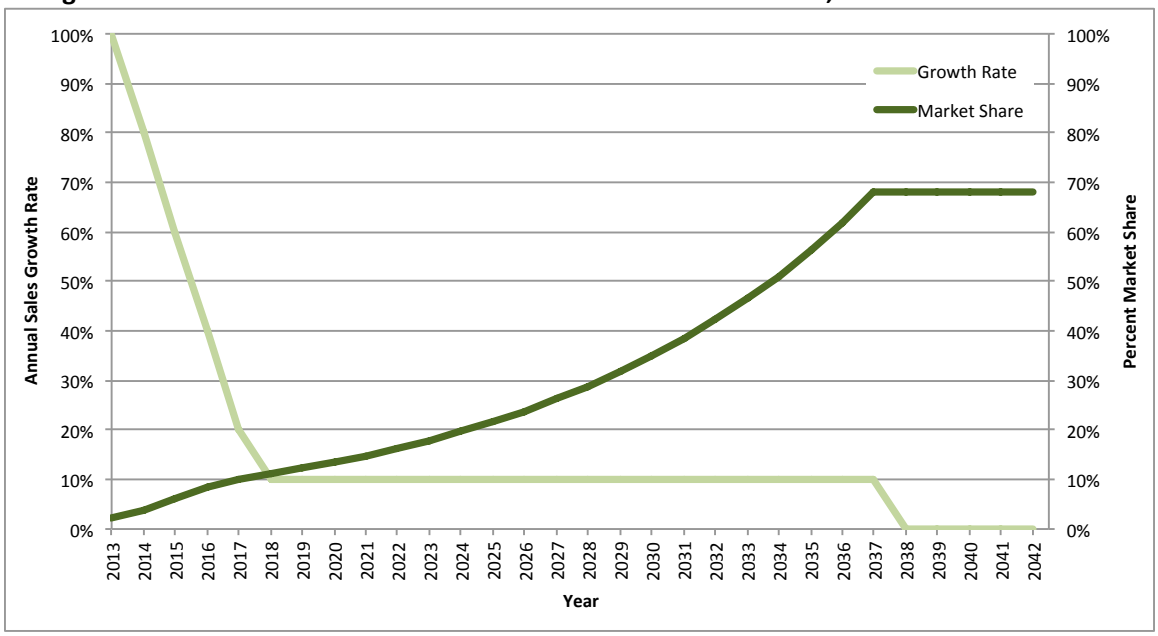
> ***Assumption*:** 95 percent of water heaters are at or below 55 gallons. Five percent of water heaters are above 55 gallons.

> ***Assumption*:** Baseline Tier 2 HPWH sales are equal to ten percent of baseline Tier 1 HPWH sales due to higher installed cost and installation difficulty.

Between 2012 and 2014, sales of all HPWH categories are derived by applying the above assumed factors to the sales of Tier 1 HPWHs with tanks at or below 55 gallons. In 2013 baseline sales double for each category, but then the panelist predicts a decline in the growth rate over time. Between 2013 and 2014 they estimate 80 percent growth.

Figure 11, below, shows the growth rate and market share for all HPWHs at or below 55 gallons. Between 2014 and 2015 baseline sales of the smaller tanks are expected to grow at a rate of 60 percent, then 40 percent between 2015 and 2016, and then 20 percent between 2016 and 2017. The growth rate continues for the smaller tank category, growing by ten percent from 2017 through 2037, ultimately leveling off in 2038 between 60 and 70 percent market share of all electric water heaters at or below 55 gallons. The baseline sales are expected to remain split 90/10 between smaller Tier 1 and Tier 2 HPWHs.

Figure 11: Baseline Sales Growth Rate and Percent Market Share, all HPWHs ≤55 Gallons



***Assumption*:** Baseline sales level off between 60 and 70 percent market share because not all homes will be able to reasonably accommodate a HPWH. Resistance water heaters will remain available for these cases.

Starting in 2015 due to the national standards, baseline sales growth is dependent on tank size; the baseline sales of HPWHs above 55 gallons are no longer pegged to the baseline sales of the smaller HPWHs. Due to national standards, Panelist D estimates that all future electric water heater sales in the Northwest will be HPWHs, regardless of utility incentive programs. Baseline sales of HPWHs above 55 gallons remain constant at 16,137, exactly five percent of the Northwest electric water heater market. Of those, 14,670 are Tier 1, and 1,467 are Tier 2 (95 and 5 percent, respectively).

***Assumption*:** All water heaters above 55 gallons sold in 2015 and subsequent years will be HPWHs.

2.4.2 Panelist D: Results

As shown in Table 12 and Figure 12, baseline sales of Tier 1 HPWHs are expected to increase substantially from 2012 estimates. For smaller tanks, Panelist D predicts increased baseline sales through 2037, which level off at 120,970 through 2042. For larger Tier 1 HPWHs, baseline sales will jump from 334 in 2014 to 14,670 in 2015, and are estimated to remain at that level of sales through 2042.

Table 13 and Figure 13 show the baseline forecasts for Tier 2 HPWHs. Market size for Tier 2 HPWHs is expected to be one-tenth that of Tier 1 HPWHs.

Panelist D did not estimate baseline market share for 2009-2011.

Table 12: Panelist D: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

TIER 1 Heat Pump Water Heaters						
Year	≤55 gallons	>55 gallons		Year	≤55 gallons	>55 gallons
2009				2026	42,399	14,670
2010				2027	46,639	14,670
2011				2028	51,303	14,670
2012	1,858	93		2029	56,433	14,670
2013	3,716	186		2030	62,077	14,670
2014	6,690	334		2031	68,284	14,670
2015	10,703	14,670		2032	75,113	14,670
2016	14,985	14,670		2033	82,624	14,670
2017	17,981	14,670		2034	90,887	14,670
2018	19,780	14,670		2035	99,975	14,670
2019	21,758	14,670		2036	109,973	14,670
2020	23,933	14,670		2037	120,970	14,670
2021	26,327	14,670		2038	120,970	14,670
2022	28,959	14,670		2039	120,970	14,670
2023	31,855	14,670		2040	120,970	14,670
2024	35,041	14,670		2041	120,970	14,670
2025	38,545	14,670		2042	120,970	14,670

Figure 12: Panelist D: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

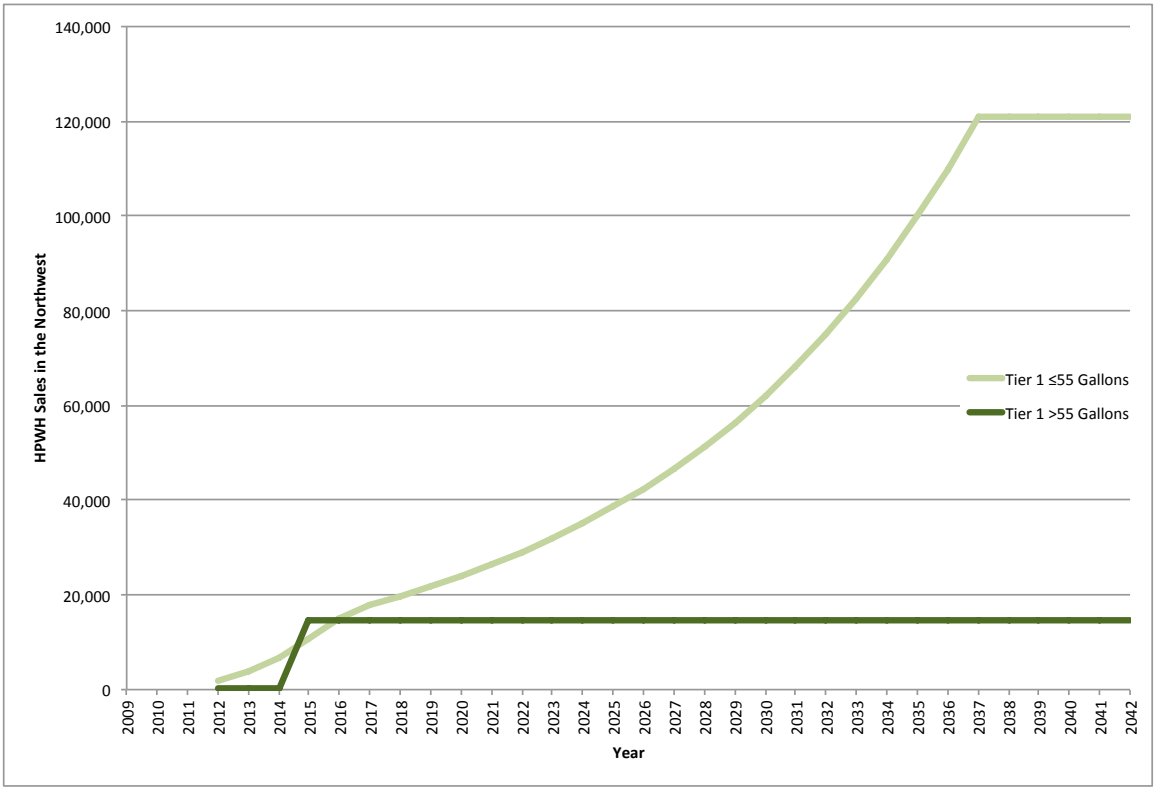
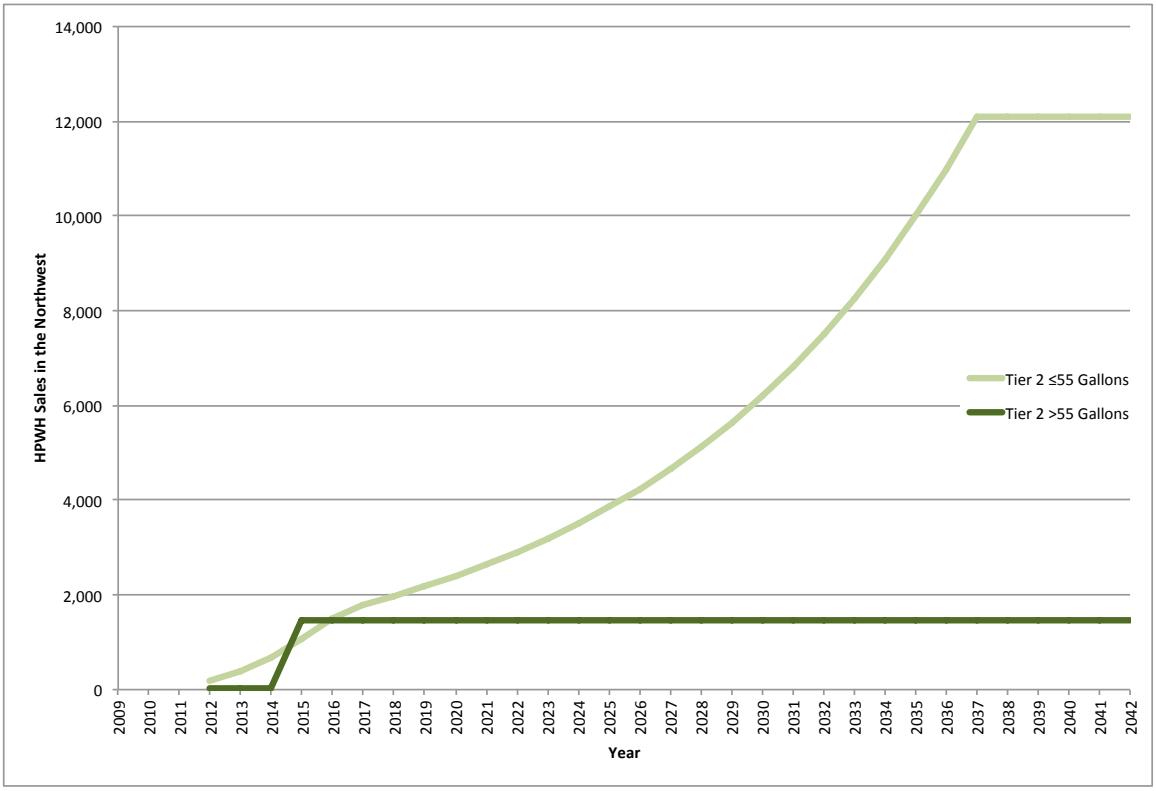


Table 13: Panelist D: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size

TIER 2 Heat Pump Water Heaters						
Year	≤55 gallons	>55 gallons		Year	≤55 gallons	>55 gallons
2009				2026	4,240	1,467
2010				2027	4,664	1,467
2011				2028	5,130	1,467
2012	186	9		2029	5,643	1,467
2013	372	19		2030	6,208	1,467
2014	669	33		2031	6,828	1,467
2015	1,070	1,467		2032	7,511	1,467
2016	1,498	1,467		2033	8,262	1,467
2017	1,798	1,467		2034	9,089	1,467
2018	1,978	1,467		2035	9,998	1,467
2019	2,176	1,467		2036	10,997	1,467
2020	2,393	1,467		2037	12,097	1,467
2021	2,633	1,467		2038	12,097	1,467
2022	2,896	1,467		2039	12,097	1,467
2023	3,186	1,467		2040	12,097	1,467
2024	3,504	1,467		2041	12,097	1,467
2025	3,854	1,467		2042	12,097	1,467

Figure 13: Panelist D: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size



2.5 Panelist E

This section presents an in-depth account of the analysis conducted by expert Panelist E. Data sources used by this panelist include:

Table 14: Panelist E: Data, Data Sources, and Application of Data

Data/Input	Source
Annual NW water heater sales (all types)	NEEA 2011 Water Heater Market Update
Percent of NW households with electric water heaters	NEEA 2011 Water Heater Market Update
Percent of NW electric water heaters, by tank size	NEEA 2012 Residential Building Stock Assessment (RBSA)
Water heater annual energy consumption	Proprietary
HPWH incremental cost	Energy Star Water Heater Market Profile
Standard resistance water heater Energy Factor (EF)	Energy Star Water Heater Market Profile
Kastovich Market Penetration Curve	"Advanced Electric Heat Pump Market and Business Analysis" (Kastovich, J.C., Lawrence, R.R., Hoffman, R.R., and Pavlak, C., 1982)

2.5.1 Panelist E: Analysis / Methodology

Panelist E developed a single baseline forecast estimate of all Tier 1 and Tier 2 HPWH sales in the Northwest. Their analysis is based on economics and the relative "utility" of HPWHs and other competing technologies, where utility is defined as reasons people purchase certain technologies outside of pure economic considerations.

> ***Assumption***: Baseline penetration of HPWHs is driven primarily by technology diffusion and first cost premiums and payback times.

> ***Assumption***: HPWHs compete for market share with other high-tech water heating technologies.

In addition to the data sources listed in Table 14, Panelist E relied on the following key assumptions and assumed parameters to guide their analysis:

> ***Assumption***: The gas and electric water heater market share will remain fixed over time.

> ***Assumption***: HPWH effective useful life is 12 years.

> ***Assumption***: Electric resistance water heaters will increase in cost in 2016 by $100 as the result of 2015 national standards.

> ***Assumption***: Average electricity cost is $0.07/kWh. The cost of electricity will escalate at a rate of 1.2 percent per year.

***Assumption*:** HPWH purchase price will decrease at a rate of three percent per year between 2013 and 2017. Price will remain at 2017 levels thereafter.

With this information, Panelist E calculated the cost of operation of HPWHs and other competing technologies. They then calculated the payback period, based on the electric rate in the current year and assumed incremental cost of HPWHs and standard water heater cost. The payback period dictates the unrestrained share of HPWHs and the other technologies, per the Kastovich Market Penetration Curves. The unrestrained share is multiplied by 80 percent, due to the assumption that while the payback may dictate adoption, approximately 20 percent of households will remain unwilling to switch technologies.

***Assumption*:** Despite payback conditions that dictate a certain proportion of the population will adopt a HPWH (or other high-tech water heater), only 80 percent of that market share will be realized due to conversion "willingness".

In Panelist E's analysis, the unrestrained shares are normalized by the relative utility of each competing technology, incorporating purchase decision factors beyond pure economics. In this case, utility is a score used to modify the market penetration calculated from the payback-acceptance curve to reflect non-cost criteria that influence choice (e.g., noise, space issues, convenience, product appeal, etc.).

In order to convert the normalized shares Panelist E relied on a Bass diffusion curve, started at year five, to approximate current competing efficient electric water heater market shares. The Bass diffusion curve estimates the rate of diffusion – essentially the rate at which new technologies are adopted over time. The result is a forecast that predicts market share of HPWHs and other competing technologies from 2012 to 2025, at which point Panelist E believes the market will become flat, with no further increases in baseline sales growth.

Lastly, the number of baseline HPWH sales is calculated by multiplying the market share and the overall market size for electric water heaters in the Northwest, adjusted annually to incorporate annual growth in the housing market.

***Assumption*:** Housing market in the Northwest will grow at 1.5 percent annually through 2025.

Panelist E created a factor matrix for determining the shares of HPWHs that are Tier 1 versus Tier 2, and for those above 55 gallons and those at or below 55 gallons. They estimate that approximately 12.5 percent of all baseline HPWH sales will be Tier 2, and 87.5 percent will be Tier 1. Based on NEEA's Residential Building Stock Assessment, they use the estimate that 88.3 percent of electric water heaters are at or below 55 gallons, and 11.7 percent are above. These factors were applied to the overall baseline forecast of HPWHs to estimate baseline sales for each category.

2.5.2 Panelist E: Results

Shown in Table 15 and Figure 14 are Panelist E's estimates for baseline forecast sales of Tier 1 HPWHs, by tank size. Shown in Table 16 and Figure 15 are estimates for Tier 2 HPWHs. Estimates for both tiers, and for HPWHs above 55 gallons and at or below 55 gallons follow a traditional forecast market curve, albeit at significantly different rates of growth.

Panelist E's analysis concludes that baseline sales of Tier 1 HPWHs at or below 55 gallons will increase from 2,684 units in 2012 to 26,152 units in 2025, and then will remain flat thereafter. Baseline sales of Tier 1 HPWHS above 55 gallons will peak at 3,465 units in 2025.

Regarding Tier 2 HPWHs, the smaller models will reach 3,736 baseline unit sales in 2025, whereas sales for the larger tanks will increase to 495 HPWHs per year, in the absence of utility rebate programs.

Panelist E did not estimate baseline market share for 2009-2011.

Table 15: Panelist E: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

TIER 1 Heat Pump Water Heaters						
Year	≤55 gallons	>55 gallons		Year	≤55 gallons	>55 gallons
2009				2026	26,152	3,465
2010				2027	26,152	3,465
2011				2028	26,152	3,465
2012	2,684	356		2029	26,152	3,465
2013	4,053	537		2030	26,152	3,465
2014	6,016	797		2031	26,152	3,465
2015	8,987	1,191		2032	26,152	3,465
2016	13,991	1,854		2033	26,152	3,465
2017	17,215	2,281		2034	26,152	3,465
2018	19,441	2,576		2035	26,152	3,465
2019	21,249	2,815		2036	26,152	3,465
2020	22,646	3,001		2037	26,152	3,465
2021	23,704	3,141		2038	26,152	3,465
2022	24,512	3,248		2039	26,152	3,465
2023	25,152	3,333		2040	26,152	3,465
2024	25,684	3,403		2041	26,152	3,465
2025	26,152	3,465		2042	26,152	3,465

Figure 14: Panelist E: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

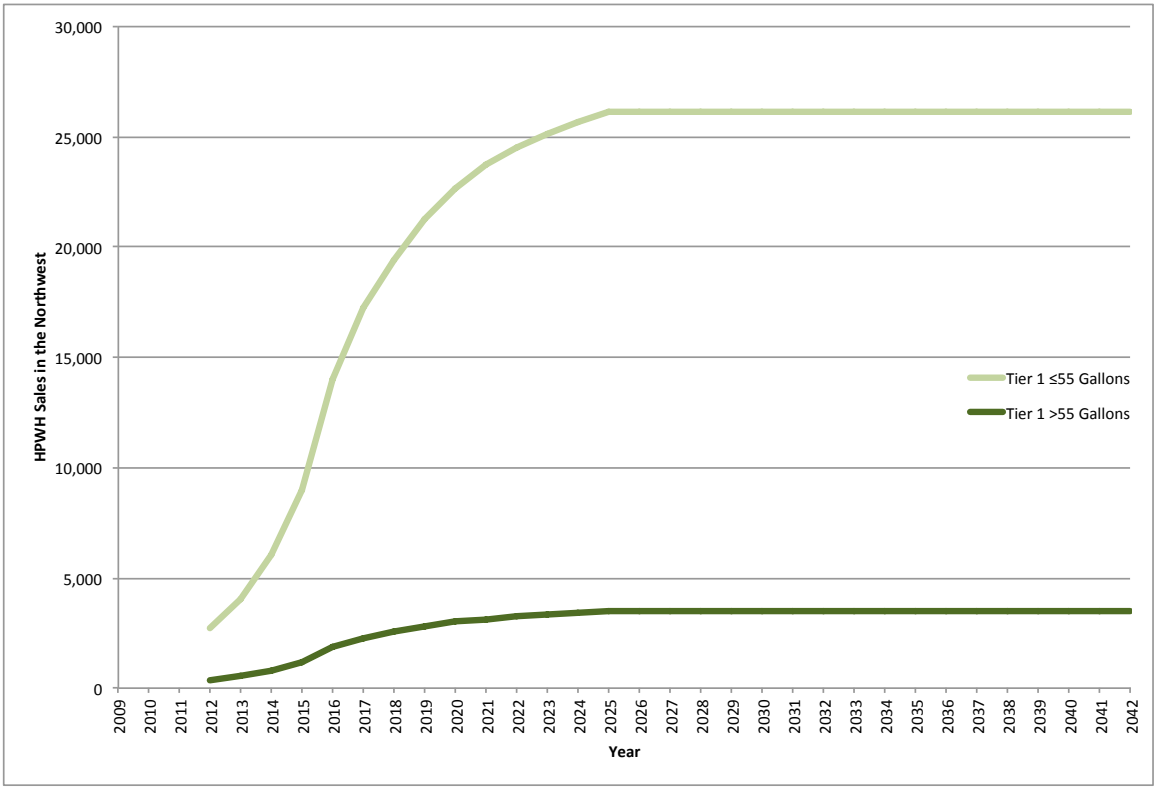
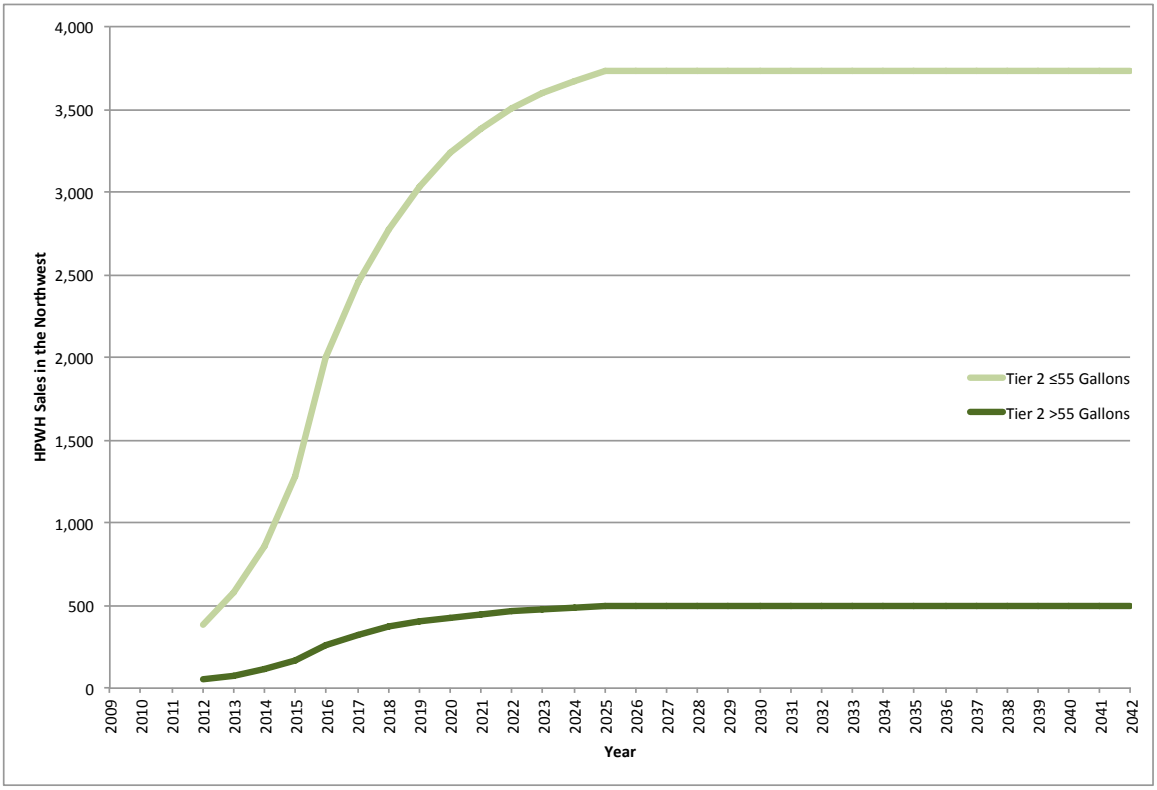


Table 16: Panelist E: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size

TIER 2 Heat Pump Water Heaters						
Year	≤55 gallons	>55 gallons		Year	≤55 gallons	>55 gallons
2009				2026	3,736	495
2010				2027	3,736	495
2011				2028	3,736	495
2012	383	51		2029	3,736	495
2013	579	77		2030	3,736	495
2014	859	114		2031	3,736	495
2015	1,284	170		2032	3,736	495
2016	1,999	265		2033	3,736	495
2017	2,459	326		2034	3,736	495
2018	2,777	368		2035	3,736	495
2019	3,036	402		2036	3,736	495
2020	3,235	429		2037	3,736	495
2021	3,386	449		2038	3,736	495
2022	3,502	464		2039	3,736	495
2023	3,593	476		2040	3,736	495
2024	3,669	486		2041	3,736	495
2025	3,736	495		2042	3,736	495

Figure 15: Panelist E: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size



2.6 Panelist F

This section presents an in-depth account of the analysis conducted by expert Panelist F. Data used by this panelist include:

Table 17: Panelist F: Data, Data Sources, and Application of Data

Data/Input	Source
2010 total water heater sales, national	NEEA 2011 Water Heater Market Update
2004, 2009, 2011-2012 total water heater sales, national	AHRI Residential Storage Water Heaters Historical Data
2010 electric storage water heater sales, NW	NEEA 2011 Water Heater Market Update
Planned water heater sales estimate; new construction water heater sales estimate	NEEA 2011 Water Heater Market Update
Fuel switch rate estimates	NEEA 2011 Water Heater Market Update

2.6.1 Panelist F: Analysis / Methodology

Panelist F began their analysis by constructing a forecast of total water heater shipments in the U.S. They relied on estimates from AHRI and the NEEA 2011 Water Heater Market Update report for estimates through 2012. Their forecast assumes that total shipments will increase to "pre-recession levels" by 2016 (roughly 9.6 million water heaters per year). After 2016, Panelist F assumes that shipments will continue to increase at a rate of 1.5 percent per year, through the remainder of the study period.

> ***Assumption*:** From 2012 to 2016, U.S. water heater shipments will grow to reach 2004 levels.

> ***Assumption*:** growth rate from 2016 to 2042 assumed 1.5 percent growth per year.

Panelist F relies on the 2011 Water Heater Market Update for total 2010 Northwest storage water heater sales (326,000 total water heaters) and, relying on the same source, estimates that 62.5 percent of total Northwest storage water heater sales are of electric storage water heaters (203,750 electric water heaters). They assume that the ratio of electric resistance water heaters sold in the Northwest to the total water heater shipments to the U.S. will remain constant, except for a 2 percent per year fuel-switching trend through 2020. From 2010 to 2020, the proportion of total U.S. water heater shipments made up by Northwest electric resistance water heater sales drops from 2.65 percent to 2.20 percent, and remains constant thereafter (in this analysis).

> ***Assumption*:** Northwest electric resistance water heater sales are proportionally related to total U.S. water heater shipments.

> ***Assumption*:** Two percent annual fuel switching (from electric to gas) through 2020.

2.6.1.1 Panelist F: Analysis / Method for Voluntary Purchases (2009-2024)

Through 2015, Panelist F assumes that almost all HPWH sales will occur in the new construction or planned replacements market (as opposed to emergency replacement). Therefore, they apply factors for "total potential market size for voluntary HPWH sales in the Northwest" in order to cap the estimated fraction of total electric resistance water heaters sold in the Northwest that are heat pump water heater models. Panelist F assumes that 25 percent of water heater sales are planned replacements, and that the new construction market will pick up from roughly seven percent (currently) to 20 percent per year in 2016 (remaining constant thereafter).

> ***Assumption*:** One quarter (25%) of water heater sales are planned.
>
> ***Assumption*:** New construction will increase from seven percent growth per year to 20 percent, by 2016.
>
> ***Assumption*:** HPWH sales driven by voluntary water heater sales market (not emergency replacement).

Next, Panelist F incorporates four key factors (the first three are assumed; the fourth is based on end-user survey data) into their analysis:

1) **Percent of homes with suitable space for HPWHs** – assumed at 60 percent through 2015, and then increases one percent every other year through 2024 (to 65%), due to advances in HPWH design, as well as homes built with HPWH spacing needs in mind.
2) **Informed consumers** – assumed at 30 percent of the Northwest population in 2009, and roughly 50 percent currently. This will continue to increase to 80 percent in 2016, and will remain constant until increasing up to 85 percent in 2023.
3) **Consumers who are willing to pay upfront cost of HPWHs** – assumed 15 percent from 2009-present, then up one percent per year through 2023 (25%).
4) **Fraction of electric resistance water heaters not covered by mandate (and replaceable by a HPWH)** – estimated from survey data from the NEEA 2011 Water Heater Market Update report regarding tank size (from survey table H-03, Appendix D), 75 percent of installed base is greater than 38 gallons and less than 55 gallons and therefore a possible voluntary HPWH purchaser (not impacted by the 2015 mandate). The fraction is assumed to drop to 50 percent (those with tanks between 38 and 55 gallons) so that voluntary purchases of 55+ gallons are not double counted.

The next step in Panelist F's analysis is to combine the four factors listed above, and multiply the resulting proportion by the total potential market size for voluntary Northwest HPWH sales, discussed above. The resulting total is the estimated total number of voluntary baseline HPWH sales in the Northwest, which is further broken down by tank size (assumed 50% below 55 gallons, and 50% above 55 gallons for voluntary replacements through 2026).

2.6.1.2 Panelist F: Analysis / Method for >55 Gallon Mandate (2015-2042)

Beginning in 2015, Panelist F includes additional sales of HPWHs in the Northwest directly related to the federal mandate (requiring all new electric storage water heaters 55 gallon or above to be HPWHs, essentially). Included in the forecast for the impact of the legislation is the percent of homes with suitable space for HPWHs (a factor discussed above). In this case, the same two reasons impact the percent of homes with a suitable space for a HPWH, although the percent is assumed to be higher (and continues to grow over time). The percent is assumed to be higher than for the previous stage of the analysis because Panelist F assumes that larger heaters are more likely to be currently installed in locations more conducive to HPWH application.

Another factor is the percent of homes with a water heater tank size above 55 gallons. This is assumed to be 25 percent of homes throughout the period 2015 – 2042.

> ***Assumption*:** Twenty-five percent of homes would replace their current electric water heater with a water heater with a tank volume above 55 gallons.

The last factor that impacts this stage of Panelist F's analysis is the percent of customers willing to pay for a HPWH. For the first round of their analysis, Panelist F assumed that a 40 percent of Northwest customers would balk at purchasing the HPWH due to the high cost, and would find a work-around solution. After reviewing other panelists' work, they increased the proportion of customers resistant to paying for a HPWH from 40 percent to 46 percent.

In both scenarios, the percent of consumers unwilling to purchase a HPWH drops over time – and thus the percent willing increases – as the cost premium is reduced and as HPWHs become more "mainstream" in the Northwest market.

In 2015, Panelist F estimates that 54 percent of consumers would be willing to pay the upfront cost of a HPWH (and unwilling to circumvent the legislation via a workaround or noncompliance of some sort). They assume that this percentage will increase each year, up to 81 percent in 2021, to 86 percent in 2023, and then to 90 percent in 2026.[7]

These factors, taken together, represent the impact of the 2015 federal legislation on the Northwest heat pump water heater market. Panelist F combines the three aforementioned factors, and multiplies them by the total Northwest electric storage water heater shipments forecast for each year from 2015 – 2042. It is assumed that 10 percent of these total sales driven by the federal legislation will actually be for HPWHs of 55 gallons or less, largely due to the lower cost. The remaining 90 percent are above 55 gallons.

[7] In the first iteration of their analysis, in 2015, Panelist F estimated that 60 percent of consumers would be willing to pay the upfront cost of a HPWH (and unwilling to circumvent the legislation via a workaround or noncompliance of some sort). It was assumed that this percentage would increase by five percent per year, up to 90 percent in 2021. Panelist F assumed it increases to 95 percent in 2023, and then to 100 percent in 2026.

2.6.1.3 Panelist F: Analysis / Method for >38 Gallon Mandate (2025-2042)

Panelist F predicts a mandate requiring all electric storage water heaters above 38 gallons have efficiencies in line with a HPWH. Therefore, they forecast the effects of such a mandate, and take an approach consistent with their method presented above. First, they estimate the percent of homes with suitable installation locations for a HPWH. From 2025 through the end of the study period, they believe that HPWHs will be physically capable of being installed in 85 percent of Northwest homes.

Panelist F relies on their expert opinion to estimate that approximately 50 percent of homes in the Northwest will have a water heater with a tank size between 38 and 55 gallons in 2025, based on survey data from the NEEA 2011 Water Heater Market Update (from survey table H-03, Appendix D).

Also similar to above, Panelist F increased their assumption regarding consumer willingness to pay for HPWHs. In their original forecast, they predicted that 20 percent of households would balk at the mandate and find a work-around. In their second-round analysis they increased the percent unwilling to 40 percent, assuming that 60 percent of Northwest consumers affected by the mandate would be willing to purchase a HPWH. They believe that the 60 percent of adopting households will grow to approximately 80 percent by 2033, 90 percent by 2040, and that the last 10 percent will not accept the technology during the forecast period.[8]

Lastly, Panelist F combines the three aforementioned factors, and multiplies them by the total Northwest electric storage water heater shipments forecast for each year from 2025 – 2042. In line with their assumptions regarding the larger water heaters, they assume 10 percent of this growth will actually occur for the larger tanks as opposed to the smaller tanks, as some households will upgrade to a larger capacity for the additional hot water supply. The remaining 90 percent are between 38 and 55 gallons.

2.6.1.4 Panelist F: Analysis / Method – Combining

The final stage of Panelist F's analysis is to combine the annual baseline sales resulting from each of the steps, listed above. They combine the HPWHs based on their size, for each of the voluntary baseline purchases, the 2015 mandate-induced baseline purchases (mostly of tanks over 55 gallons) and the 2024 mandate-induced baseline purchases. The resulting totals cover both Tier 1 and Tier 2 HPWHs, and are subsequently split by tier to fit the forecast parameters.

Panelist F did not believe that the potential 2015 waiver would have any significant effect on baseline or overall sales of HPWHs at any point in the study period, for any of the Tiers or tank sizes.

[8] In their first round analysis, Panelist F believed that the 80 percent of amenable households would increase to approximately 95 percent by 2033, and that the last five percent wouldn't accept the technology (through the end of the study period).

2.6.2 Panelist F: Results

This section presents the results of the analysis and estimation described above.

The forecast baseline estimates for Tier 1 HPWHs are shown below in Table 18, and graphically in Figure 16. As shown, Panelist F predicts no Tier 1 baseline sales after 2018. The reason Panelist F believes Tier 1 sales will drop to zero is that manufacturers will integrate Tier 2 features in all "standard" HPWHs sold throughout the country, effectively causing Tier 1 models to disappear from the market. Panelist F believes Tier 1 baseline sales will peak in 2015 at approximately 1,880 HPWHs at or below 55 gallons, and approximately 9,323 Tier 1 HPWHs with larger tanks.

Table 19 and Figure 17 show the forecast baseline estimates for Tier 2 HPWHs. While baseline sales of all Tier 2 HPWHs is expected to remain low in the near future, this panelist predicts significant baseline growth for the Tier 2 product class over the course of the study period. Baseline sales of the larger HPWH tanks (above 55 gallons) are forecasted to increase significantly starting in 2015, with baseline sales of their counterparts (the smaller tanks) rapidly increasing after the predicted 2025 mandate.

Table 18: Panelist F: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

TIER 1 Heat Pump Water Heaters						
Year	≤55 gallons	>55 gallons		Year	≤55 gallons	>55 gallons
2009	643	643		2026	0	0
2010	770	770		2027	0	0
2011	889	889		2028	0	0
2012	971	971		2029	0	0
2013	1,268	1,268		2030	0	0
2014	1,736	1,736		2031	0	0
2015	1,880	9,323		2032	0	0
2016	1,083	5,226		2033	0	0
2017	705	3,454		2034	0	0
2018	252	1,259		2035	0	0
2019	0	0		2036	0	0
2020	0	0		2037	0	0
2021	0	0		2038	0	0
2022	0	0		2039	0	0
2023	0	0		2040	0	0
2024	0	0		2041	0	0
2025	0	0		2042	0	0

Figure 16: Panelist F: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

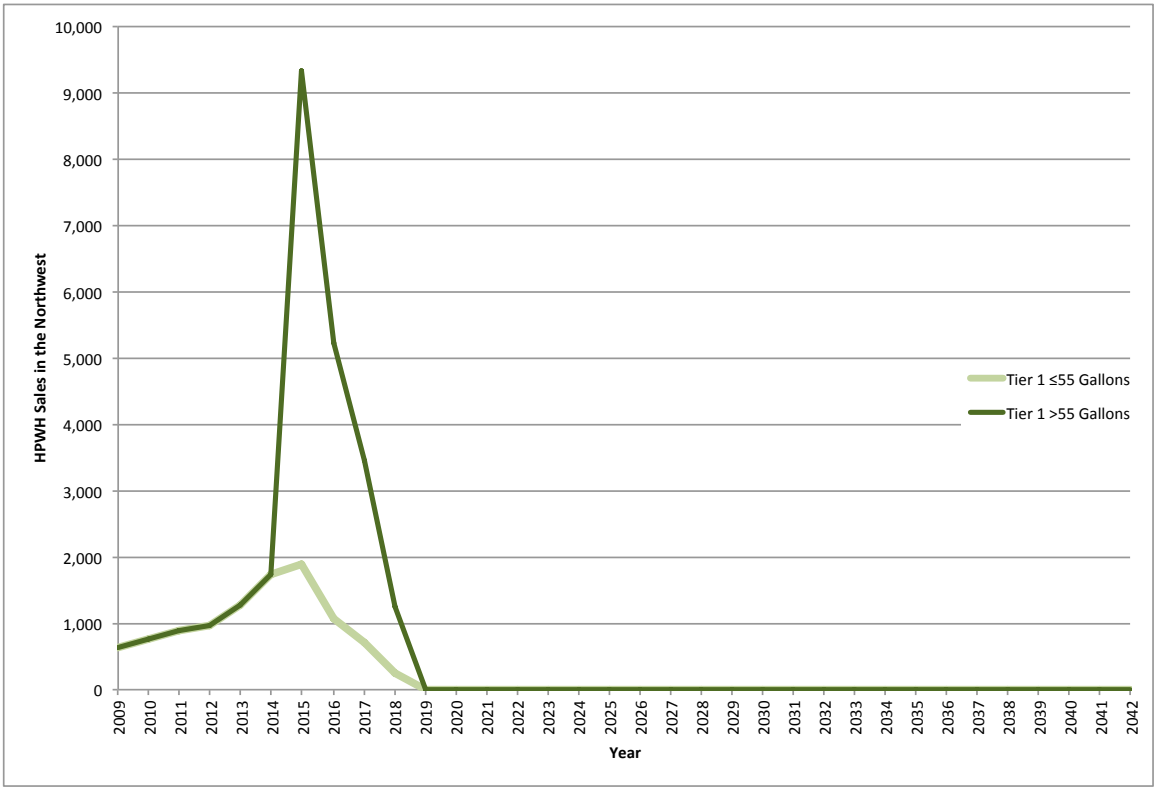
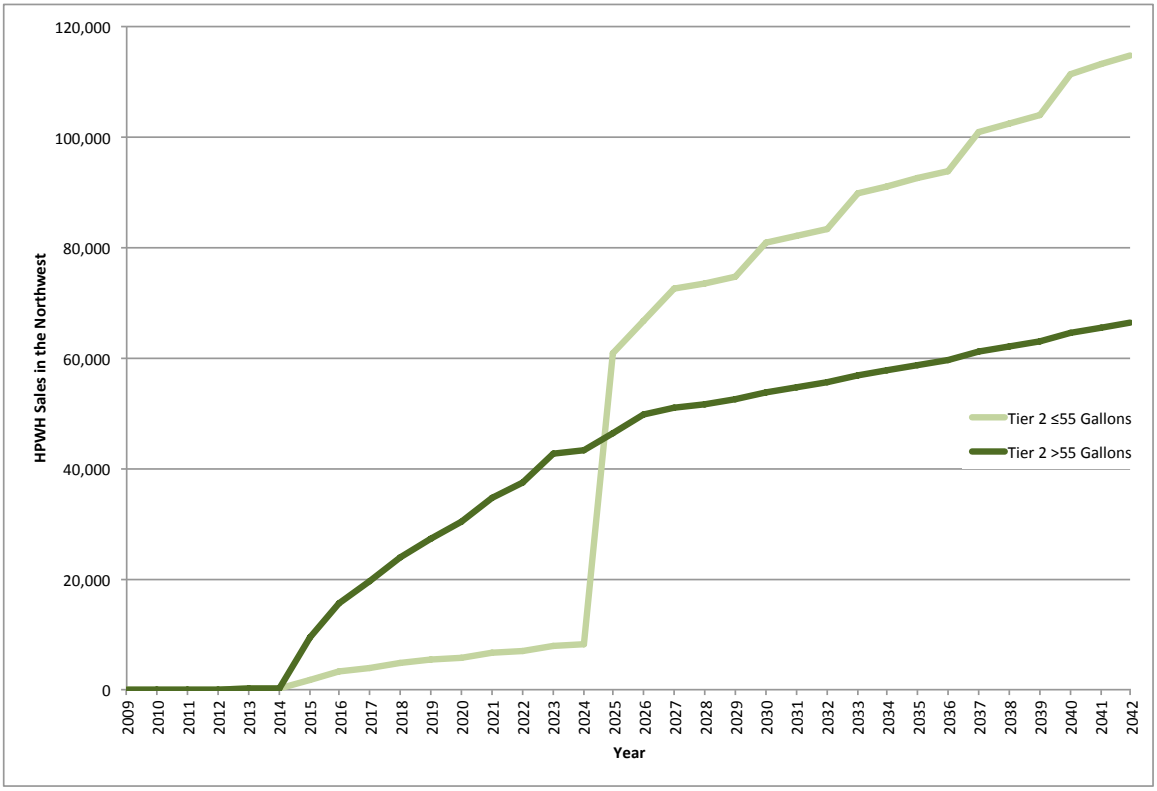


Table 19: Panelist F: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size

TIER 2 Heat Pump Water Heaters						
Year	≤55 gallons	>55 gallons		Year	≤55 gallons	>55 gallons
2009	0	0		2026	66,641	49,716
2010	0	0		2027	72,472	50,999
2011	0	0		2028	73,559	51,764
2012	10	10		2029	74,663	52,541
2013	67	67		2030	80,835	53,890
2014	193	193		2031	82,047	54,698
2015	1,880	9,323		2032	83,278	55,519
2016	3,248	15,679		2033	89,810	56,939
2017	3,996	19,575		2034	91,157	57,793
2018	4,789	23,926		2035	92,525	58,660
2019	5,430	27,452		2036	93,913	59,539
2020	5,887	30,265		2037	100,929	61,056
2021	6,570	34,641		2038	102,442	61,971
2022	7,041	37,432		2039	103,979	62,901
2023	8,023	42,620		2040	111,402	64,496
2024	8,144	43,259		2041	113,073	65,463
2025	60,732	46,350		2042	114,769	66,445

Figure 17: Panelist F: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size



2.7 Panelist G

This section presents an in-depth account of the analysis conducted by expert Panelist G. Data sources used by this panelist include:

Table 20: Panelist G: Data, Data Sources, and Application of Data

Data/Input	Source
Base case shipments forecast, electric water heaters, U.S.	DOE National Impact Analysis – Water Heaters (3/23/2010)
Percent of water heaters that are electric water heaters, NW	NEEA 2011 Water Heater Market Update
Percent of electric water heaters, by tank volume	DOE National Impact Analysis – Water Heaters (3/23/2010)
HWPH Market Share Forecast Estimates	DOE National Impact Analysis – Water Heaters (3/23/2010)
2010 electric storage water heater sales, NW	NEEA 2011 Water Heater Market Update

2.7.1 Panelist G: Analysis / Methodology

Panelist G begins their analysis with the U.S. Department of Energy (DOE) electric water heater shipment historical data and forecasts (through 2044). The forecast data Panelist G uses is for all electric water heaters, and covers the entire U.S.

The first step in this analysis is to estimate the fraction of all Northwest water heater sales comprised of electric water heaters. Panelist G assumes that 62.5 percent of water heaters sold in the Northwest are electric (based on the NEEA 2011 Water Heater Market Update report).

Panelist G assumes that the growth in total U.S. electric water heater sales will be equal to the growth rate of Northwest electric water heater sales (for the entire study period). Therefore, they determine the 2010 to 2011 sales growth rate based on the national forecast (from DOE) and apply it to the 2010 Northwest electric water heater estimate (from the NEEA 2011 Water Heater Market Update report) to estimate 2011 Northwest electric water heater sales. They continue to apply the national sales growth rates to the current-year Northwest estimate through the remainder of the study forecast period (through 2042). The output from this stage of the analysis is a forecast for electric water heater sales in the Northwest.

> ***Assumption*:** The Northwest region has a similar water heater annual replacement percentage and overall sales growth as the U.S. overall.

Panelist G splits the forecasted Northwest electric water heater sales by tank volume, predicting that 66.2 percent will be at or below 55 gallons, with the remaining 33.8 percent above 55 gallons. These estimates are based on the DOE workbook.

Relying on the DOE estimated HPWH market share forecasts (which were developed in 2010, prior to an initiative in the Northwest), Panelist G estimates the number of 55 gallon or smaller HPWHs that will be sold to the Northwest under baseline conditions. To do this, they multiply the market share for HPWHs by the total number of electric water heater sales assumed to occur in the Northwest, based on the forecast of electric water heater sales (described above). They applied the 2015 market share estimate from DOE to the years prior, going back to 2009 (5.17% of electric water heater sales).

To account for the 2015 mandate (requiring electric storage water heaters to meet efficiencies in line with HPWHs), Panelist G assumes that the market share of HPWHs with volumes greater than 55 gallons will exceed the DOE market share estimates. Panelist G assumes all replacements of electric water heaters above 55 gallons will be HPWHs by 2015. To ramp up baseline sales to this level by 2015, Panelist G assumes that baseline market share of HPWHs for water heaters above 55 gallons is approximately 10 percent in 2010, 15 percent in 2011, 35 percent in 2012, 45 percent in 2013, 75 percent in 2014, and 100 percent in 2015. They predict that HPWHs will make up the entire share of larger volume electric water heater sales in the Northwest from 2015 through the end of the study period, and thus baseline HPWH sales will effectively be 100 percent of above 55 gallon electric water heater sales.

> ***Assumption*:** Baseline HPWH sales market share for units at or below 55 gallons in volume in the Northwest is analogous to sales market share in the U.S., overall.
>
> ***Assumption*:** All 55 gallon and above electric water heaters sold in the Northwest will be HPWHs from 2015-2042.

Panelist G assumes that a new federal standard will be implemented in 2030 (they are not *certain* it will occur in 2030, but believe it will occur near that time). This standard will affect all electric storage water heaters, and will ultimately lead to 100 percent baseline sales market share for HPWHs (of the electric storage water heater market in the Northwest). Beginning in 2027, the baseline market share for smaller HPWHs is expected to diverge from the DOE forecast, similar to above for the larger tank sizes. In 2027, Panelist G assumes that smaller HPWHs will comprise 25 percent of the smaller tank volume baseline sales market share for electric water heaters, increasing to 45 percent in 2028, 65 percent in 2029, 75 in 2030 and 100 percent from 2031 through the end of the study period.

> ***Assumption*:** Federal standard in 2030 mandating sales of electric storage water heaters of all sizes meet HPWH level of efficiency; all electric water heaters sold in the Northwest will be HPWHs from 2030-2042.

The final stage of Panelist G's analysis is to split their forecasted HPWH sales (already broken down by tank volume) by HPWH performance Tier. Panelist G assumes all baseline HPWH sales in the Northwest through 2014 are Tier 1 HPWHs. From 2015 through 2029, they predict that 15 percent of HPWHs will be Tier 2, and 85 percent will be Tier 1. Beginning in 2013, they estimate that one quarter of HPWH baseline sales in the Northwest

will be Tier 2 units, with the remainder Tier 1. These estimates apply equally to smaller and larger tank volumes.

***Assumption*:** Tier 2 HPWH baseline sales begin in 2015 and comprise 15 percent of HPWH sales in the Northwest.

***Assumption*:** Beginning in 2030, Tier 2 baseline sales are estimated to comprise 25 percent of HPWH baseline sales in the Northwest.

The output from this final stage is an annual forecast of baseline HPWH sales in the Northwest, by tank volume and performance Tier. Panelist G did not believe that the potential 2015 waiver would have any significant effect on baseline or overall sales of HPWHs at any point in the study period, for any of the Tiers or tank sizes.

2.7.2 Panelist G: Results

This section presents the results of the analysis and estimation described above.

As shown in Table 21 and Figure 18, below, Panelist G estimates annual baseline sales of Tier 1 HPWHs at or below 55 gallons between 6,900 and 14,000 units through 2026. Beginning in 2027, baseline sales of the smaller Tier 1 HPWHs increase significantly, to more than 127,000 by 2031 (the result of a federal mandate assumed to take effect in 2030).

Panelist G estimates that baseline sales of Tier 1 HPWHs with storage volume above 55 gallons will increase rapidly through 2015 (reaching nearly 64,000 baseline units sold in 2015). From 2015 through the end of the study period, they anticipate relatively flatter baseline sales, between 64,000 and 73,000 per year.

Table 22 and Figure 19 contain estimates for Tier 2 HPWHs. As shown, baseline sales of all Tier 2 HPWHs are expected to remain low through 2015, at which point baseline sales for the larger, above 55 gallon tanks are expected to outpace the smaller tanks. Similar to the forecast for Tier 1 HPWHs, baseline sales of the smaller Tier 2 HPWHs are expected to increase significantly starting in 2026, resulting from a 2030 federal mandate.

Table 21: Panelist G: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

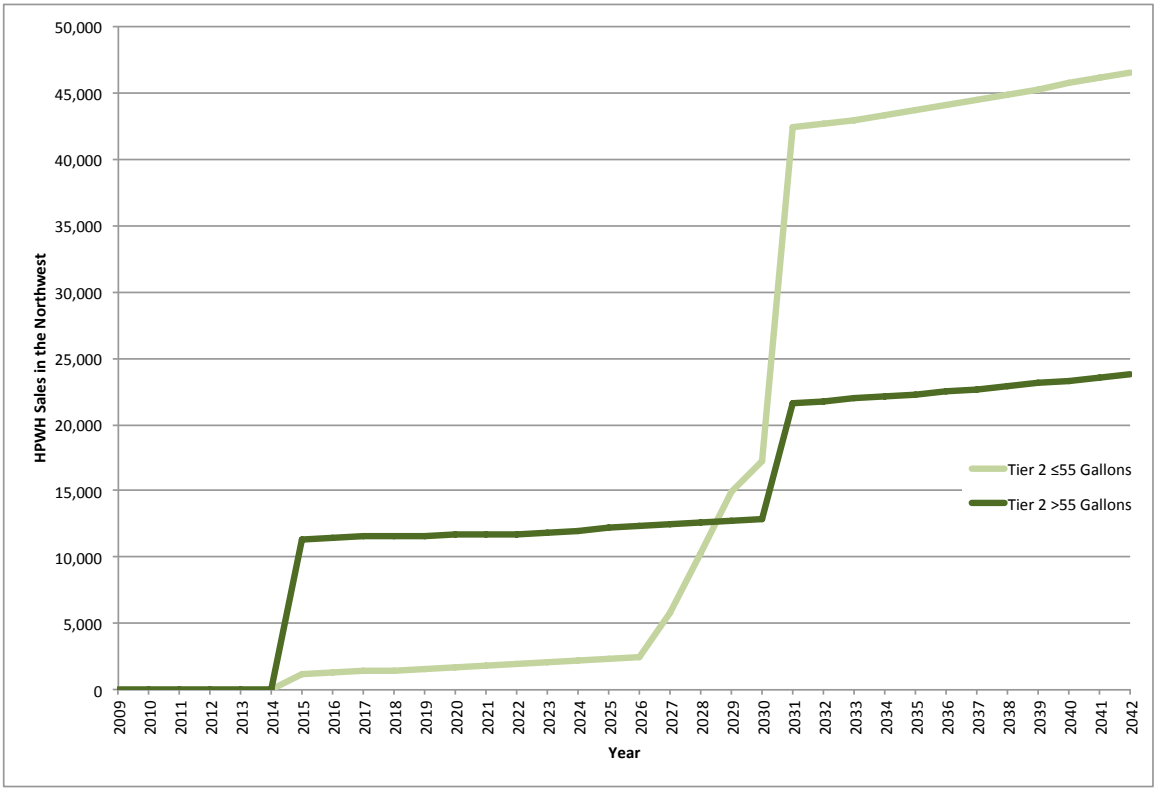
TIER 1 Heat Pump Water Heaters					
Year	≤55 gallons	>55 gallons	Year	≤55 gallons	>55 gallons
2009	8,893	4,540	2026	14,036	69,969
2010	6,973	6,887	2027	32,563	70,816
2011	6,920	10,251	2028	58,614	71,530
2012	7,196	24,872	2029	84,664	72,267
2013	7,348	32,654	2030	97,690	73,081
2014	7,468	55,311	2031	127,314	65,003
2015	6,473	63,925	2032	128,040	65,374
2016	7,164	64,958	2033	128,943	65,835
2017	7,799	65,365	2034	129,980	66,364
2018	8,422	65,618	2035	130,993	66,882
2019	9,061	65,956	2036	132,135	67,465
2020	9,695	66,216	2037	133,320	68,070
2021	10,300	66,258	2038	134,552	68,699
2022	10,945	66,545	2039	135,826	69,349
2023	11,646	67,123	2040	137,119	70,009
2024	12,403	67,947	2041	138,411	70,669
2025	13,216	68,988	2042	139,684	71,319

Figure 18: Panelist G: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

Table 22: Panelist G: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size

TIER 2 Heat Pump Water Heaters					
Year	≤55 gallons	>55 gallons	Year	≤55 gallons	>55 gallons
2009	0	0	2026	2,477	12,347
2010	0	0	2027	5,746	12,497
2011	0	0	2028	10,344	12,623
2012	0	0	2029	14,941	12,753
2013	0	0	2030	17,239	12,897
2014	0	0	2031	42,438	21,668
2015	1,142	11,281	2032	42,680	21,791
2016	1,264	11,463	2033	42,981	21,945
2017	1,376	11,535	2034	43,327	22,121
2018	1,486	11,580	2035	43,664	22,294
2019	1,599	11,639	2036	44,045	22,488
2020	1,711	11,685	2037	44,440	22,690
2021	1,818	11,693	2038	44,851	22,900
2022	1,931	11,743	2039	45,275	23,116
2023	2,055	11,845	2040	45,706	23,336
2024	2,189	11,991	2041	46,137	23,556
2025	2,332	12,174	2042	46,561	23,773

Figure 19: Panelist G: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size



2.8 Panelist H

This section presents an in-depth account of the analysis conducted by expert Panelist H. Data sources used by this panelist include:

Table 23: Panelist H: Data, Data Sources, and Application of Data

Data/Input	Source
2010 electric storage water heater sales, NW	NEEA 2011 Water Heater Market Update
1992-2011 water heater sales data, U.S.	AHRI Water Heater Sales Data
Total NW water heater market	NEEA 2011 Water Heater Market Update
Percent of total NW water heater market that are electric water heaters	NEEA 2011 Water Heater Market Update
Electricity and natural gas pricing projections, U.S. and Pacific Region	U.S. Energy Information Administration (EIA)
Proportion of water heaters in the Northwest above 50 gallons	U.S. Energy Information Administration (EIA) Residential Energy Consumption Survey (RECS) 2009

2.8.1 Panelist H: Analysis / Methodology

Panelist H begins their analysis with a forecast of overall water heater market growth, based on historical sales data from AHRI and forecasted from 2011 based on the average sales growth from 1992 to 2006 (approximately 1.56% annual growth). From this total water heater sales forecast, the panelist estimates the number of water heaters sold in the Northwest, based on a constant proportion of U.S. sales occurring in the Northwest (Northwest water heater sales data is from the NEEA 2011 Water Heater Market Update report; 4.3% of national market). This creates the basis for a forecast of total water heater sales in the Northwest.

> ***Assumption*:** The Northwest region has a similar water heater annual replacement percentage and overall sales growth as the U.S. overall.

Panelist H then estimates the number of annual Northwest water heater sales comprised of electric water heaters. This is accomplished two ways. First, for the period through 2011, the panelist relies on data from the NEEA 2011 Water Heater Market Update report, which estimates that approximately 61 percent of homes in the Northwest have electric water heaters (and thus would most likely replace with an electric water heater, potentially an electric HPWH). From 2012 on, the panelist relies on estimates of homes with electric water heaters based on survey data of fuel switching and electricity and natural gas price projections from the U.S. Energy Information Administration (EIA). The panelist's annual estimates range from a low of 53 percent electric (between 2015-2021) up to 64 percent in 2042.

Next, Panelist H relied on EIA Residential Energy Consumption Survey (RECS) 2009 data to estimate the proportion of electric water heaters in the Northwest above 50 gallons (21.6%) and between 30-50 gallons (33%). They multiply the number of electric water

heater sales in the Northwest by the proportion of existing electric water heaters that are above 50 gallons to determine the number of sales per year of electric storage water heaters above 50 gallons in volume. The same logic is applied for electric storage water heaters between 30-50 gallons, with a corresponding output.

> ***Assumption*:** Residential Energy Consumption Survey (RECS) estimates water heater sizes (i.e., 31-49 gallons; 50 gallons or more) are used as proxies for potential market size of HPWHs at or below 55 gallons, and above 55 gallons.

> ***Assumption*:** The tank volume disposition of electric water heater sales in the Northwest (replacements) is proportionally equivalent to the disposition of the existing stock.

From this point forward, Panelist H conducts separate forecasts for baseline sales of HPWHs above 55 gallons and those below.

2.8.1.1 Panelist H: Analysis / Method for HPWHs 55 Gallons or Smaller

Panelist H believes there were zero baseline sales of HPWHs at or below 55 gallons in volume in 2009 and 2010. In order to develop a forecast estimate, they assume that 12/15ths of all electric storage water heaters sales of units between 30 and 55 gallons will consist of baseline HPWH sales in 2042 (approximately 146,700 baseline sales in 2042).

> ***Assumption:*** By 2042, 12/15ths of electric storage water heater sales between 30-55 gallons will be baseline HPWH sales.

From this assumption they develop annual baseline sales forecasts. They peg three other years for constant sales, and estimate linear growth between those three years. For this analysis, they believe that there will be approximately 3,000 baseline sales of smaller HPWHs in 2015, 14,000 baseline sales in 2025, and 40,000 baseline sales in 2030. The growth rate increases significantly leading up to 2030 because they predict a federal standard impacting the market for electric water heaters between 30 and 55 gallons in that year – a revision from their first analysis that leads to significantly higher baseline sales of smaller HPWHs, as well as a shift in sales from Tier 1 to Tier 2 during the second half of the forecast (discussed below).

Baseline sales increase linearly from 2030 to 2042, at a very rapid rate due to the impact of the predicted federal standard.

2.8.1.2 Panelist H: Analysis / Method for HPWHs Larger than 55 Gallons

Panelist H believes that the overall 2010 HPWH market share estimate of 0.7 percent HPWHs from the NEEA 2011 Water Heater Market Update report consist entirely of larger volume HPWHs. This produces an estimate of slightly more than 2,000 HPWHs above 55 gallons sold in the Northwest in 2010.

The next step in this analysis is to estimate the annual Northwest sales penetration of the larger HPWHs. Panelist H predicts that all sales of electric storage water heaters above 55 gallons will consist of baseline HPWH sales in 2042. In order to forecast from the 2010

sales estimate through the 2042 estimate – assumed to be approximately 121,633 HPWHs – the panelist relies on a linear growth equation to calculate the total large-volume HPWH sales per year.

> ***Assumption*:** Baseline sales of total Tier 1 and Tier 2 large-volume HPWH experiences linear growth in the Northwest.

> ***Assumption*:** By 2042, all electric storage water heater sales above 55 gallons will be baseline HPWH sales.

2.8.1.3 Panelist H: Analysis / Method for HPWHs Splitting by Performance Tier

The final stage of this analysis is to differentiate by performance Tier 1 and Tier 2 for the HPWH baseline sales estimations, by tank size, developed based on the explanations above.

To accomplish this, Panelist H inferred growth rates from general market trends and their expert opinions. They believe that the assumed 2030 federal standard affecting smaller volume HPWHs will drive up all HPWH sales so significantly – baseline sales included – that production costs will decrease for manufacturers. In turn, they will integrate more Tier 2 features into their HPWHs, thus increasing the proportion of Tier 2 water heater sales significantly over the duration of the forecast period (this applies to baseline sales in the same proportion as it does to total sales).

To apportion Tier 1 and Tier 2 baseline sales, this panelist estimated that from 2009-2011, 100 percent of HPWH baseline sales in the Northwest were of Tier 1 models. In 2020, they estimate that 10 percent of baseline sales will consist of Tier 2 HPWHs, 15 percent in 2028, and 60 percent in 2042. Between these years, the percent of Tier 2 HPWHs (of all baseline HPWH sales in the Northwest) is anticipated to grow in a linear fashion. The percent of baseline HPWHs comprised of Tier 1 models is expected to decline in concert with the Tier 2 increases.

> ***Assumption*:** Tier-apportioned forecasts assumed based on current market availability and assumptions about growth in market and the impact of 2013 federal standards on product mix; no concrete data to suggest growth in these markets, so inferences drawn from general market trends.

Taken together, the outcome is a forecast of baseline sales of HPWHs in the Northwest, by tank size and performance Tier. The annual estimates and forecast of baseline sales are rounded to show three significant digits for demonstration simplicity. Panelist H did not believe that the potential 2015 waiver would have any significant effect on baseline or overall sales of HPWHs at any point in the study period, for any of the Tiers or tank sizes.

2.8.2 Panelist H: Results

This section presents the results of the analysis and estimation described above.

Table 24 and Figure 20 show Panelist H's forecast estimates for Tier 1 HPWHs. As shown, baseline sales of the larger tanks are estimated to increase significantly leading up to the

onset of the federal standards in 2015, and then continue to grow steadily through 2028, at which point their growth rate declines. Peak baseline sales for this category of HPWH are estimated to occur in 2032 (60,900 units), at which point the panelist predicts a decline in annual sales, largely the result of a transition towards production of more Tier 2 HPWHs.

The smaller Tier 1 HPWHs start with relatively lower levels of baseline sales, but sales increase significantly beginning in 2025 as the effects of a 2030 federal standard begin to impact the market for smaller electric water heaters. Baseline sales are estimated to grow until 2040, at which point annual baseline sales begin to decline (also due to a shift towards greater Tier 2 production).

Table 25 and Figure 21 show forecast estimates for Tier 2 HPWHs. As shown, Panelist H believes there will be relatively minimal baseline sales of Tier 2 HPWHs at or below 55 gallons until federal legislation influences the market in 2015. They predict slightly higher sales of the larger Tier 2 HPWHs through 2015.

Baseline sales for large HPWHs will reach 10,000 units per year (counting both large and small HPWHs) around 2024, at which point baseline sales for both categories of Tier 2 HPWHs are anticipated to increase significantly. Panelist H estimates that baseline sales of larger Tier 2 HPWHs will grow to over 70,000 per year in 2042, and baseline sales of smaller Tier 2 HPWHs will reach 88,000 per year in the Northwest in the same year.

Table 24: Panelist H: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

TIER 1 Heat Pump Water Heaters					
Year	≤55 gallons	>55 gallons	Year	≤55 gallons	>55 gallons
2009	0	0	2026	16,600	53,500
2010	0	2,320	2027	20,900	56,300
2011	600	6,050	2028	25,200	59,000
2012	1,090	9,670	2029	28,500	59,800
2013	1,560	13,200	2030	31,400	60,400
2014	2,030	16,700	2031	36,800	60,800
2015	2,870	20,000	2032	41,700	60,900
2016	3,870	23,300	2033	46,000	60,700
2017	4,850	26,500	2034	49,700	60,300
2018	5,810	29,600	2035	52,800	59,700
2019	6,740	32,700	2036	55,400	58,800
2020	7,650	35,600	2037	57,300	57,700
2021	8,580	38,700	2038	58,800	56,400
2022	9,500	41,800	2039	59,600	54,800
2023	10,400	44,800	2040	59,900	53,000
2024	11,300	47,700	2041	59,600	51,000
2025	12,200	50,600	2042	58,700	48,700

Figure 20: Panelist H: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

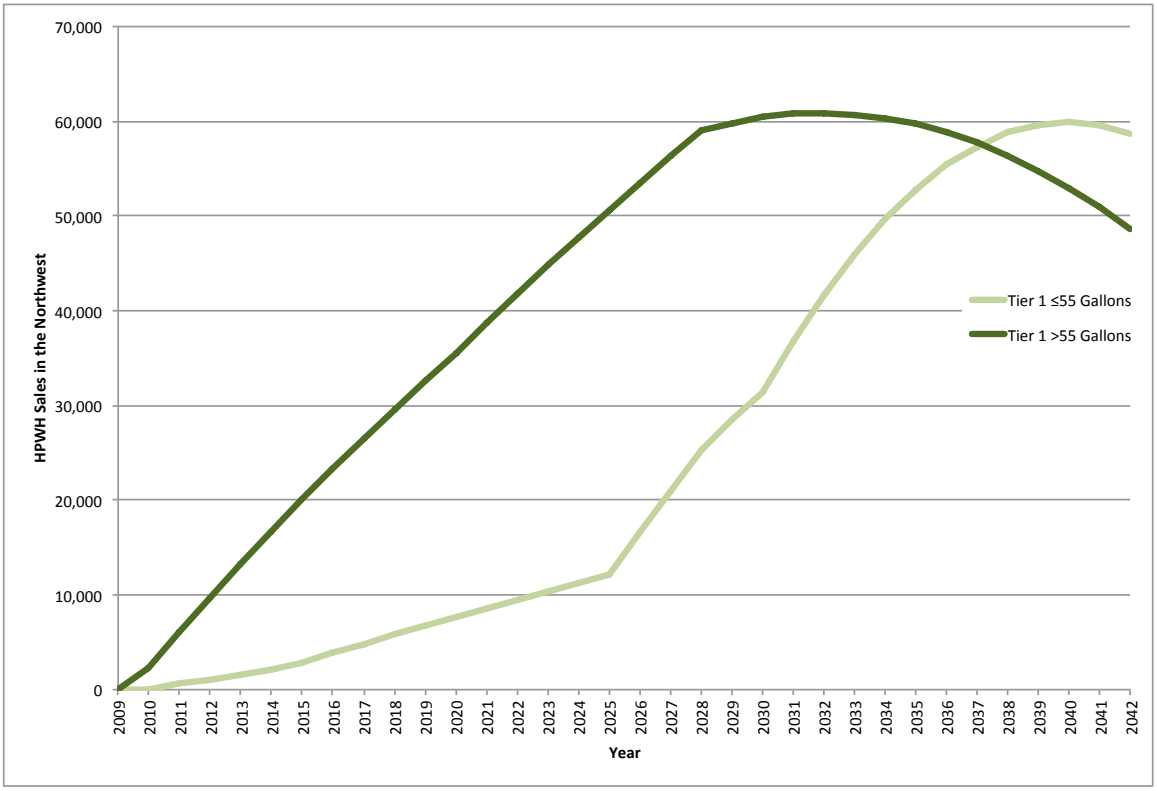
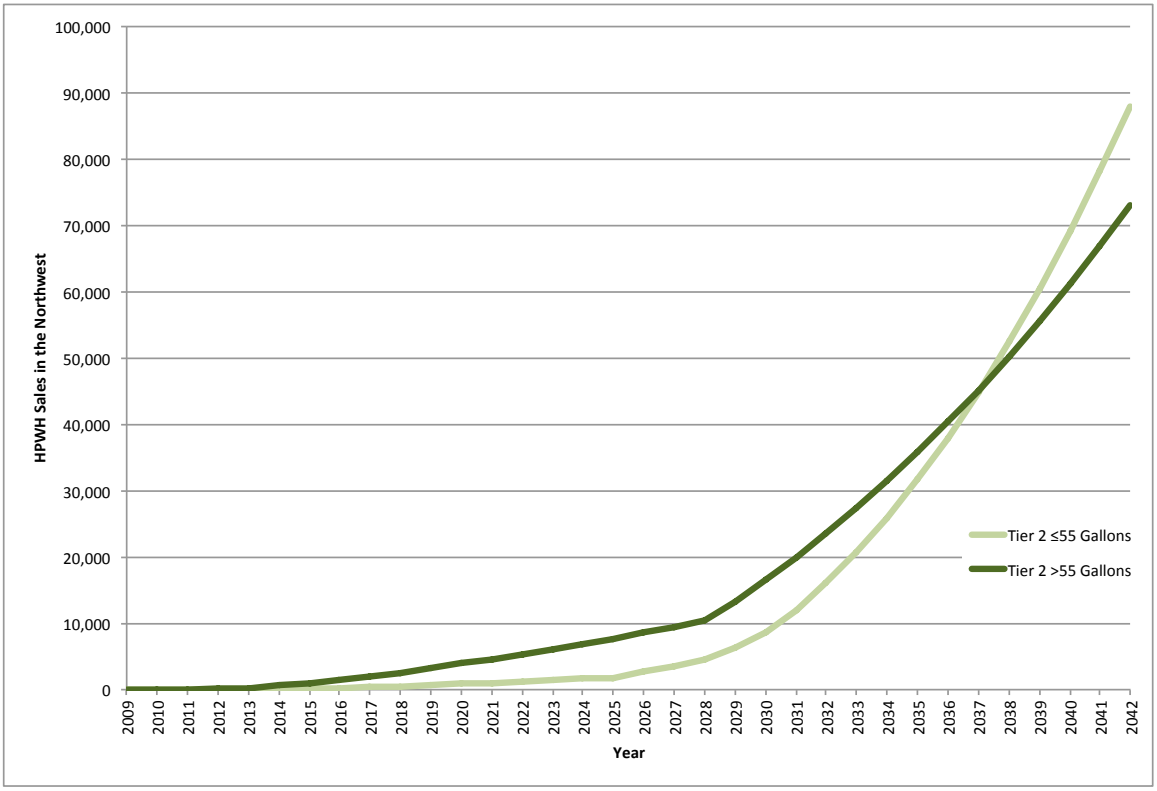


Table 25: Panelist H: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size

TIER 2 Heat Pump Water Heaters					
Year	≤55 gallons	>55 gallons	Year	≤55 gallons	>55 gallons
2009	0	0	2026	2,640	8,520
2010	0	0	2027	3,510	9,450
2011	0	0	2028	4,440	10,400
2012	12	109	2029	6,340	13,300
2013	36	300	2030	8,570	16,500
2014	70	575	2031	12,000	19,900
2015	133	932	2032	16,100	23,500
2016	228	1,370	2033	20,700	27,400
2017	347	1,890	2034	25,900	31,500
2018	490	2,500	2035	31,700	35,800
2019	658	3,190	2036	38,000	40,400
2020	850	3,960	2037	44,900	45,200
2021	1,020	4,600	2038	52,400	50,300
2022	1,200	5,290	2039	60,500	55,600
2023	1,400	6,030	2040	69,100	61,200
2024	1,610	6,820	2041	78,300	67,000
2025	1,840	7,650	2042	88,000	73,000

Figure 21: Panelist H: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size



2.9 Panelist I

This section presents an in-depth account of the analysis conducted by expert Panelist I. Data sources used by this panelist include:

Table 26: Panelist I: Data, Data Sources, and Application of Data

Data/Input	Source
Base case shipments forecast, all water heaters, U.S.	DOE National Impact Analysis – Water Heaters (3/23/2010)
Percent of NW households with electric water heaters	NEEA 2011 Water Heater Market Update
Preliminary national forecasts	Verify Markets
HPWH base case market share forecast, U.S.	DOE National Impact Analysis – Water Heaters (3/23/2010)

2.9.1 Panelist I: Analysis / Methodology

Panelist I begins their analysis with the DOE total U.S. water heater shipments base case forecast. They estimate the number of annual shipments to the Northwest based on the ratio of water heater sales provided in the NEEA 2011 Water Heater Market Update – in 2010, the Northwest was estimated to account for 4.26 percent of total U.S. water heater shipments (326,000 to the Northwest; 7,650,000 to the overall U.S.). Panelist I uses this factor to estimate Northwest water heater shipments for the 2009-2042 study period.

> ***Assumption*:** The Northwest region has a similar water heater annual replacement percentage and overall sales growth as the U.S. overall.

Panelist I then accounts for the split between electric and natural gas water heaters in the Northwest. According to the 2011 Water Heater Market Update, 61 percent of water heaters in the Northwest were electric. Panelist I applies this percentage to the overall Northwest water heater shipment forecast, estimated above, to determine a forecast of all electric water heater sales in the Northwest.

> ***Assumption*:** The Northwest region will maintain the same electric water heater to gas water heater ratio over the forecast period.

The next stage of the analysis estimates the overall number of HPWHs sold in the Northwest. This stage is split into two timeframes, with one set of data and assumptions guiding the period from 2009-2014, and another set of data and assumptions incorporated into the forecast for 2015-2042.

Panelist I relies on data from Verify Markets to estimate the percentage of total U.S. water heater shipments (from DOE) that are comprised of HPWHs. In 2009, 0.1 percent of national water heater sales were HPWHs. By 2014, HPWHs are forecasted to reach 1.4 percent. These percentages are assumed to apply to the Northwest market. To estimate the annual sales of HPWHs in the Northwest for each year 2009-2014, Panelist I multiplies the

percentages derived using the Verify Markets market share by the total Northwest water heater sales estimated for that year (discussed in the first paragraph of this section on page 49).

> ***Assumption*:** Between 2009-2014, the Northwest region has a similar HPWH annual baseline sales growth as the U.S. overall HPWH sales growth (estimated by Verify Markets).

> ***Assumption*:** The Verify Markets forecast estimate (based on the percent market share) is transferable to the Northwest as baseline market share because the forecast was developed prior to an initiative.

From 2015-2042, Panelist I relies on the DOE estimated HPWH market share forecasts (which were developed in 2010) to estimate the number of baseline HPWH sales in the Northwest. To do this, they multiply the national HPWH market share forecasted by DOE by the total number of electric water heater sales assumed to occur in the Northwest, based on the forecast of electric water heater sales (described above).

> ***Assumption*:** From 2015-2042, the Northwest has a similar HPWH annual baseline sales growth as the U.S. overall HPWH sales growth (estimated by DOE).

> ***Assumption*:** The DOE forecast estimate (based on the percent market share) is transferable to the Northwest as baseline market share because the forecast was developed prior to an initiative.

The next stage of Panelist I's analysis is to split the total HPWH sales by tank volume. Panelist I incorporates findings from the NEEA 2011 Water Heater Market Update report regarding tank size (from survey table H-03, Appendix D). According to the report, 74.75 percent of water heaters are below 55 gallons in volume (and 25.25 percent are at or below 55 gallons). This ratio is applied to the overall baseline sales of HPWHs in the Northwest to determine the baseline sales for both larger and smaller tank volumes.

> ***Assumption*:** No change in water heater tank size distribution in the Northwest over the study period.

In order to apportion baseline sales by Northern Climate Specification performance Tier, Panelist I developed reasoned estimations for the share of baseline HPWH sales for each Tier, for both sizes. They predict federal standards and standard updates in 2015, 2023, and 2030. They assume that each federal standard will provide a shift in baseline sales, from Tier 1 to Tier 2 HPWHs, and they assume that in 2030 all HPWH sales in the Northwest (baseline and incentivized) will be products meeting the Tier 2 level.

> ***Assumption*:** Federal standard will increase HPWH market share of Tier 2 products versus Tier 1 products.

> ***Assumption*:** All HPWHs sold in the Northwest will meet Tier 2 criteria in 2030.

For HPWHs below 55 gallons, they assume all baseline sales in 2010 were Tier 1 products. This remains true until 2015, at which point they estimate that three percent of the smaller HPWHs sold in the Northwest without an incentive will be Tier 2 units. Each year from 2015-2022 they believe that the Tier 2 baseline sales will account for three percent more of the sales of smaller HPWHs than the year prior. In 2023, due to the federal standard update discussed above, they predict that half of the baseline sales of smaller HPWHs will be Tier 2 HPWHs. Through 2029, each year will see a five percent shift in baseline sales from Tier 1 to Tier 2, and in 2030 and beyond, all baseline sales of smaller HPWHs will be Tier 2.

Similar logic is applied to apportion sales of larger HPWHs across performance Tiers. In 2010, Panelist I assumes that all baseline sales of larger HPWHs were Tier 1 units. In 2011 and 2012, they believe 10 percent were Tier 2, and in 2013 and 2014, they estimate that 17 percent are Tier 2. In 2015 they predict that 20 percent of higher-volume baseline sales will be Tier 2 products and 80 percent will remain Tier 1. Then, from 2015-2022, they estimate that each year Tier 2 baseline sales of these larger tank HPWHs will account for five percent more than the year before, jumping to 70 percent in 2023 (from the standard update). Similar to the smaller HPWHs, through 2029 they predict an annual shift from Tier 1 to Tier 2 of five percentage points, jumping again to 100 percent in 2030.

In the end, the outputs from this analysis are four forecasts of baseline sales, one for each combination of performance Tier and tank volume. Panelist I did not believe that the potential 2015 waiver would have any significant effect on baseline or overall sales of HPWHs at any point in the study period, for any of the Tiers or tank sizes.

2.9.2 Panelist I: Results

This section presents the results of the analysis and estimation described above.

Table 27 and Figure 22 show Panelist I's baseline forecasts for Tier 1 HPWHs. As shown, baseline sales are expected to increase rapidly through 2015 as the result of the upcoming standards affecting the market, and then taper off considerably. Annual baseline sales for larger Tier 1 HPWHs begin to decline in 2018, and baseline sales of smaller units are anticipated to begin declining in 2023. No Tier 1 HPWH baseline sales are forecast beginning in 2029 for larger tanks and 2030 for smaller tanks (through the end of the forecast period).

Table 28 and Figure 23 show baseline sales estimated for Tier 2 HPWHs, by tank size. As shown, baseline sales for HPWHs above 55 gallons began in 2011 and increase to 277 before the 2015 legislation impacts the market. There are no baseline sales of smaller Tier 2 HPWHs until 2015.

From 2015 on, baseline sales of Tier 2 HPWHs rise steadily, with significant increases resulting from predicted standard updates in 2023 and 2030. In 2030, Tier 2 HPWHs will account for all baseline HPWH sales in the Northwest.

Table 27: Panelist I: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

Tier 1 Heat Pump Water Heaters						
Year	≤55 gallons	>55 gallons		Year	≤55 gallons	>55 gallons
2009	253	85		2026	8,280	1,199
2010	517	175		2027	7,532	848
2011	945	287		2028	6,635	448
2012	1,531	465		2029	5,552	0
2013	2,716	761		2030	0	0
2014	4,819	1,351		2031	0	0
2015	10,768	3,000		2032	0	0
2016	11,381	3,067		2033	0	0
2017	12,023	3,124		2034	0	0
2018	12,590	3,141		2035	0	0
2019	12,945	3,086		2036	0	0
2020	13,427	3,042		2037	0	0
2021	13,639	2,916		2038	0	0
2022	14,025	2,805		2039	0	0
2023	9,871	2,001		2040	0	0
2024	9,405	1,765		2041	0	0
2025	8,954	1,512		2042	0	0

Figure 22: Panelist I: Forecast Baseline for Tier 1 HPWHs in the Northwest, by Tank Size

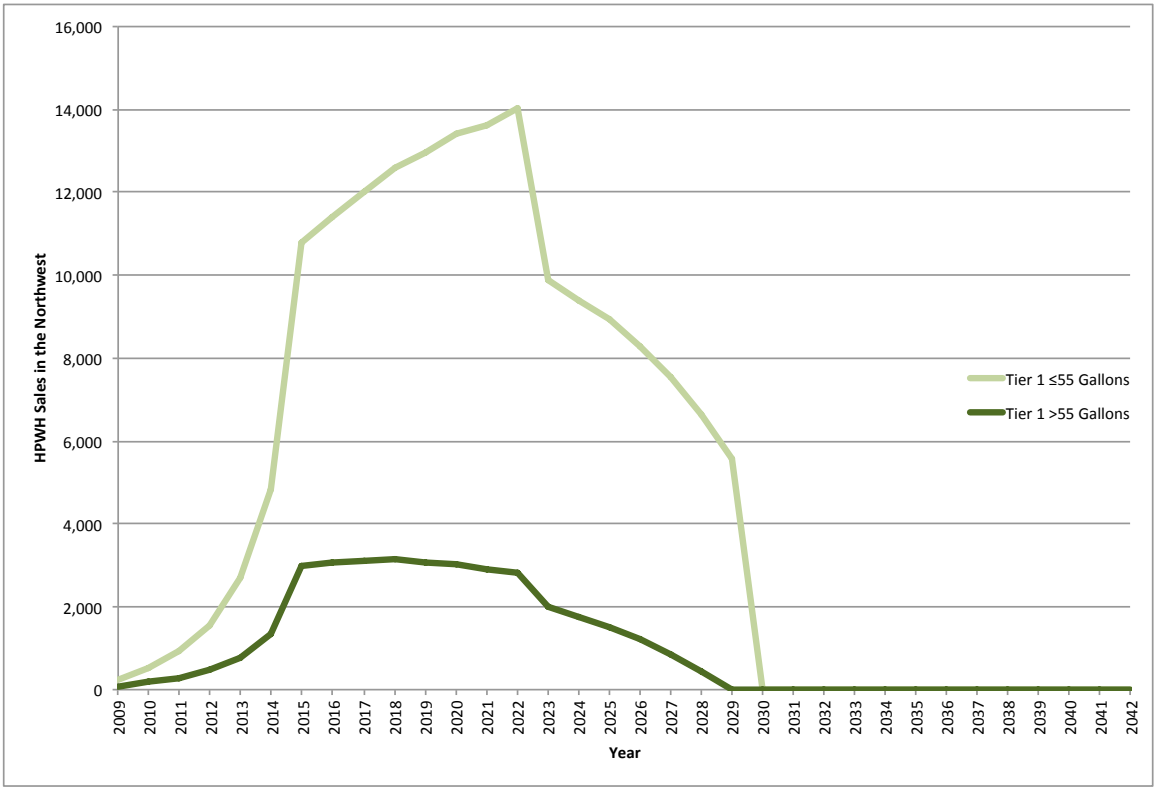
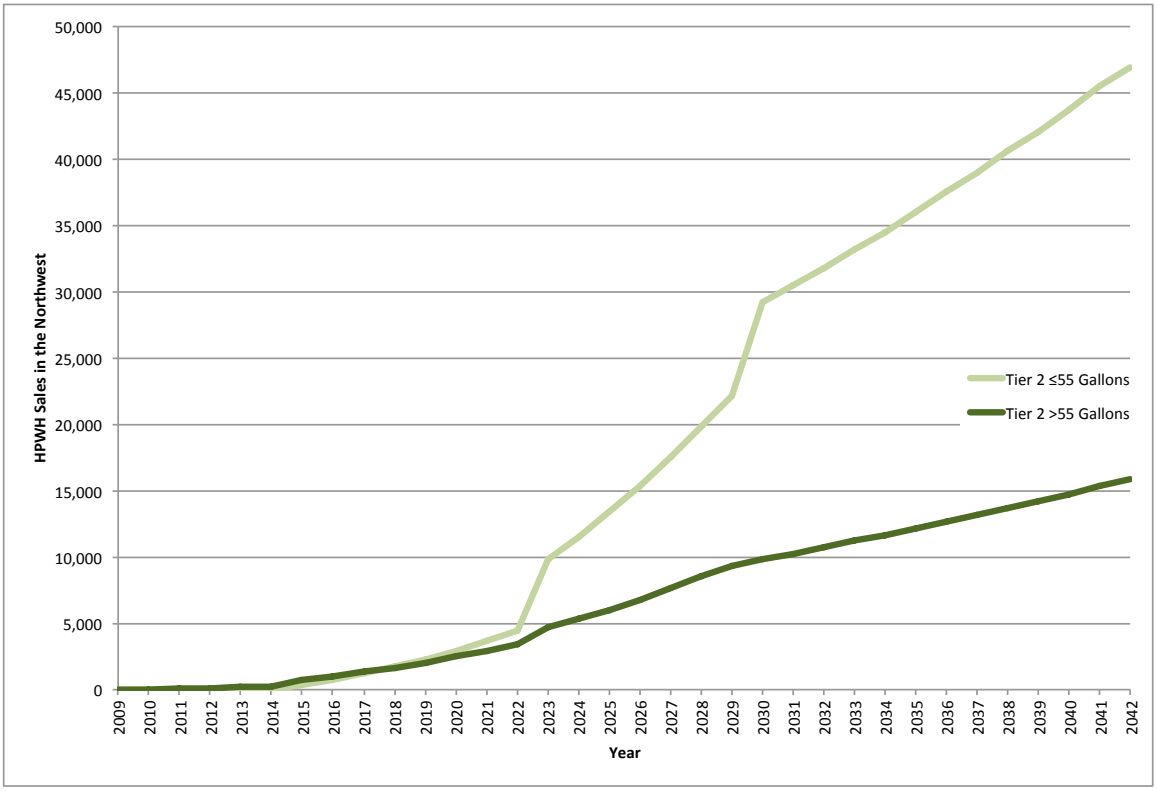


Table 28: Panelist I: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size

Tier 2 Heat Pump Water Heaters					
Year	≤55 gallons	>55 gallons	Year	≤55 gallons	>55 gallons
2009	0	0	2026	15,377	6,792
2010	0	0	2027	17,575	7,633
2011	0	32	2028	19,907	8,518
2012	0	52	2029	22,208	9,377
2013	0	156	2030	29,262	9,885
2014	0	277	2031	30,448	10,285
2015	333	750	2032	31,817	10,748
2016	726	1,023	2033	33,251	11,232
2017	1,189	1,339	2034	34,506	11,656
2018	1,717	1,692	2035	36,027	12,170
2019	2,284	2,058	2036	37,596	12,700
2020	2,948	2,489	2037	38,933	13,151
2021	3,625	2,916	2038	40,604	13,716
2022	4,429	3,429	2039	42,104	14,222
2023	9,872	4,668	2040	43,728	14,771
2024	11,496	5,295	2041	45,471	15,360
2025	13,432	6,050	2042	46,939	15,856

Figure 23: Panelist I: Forecast Baseline for Tier 2 HPWHs in the Northwest, by Tank Size



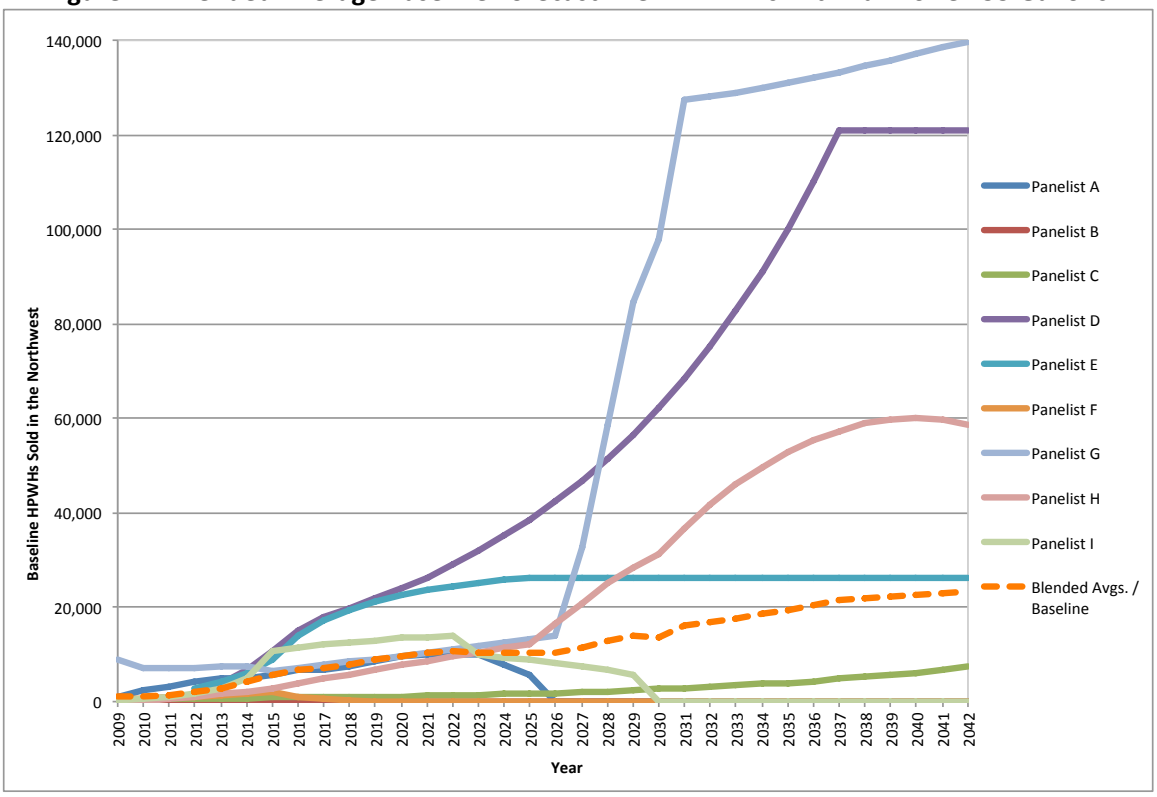
3 Aggregated Results and Blended Average Forecast

This section provides the aggregated results and the blended average forecasts for baseline HPWH sales in the Northwest. As evident, panelists were unable to come to a consensus regarding the future baseline sales of HPWHs in the Northwest over the length of the study period. However, estimates in the near- and mid-term align significantly better than later years.

Figure 24, below, shows the forecasts for smaller Tier 1 HPWHs. As shown, Panelists D and G (and Panelist H to a lesser degree) forecast significant long-term growth in baseline sales for Tier 1 HPWHs at or below 55 gallons. Panelist E forecasts strong near-term baseline growth, tapering off over time.

The blended average baseline increases to around 10,000 HPWH sales by 2021, and surpasses 20,000 in 2036.

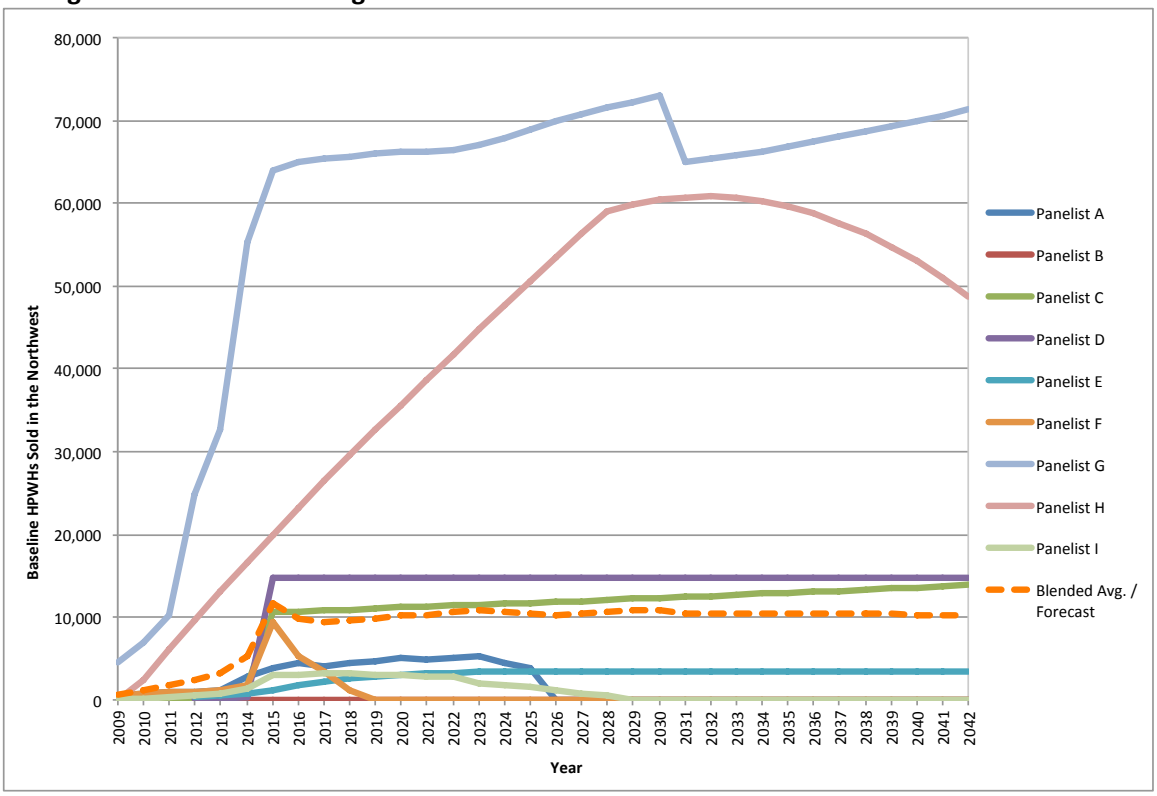
Figure 24: Blended Average Baseline Forecast: Tier 1 HPWHs with Tank Size ≤55 Gallons



The panel baseline forecasts and blended average baseline forecasts are presented in Figure 25 for larger volume Tier 1 HPWH sales in the Northwest. The forecasts of two panelists – Panelist G and Panelist H – show strong optimism with respect to current and future baseline sales of HPWHs in the Northwest.

The blended average baseline shows the impact of the 2015 legislation for larger tank electric storage water heaters, assumed to impact baseline sales by nearly all panelists (to different degrees). However, baseline sales remain slightly below 2015 levels thereafter, based on the blended average of panelist forecasts.

Figure 25: Blended Average Baseline Forecast: Tier 1 HPWHs with Tank Size >55 Gallons



Forecasts for small volume Tier 2 HPWHs are presented in Figure 26. Long-term forecasts are high for Panelist A and Panelists F – I, and much lower for Panelists B – E.

The blended average forecast baseline shows low baseline sales in the near and mid-term, reaching approximately 10,000 baseline sales in 2028. The blended average is more closely aligned with Panelists F – I in the long term.

Figure 26: Blended Average Baseline Forecast: Tier 2 HPWHs with Tank Size ≤55 Gallons

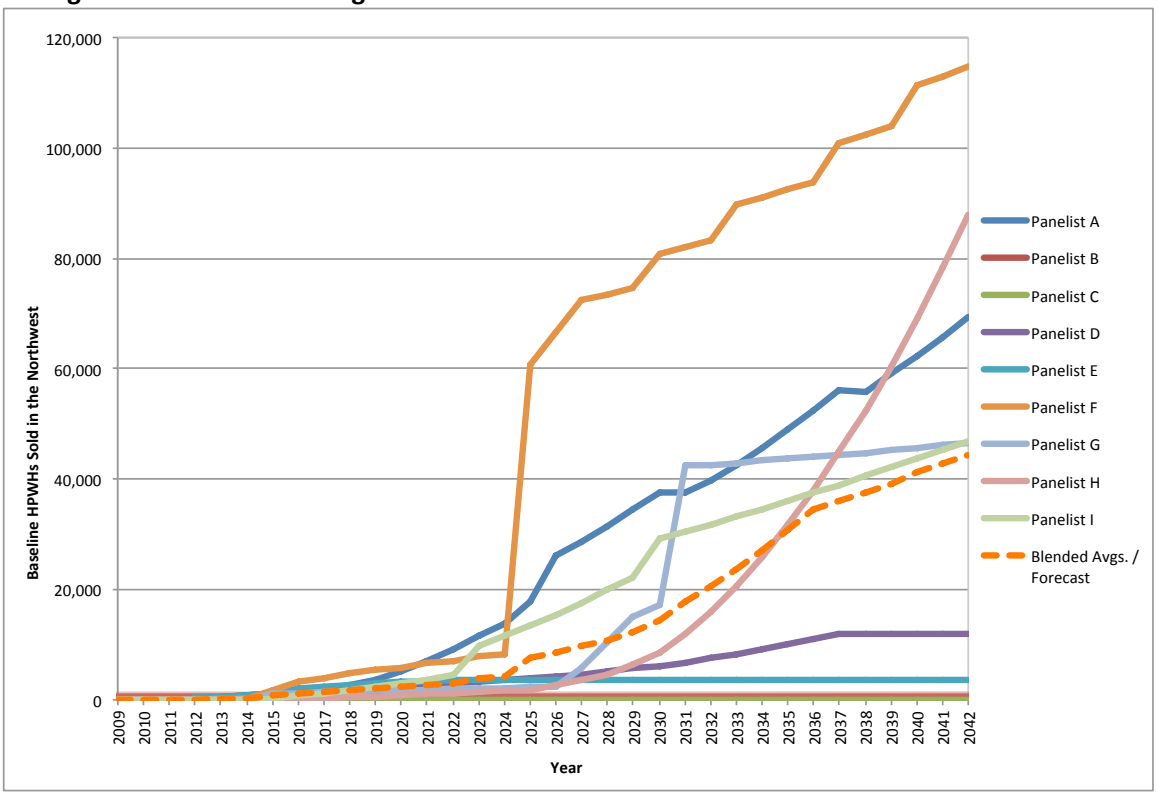
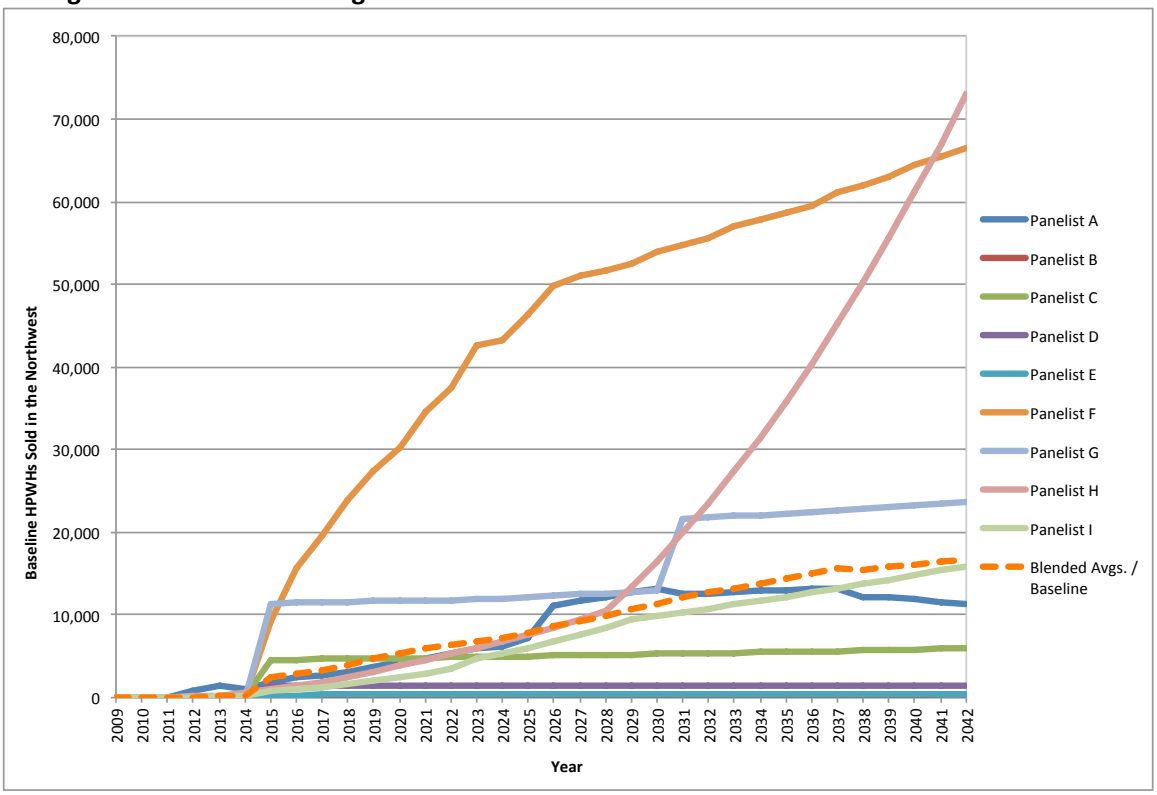


Figure 27 shows panelist forecasts for Tier 2 HPWHs above 55 gallons, including the blended average forecast baseline. The figure shows a similar trend among panelists' estimates as for smaller Tier 2 HPWHs. Namely, the estimates of Panelists F – I are all near or above the blended average baseline, whereas the majority of Panelists A – E (expect for Panelist A) are below.

The blended average of the panelist forecasts shows growth in baseline sales associated with the 2015 legislation. After 2015, the blended average of forecasts predicts relatively linear growth in baseline sales.

Figure 27: Blended Average Baseline Forecast: Tier 2 HPWHs with Tank Size >55 Gallons



4 Panelist Comparisons, Discussion and Recommendations

This section compares the results of the sequenced Delphi panel forecasting for baseline sales of HPWHs in the Northwest. In addition, we provide a recommendation regarding how to integrate the Delphi panel results into NEEA's Alliance Cost Effectiveness model.

4.1 Panelist Comparisons

In this section we compare the results from Panelists A – E with those from Panelists F – I, by HPWH performance tier and tank size.

4.1.1 Tier 1 HPWHs with Tank Size 55 Gallons or Less

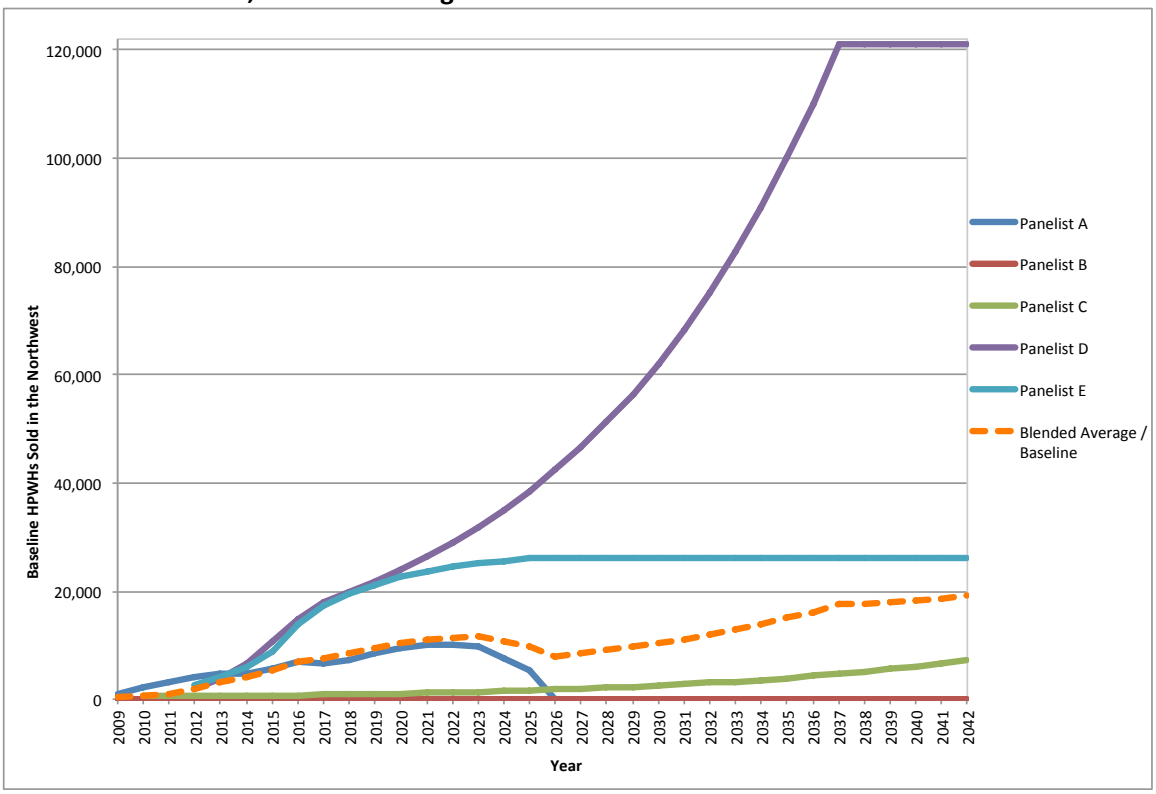
The blended average forecast for baseline sales of Tier 1 HPWHs with tank size of 55 gallons or less, as produced by Panelists A – E, is presented below in Table 29 and Figure 28. In the figure, the blended average is presented alongside the estimates of the panelists (A – E).

The slight drop in the blended average annual baseline sales forecast from 2023 to 2026 is the result of Panelist A's belief that Tier 2 HPWHs will gain market share from Tier 1 HPWHs as the overall HPWH product class matures. We believe this is plausible, as the specification for the Tier 2 HPWHs better addresses the needs of customers in the Northwest in the mid- and long-term, although the product is currently still very expensive and relatively untested in the market.

Table 29: Panelist A – E, Blended Average Baseline Forecast: Tier 1 HPWHs with Tank Size ≤55 Gallons

TIER 1 Heat Pump Water Heaters ≤55 Gallons				
Year	Baseline		Year	Baseline
2009	484		2026	7,955
2010	788		2027	8,479
2011	1,021		2028	9,054
2012	1,873		2029	9,686
2013	3,200		2030	10,380
2014	4,262		2031	11,142
2015	5,438		2032	11,980
2016	7,097		2033	12,899
2017	7,656		2034	13,909
2018	8,429		2035	15,018
2019	9,483		2036	16,236
2020	10,477		2037	17,574
2021	11,210		2038	17,834
2022	11,535		2039	18,117
2023	11,735		2040	18,426
2024	10,861		2041	18,763
2025	9,951		2042	19,131

Figure 28: Panelist A – E, Blended Average Baseline Forecast: Tier 1 HPWHs with Tank Size ≤55 Gallons



For Panelists F – I, the blended average forecast for baseline sales 55 gallon or smaller Tier 1 HPWHs are shown below, in Table 30 and Figure 29. The panelists' forecasts are shown alongside the blended average in Figure 29.

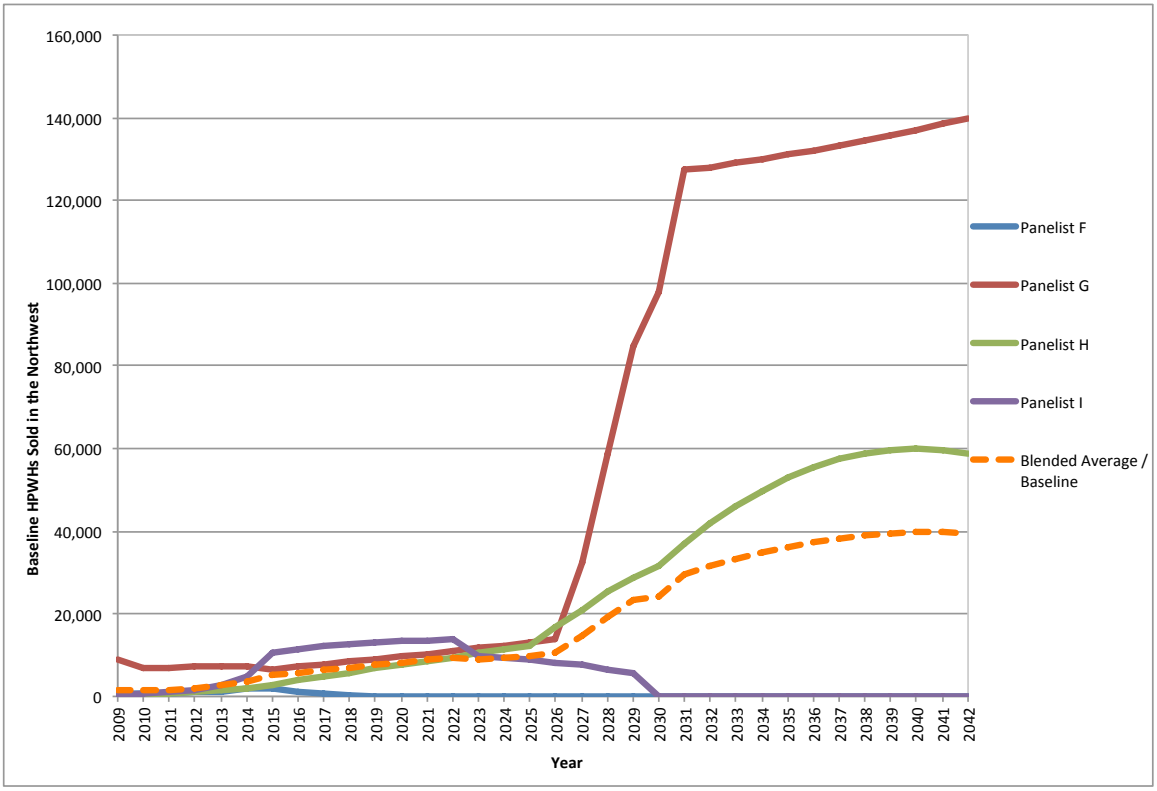
Two of these panelists predicted that baseline sales of the smaller Tier 1 HPWHs would cease at a certain point, and two panelists predicted that baseline sales would increase throughout most or all of the forecast period. This divergence of opinions is reflected in the blended average forecast, although Panelist G's forecast skews the blended average upwards. The blended average baseline forecast is plausible, especially through 2026, when Panelist G predicts relatively fast market saturation of baseline HPWHs across all Tiers and sizes. Furthermore, Panelist G is optimistic that Tier 1 HPWH baseline sales will far outpace Tier 2 baseline HPWH sales, increasing the effect of their estimation on the overall blended average forecast for Tier 1 HPWHs of both sizes.

As shown, the near-term blended average forecasts (through approximately 2025) are well aligned. The blended average for Panelists F – I reflects more rapid baseline growth after 2025 than for Panelists A – E.

Table 30: Panelist F – I, Blended Average Baseline Forecast: Tier 1 HPWHs with Tank Size ≤55 Gallons

TIER 1 Heat Pump Water Heaters ≤55 Gallons				
Year	Baseline		Year	Baseline
2009	1,448		2026	10,443
2010	1,354		2027	14,732
2011	1,628		2028	19,265
2012	2,004		2029	23,353
2013	2,680		2030	23,986
2014	3,719		2031	29,714
2015	5,085		2032	31,642
2016	5,696		2033	33,368
2017	6,335		2034	34,885
2018	6,942		2035	36,174
2019	7,544		2036	37,292
2020	8,183		2037	38,152
2021	8,785		2038	38,869
2022	9,420		2039	39,328
2023	9,057		2040	39,602
2024	9,315		2041	39,651
2025	9,585		2042	39,473

Figure 29: Panelist F – I, Blended Average Baseline Forecast: Tier 1 HPWHs with Tank Size ≤55 Gallons



4.1.2 Tier 1 HPWHs with Tank Size Greater than 55 Gallons

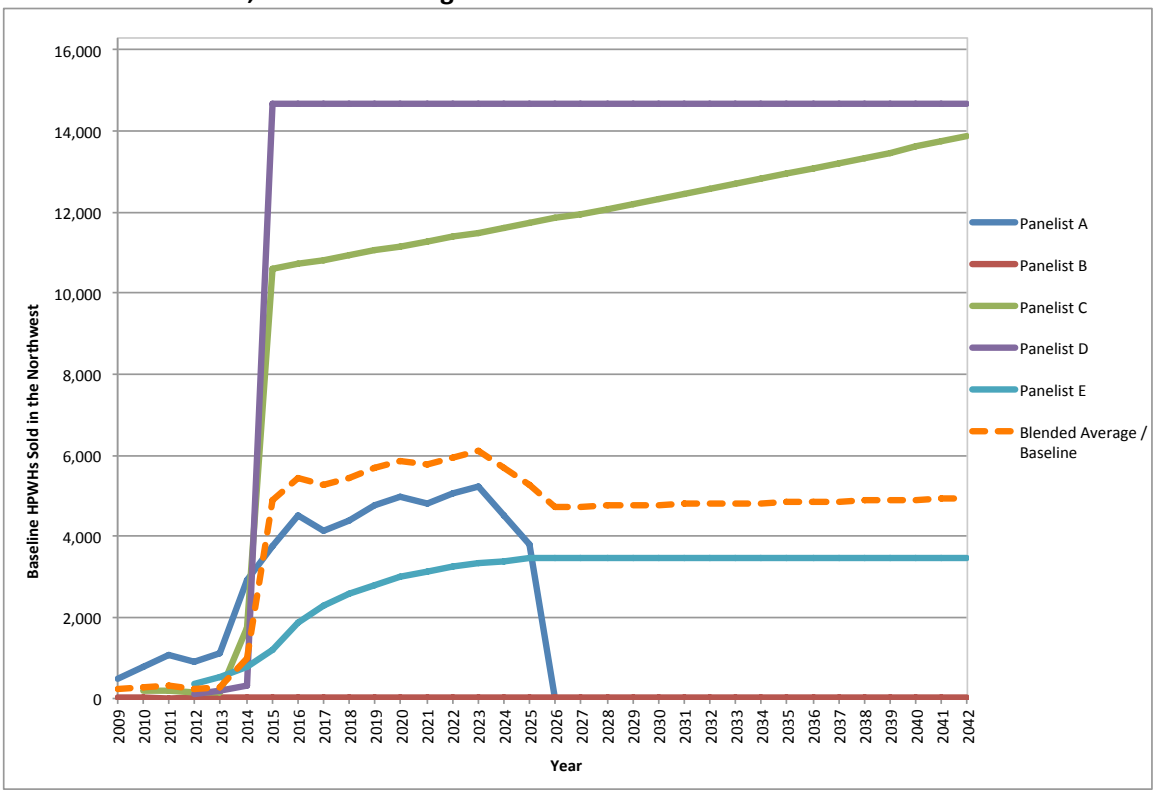
The blended average of Panelist A – E forecasts shows a perceived impact of 2015 water heater standards on the baseline for Tier 1 HPWHs larger than 55 gallons. As shown in Table 31 and Figure 30, Panelists A – E forecast baseline sales in the Northwest to jump from under 1,000 per year to nearly 5,000 in 2015. Similar to the smaller Tier 1 HPWHs, an increase in Tier 2 baseline sales of comparably sized tanks leads to a slight decrease in the blended average baseline sales forecasted for Tier 1 HPWHs in this tank size category between 2023 and 2026.

We believe the increase in 2015 is plausible. The decrease in blended average baseline sales estimate between 2023 and 2026 is due to the analysis of Panelist A, and is plausible due to shifting demand towards Tier 2 HPWHs better suited for the Northwest climate.

Table 31: Panelist A – E, Blended Average Baseline Forecast: Tier 1 HPWHs with Tank Size >55 Gallons

TIER 1 Heat Pump Water Heaters >55 Gallons				
Year	Baseline		Year	Baseline
2009	255		2026	4,731
2010	262		2027	4,743
2011	310		2028	4,755
2012	224		2029	4,767
2013	294		2030	4,779
2014	977		2031	4,791
2015	4,907		2032	4,804
2016	5,436		2033	4,816
2017	5,261		2034	4,829
2018	5,444		2035	4,842
2019	5,703		2036	4,855
2020	5,881		2037	4,868
2021	5,792		2038	4,881
2022	5,960		2039	4,895
2023	6,093		2040	4,908
2024	5,672		2041	4,922
2025	5,265		2042	4,935

Figure 30: Panelist A – E, Blended Average Baseline Forecast: Tier 1 HPWHs with Tank Size >55 Gallons



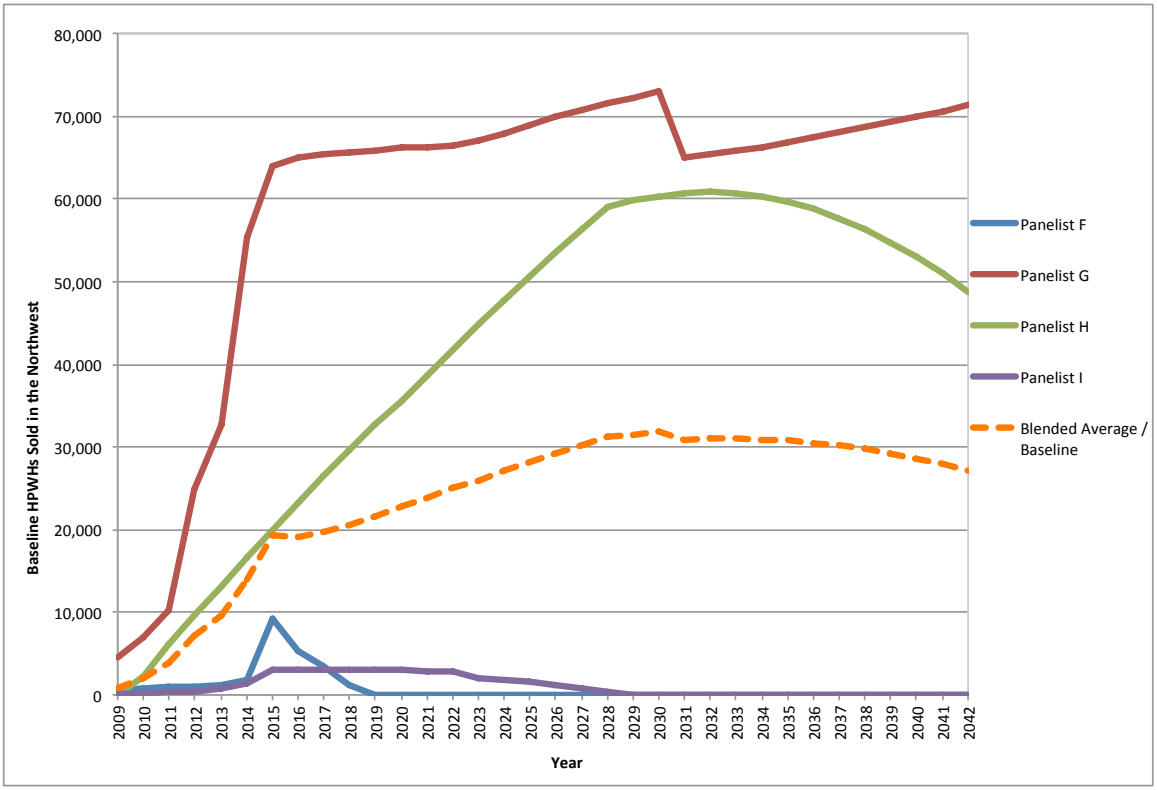
Similar to the results for the smaller Tier 1 HPWHs, Panelists F – I had diverging opinions regarding the baseline forecast for Tier 1 HPWHs with tank volumes of more than 55 gallons. The blended average baseline forecast is shown in Table 32 and Figure 31, with their individual estimates also shown in the figure.

As with the smaller Tier 1 HPWH forecasts, Panelist G and Panelist H predict higher levels of baseline sales, with Panelists F and I predicting near-term baseline sales, with Tier 2 sales taking over the entire market share in future years. Panelist G and Panelist H predicted higher levels of baseline sales than all Panelists A – E, driving the blended average baseline forecast above 30,000 units by 2027.

Table 32: Panelist F – I, Blended Average Baseline Forecast: Tier 1 HPWHs with Tank Size >55 Gallons

TIER 1 Heat Pump Water Heaters >55 Gallons				
Year	Baseline		Year	Baseline
2009	841		2026	29,258
2010	2,042		2027	30,283
2011	3,919		2028	31,234
2012	7,157		2029	31,458
2013	9,602		2030	31,785
2014	13,996		2031	30,925
2015	19,362		2032	31,009
2016	19,201		2033	30,992
2017	19,794		2034	30,908
2018	20,638		2035	30,748
2019	21,664		2036	30,483
2020	22,768		2037	30,146
2021	23,888		2038	29,737
2022	25,045		2039	29,219
2023	25,941		2040	28,626
2024	27,043		2041	27,959
2025	28,166		2042	27,177

Figure 31: Panelist F – I, Blended Average Baseline Forecast: Tier 1 HPWHs with Tank Size >55 Gallons



4.1.3 Tier 2 HPWHs with Tank Size 55 Gallons or Less

The blended average forecast for Panelists A – E for Tier 2 HPWHs with tank sizes of 55 gallons or below shows relatively steady baseline sales growth of these HPWHs through 2042. Presented in Table 33 and Figure 32, their blended average forecast of sales remains under 100 units per year through 2013, but then increases to over 500 HPWHs in 2014 with steady growth thereafter, ultimately reaching more than 10,000 units per year in 2042.

We believe that this forecast is plausible, although it is limited in one respect. Noticeably absent from the blended average baseline forecast is a significant increase in sales during the 2023 to 2026 period. A large increase in baseline sales of Tier 2 HPWHs would account for the reduction in baseline sales presented in Section 4.1.1, above, regarding the Tier 1 HPWHs of the same size.

Panelist A's forecast includes complimentary estimates for Tier 2 and Tier 1 products, which are internally consistent. However, this is a special case where Panelist A's forecast is an outlier for Tier 2 HPWHs and the median for Tier 1 HPWHs, and thus there is an inconsistency, as the blended average approach discounts outliers but not median estimates. To a degree, using the blended average approach compromises their internal consistency, but we would lose resolution at the Tier- and tank size-level if the findings are presented for the entire HPWH market in the Northwest.

Table 33: Panelist A – E, Blended Average Baseline Forecast: Tier 2 HPWHs with Tank Size ≤55 Gallons

TIER 2 Heat Pump Water Heaters ≤55 Gallons				
Year	Baseline		Year	Baseline
2009	0		2026	5,281
2010	0		2027	5,579
2011	1		2028	5,905
2012	60		2029	6,256
2013	98		2030	6,612
2014	585		2031	6,697
2015	897		2032	6,977
2016	1,271		2033	7,336
2017	1,509		2034	7,720
2018	1,728		2035	8,134
2019	1,981		2036	8,578
2020	2,260		2037	9,055
2021	2,613		2038	9,024
2022	3,009		2039	9,374
2023	3,450		2040	9,696
2024	3,854		2041	10,035
2025	4,423		2042	10,391

Figure 32: Panelist A – E, Blended Average Baseline Forecast: Tier 2 HPWHs with Tank Size ≤55 Gallons

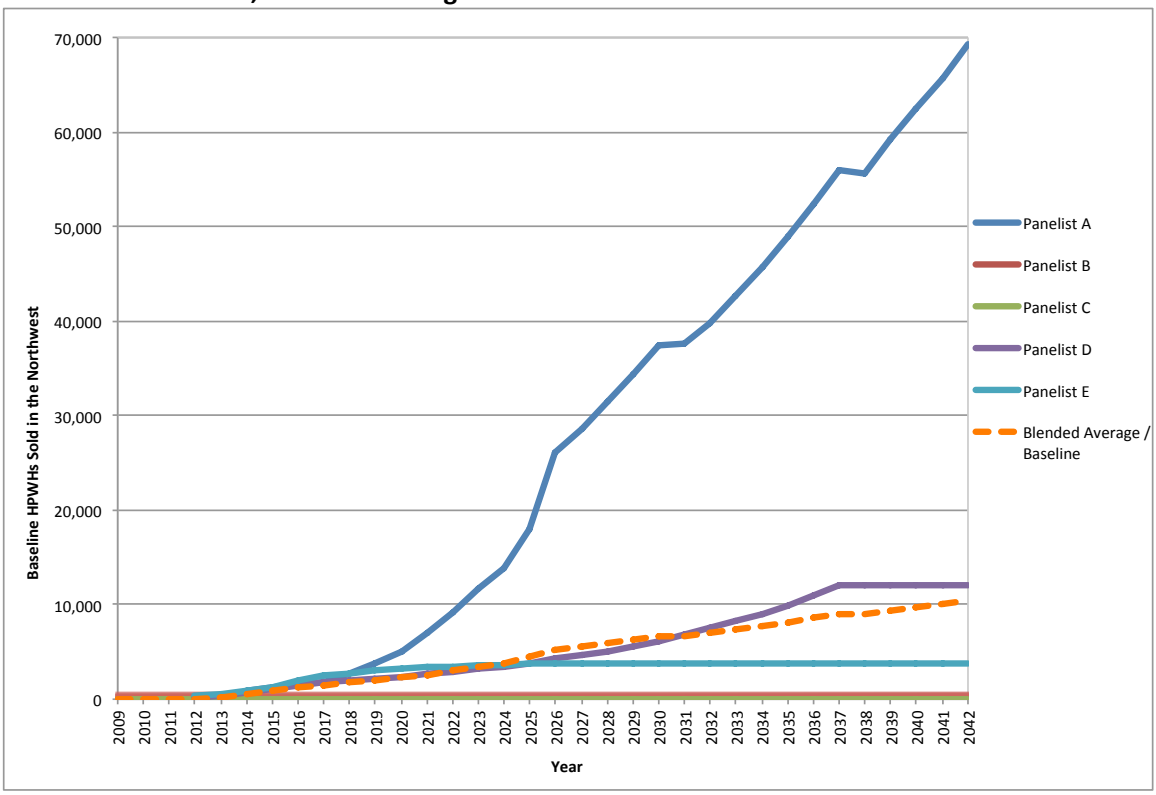


Table 34 and Figure 33 show the blended average forecast baseline sales of Panelists F – I for Tier 2 HPWHs with volumes of 55 gallons or less. The blended average is shown with the estimates of each panelist in the figure.

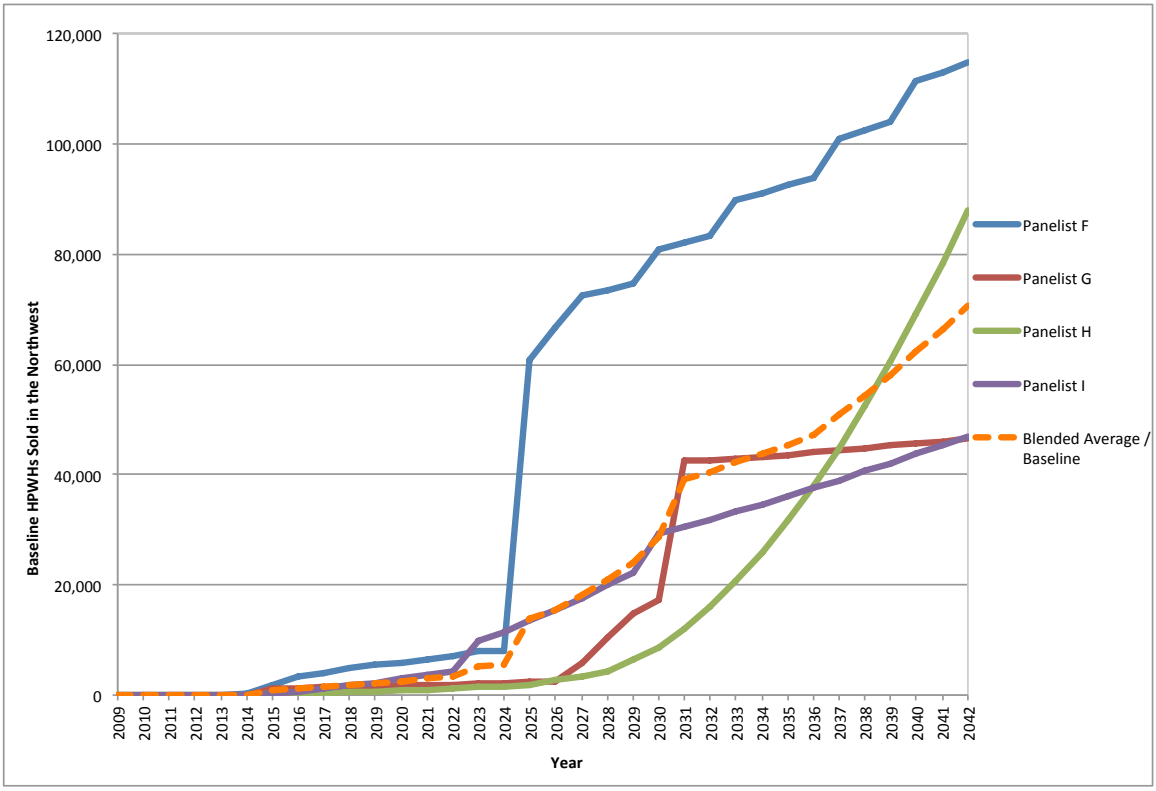
As shown, the blended average forecast of baseline sales remains low through 2022, in line with estimates from Panelists A – E. In 2023 the blended average increases significantly, and more than doubles between 2024 and 2025. While Panelist F's forecast of a huge jump in baseline sales in 2025 (the effect of sales ramping up in advance of a predicted mandate) disproportionally impacts the blended average through approximately 2030, the long-term blended average is consistent with the Panelist F – I group's individual forecasts overall.

Panelists F, G, and H predict a federal mandate between 2025 and 2030 that will require small volume electric water heaters sold in the U.S. to exhibit efficiencies in line with HPWH technology. This is inconsistent with the majority of forecasts from Panelists A – E. Therefore, the underlying assumption of a mandate around that time drives a significant divergence in the blended average baseline forecasts.

Table 34: Panelist F – I, Blended Average Baseline Forecast: Tier 2 HPWHs with Tank Size ≤55 Gallons

TIER 2 Heat Pump Water Heaters ≤55 Gallons				
Year	Baseline		Year	Baseline
2009	0		2026	15,396
2010	0		2027	18,243
2011	0		2028	21,094
2012	5		2029	24,056
2013	22		2030	28,614
2014	50		2031	39,088
2015	805		2032	40,359
2016	1,181		2033	42,401
2017	1,505		2034	43,819
2018	1,861		2035	45,412
2019	2,217		2036	47,205
2020	2,589		2037	50,985
2021	2,990		2038	54,350
2022	3,415		2039	57,926
2023	5,188		2040	62,444
2024	5,513		2041	66,482
2025	13,733		2042	70,768

Figure 33: Panelist F – I, Blended Average Baseline Forecast: Tier 2 HPWHs with Tank Size ≤55 Gallons



4.1.4 Tier 2 HPWHs with Tank Size Greater than 55 Gallons

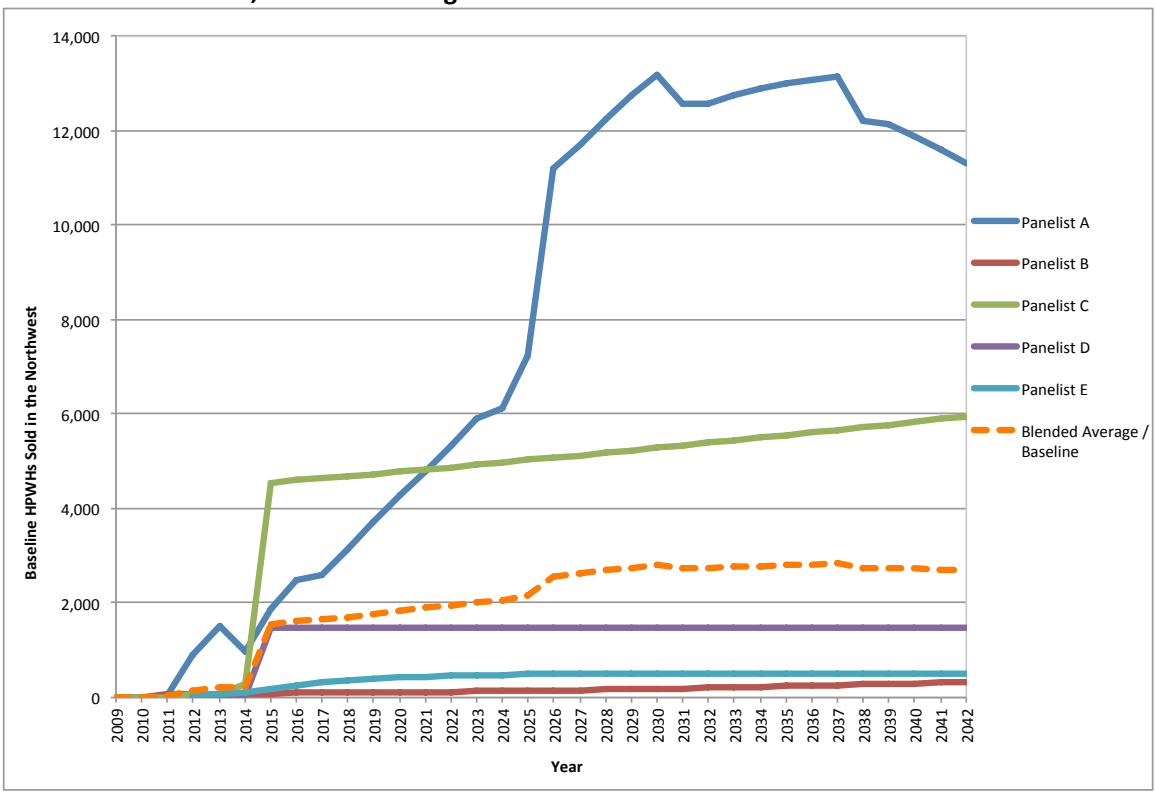
Based on the blended average forecasts of Panelists A – E, the larger Tier 2 HPWH baseline sales are forecast to remain relatively low over the study period. Steady growth is interrupted in 2015 as the federal standard is predicted to impact baseline sales, as shown in both Table 35 and Figure 34, below. The blended average baseline sales forecast for Panelists A – E remains fairly constant between 2026 and 2042, with between 2,573 and 2,836 annual sales predicted in absence of utility rebates.

We believe this blended average baseline forecast estimate is plausible. While the increase in baseline sales between 2023 and 2026 does not entirely supplant the decrease in baseline sales of Tier 1 units of the same size (resulting from Panelist A's assessment), the forecast does account for this effect enough, in our opinion.

Table 35: Panelist A – E, Blended Average Baseline Forecast: Tier 2 HPWHs with Tank Size >55 Gallons

TIER 2 Heat Pump Water Heaters >55 Gallons				
Year	Baseline		Year	Baseline
2009	0		2026	2,573
2010	0		2027	2,631
2011	39		2028	2,689
2012	138		2029	2,746
2013	211		2030	2,794
2014	208		2031	2,740
2015	1,549		2032	2,747
2016	1,625		2033	2,770
2017	1,647		2034	2,791
2018	1,711		2035	2,809
2019	1,777		2036	2,824
2020	1,841		2037	2,836
2021	1,901		2038	2,752
2022	1,962		2039	2,749
2023	2,023		2040	2,733
2024	2,052		2041	2,713
2025	2,172		2042	2,688

Figure 34: Panelist A – E, Blended Average Baseline Forecast: Tier 2 HPWHs with Tank Size >55 Gallons



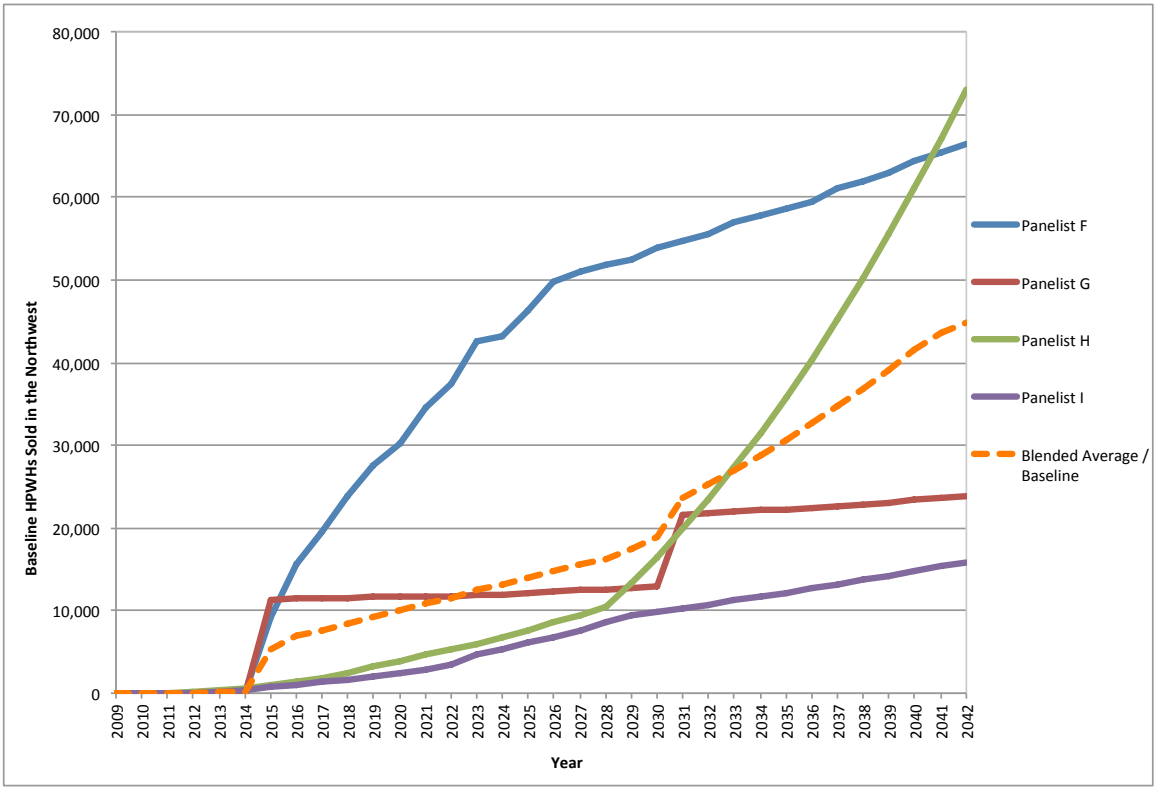
Shown in Table 36 and Figure 35 are the blended average baseline forecasts of Tier 2 HPWHs with tank sizes greater than 55 gallons, based on estimates provided by Panelists F – I.

As shown, both Panelist F and Panelist G believe the 2015 federal standard will have a significant effect on baseline sales in 2015. Panelist F believes that sales will continue to grow from the impact of the mandate, whereas Panelist G believes that they will reach approximately 10,000 units per year, and flatten out. Panelist G believes a mandate in 2030 will have the same effect, doubling annual baseline sales to over 20,000 per year for the Northwest. Panelist H believes that annual baseline sales will grow during the entire study period, but will grow at a much slower pace than Panelists F and G until 2028, when they estimate baseline sales to increase significantly, through the end of the forecast period. Panelist I forecasts relatively linear baseline sales of the larger tank volume Tier 2 HPWHs over the duration of the forecast period.

Table 36: Panelist F – I, Blended Average Baseline Forecast: Tier 2 HPWHs with Tank Size >55 Gallons

TIER 2 Heat Pump Water Heaters >55 Gallons				
Year	Baseline		Year	Baseline
2009	0		2026	14,889
2010	0		2027	15,559
2011	4		2028	16,169
2012	37		2029	17,510
2013	121		2030	18,996
2014	248		2031	23,711
2015	5,349		2032	25,268
2016	6,900		2033	27,026
2017	7,649		2034	28,789
2018	8,482		2035	30,639
2019	9,250		2036	32,613
2020	9,961		2037	34,735
2021	10,804		2038	36,911
2022	11,495		2039	39,159
2023	12,614		2040	41,610
2024	13,123		2041	43,677
2025	13,984		2042	44,939

Figure 35: Panelist F – I, Blended Average Baseline Forecast: Tier 2 HPWHs with Tank Size >55 Gallons



4.2 Discussion

Panelists were provided the same background information and allowed to conduct analysis based on all available data sources, forecasts, assumptions, and opinion. However, many of the key factors influencing the outcome of the analysis were significantly different for Panelists A – E than for Panelists F – I. Key factors are listed below:

Panelists A – E:

- Approaches and assumptions better suited to account for unique market characteristics in the NW.
- Diverse set of approaches relied upon by panelists.
- Baseline sales of HPWHs never approach total electric water heater sales.
- Panelists assumed 2015 mandate the sole standard during the forecast period.
- Panelists assume lower levels of compliance with federal mandates in absence of incentives.

Panelists F – I:

- Market forecasts based largely on national conditions.
- Largely homogenous set of approaches relied upon by panelists.
- Baseline sales of HPWHs account for all (or nearly all) electric water heater sales by 2040.
- Three out of four panelists assumed an additional standard update affecting small volume HPWHs.
- Panelists assume higher levels of compliance with federal mandates in absence of incentives.

These significant differences led to divergent forecasts between the two sets of panelists. The key findings from the forecasts are presented below, and shown in Figure 36 and Figure 37:

Panelists A – E (Figure 36**):**

- Increase in baseline sales associated with 2015 mandate.
- Total HPWH baseline sales surpass 10,000 in 2015.
- Total HPWH baseline sales surpass 25,000 in 2031.

Panelists F – I (Figure 37**):**

- Increase in baseline sales associated with 2015 mandate.
- Increase in baseline sales associated with ~2025-2030 mandates.
- Total HPWH baseline sales surpass 10,000 in 2013.
- Total HPWH baseline sales surpass 25,000 in 2015.
- Total HPWH baseline sales surpass 50,000 in 2023.
- Total HPWH baseline sales surpass 100,000 in 2030.
- Total HPWH baseline sales surpass 150,000 in 2037.

The overall blended average forecasts are shown in Figure 24, Figure 25, Figure 26, and Figure 27, above. These forecasts are problematic, due to the limitations of the results from Panelists F – I, discussed above, and the significant differences in the assumptions of panelists in the long term (i.e., the assumed onset of new standards). Since the panels were conducted sequentially and panelists were thus not able to review the interim results of the other panel, we do not believe the overall blended averages of *all* panelist results is necessarily a sound approach to overcome the differences.

4.3 Recommendation

We recommend NEEA adopt a blended average baseline forecast for HPWHs sales in the Northwest to include in the ACE Model based solely on results from Panelists A – E. Panelists F – I provided key insights regarding the potential impacts of future federal mandates (or updates to the 2015 standard). Nevertheless, the analyses of these panelists do not account for the unique conditions of the Northwest water heater market compared to Panelists A – E.

This is a matter of opinion, but is grounded in Evergreen's unique perspectives regarding incentivized HPWH sales in the Northwest. Our recent assessment of NEEA's Heat Pump Water Heater Market Test [9]demonstrated that even sales assisted by NEEA and Northwest utilities remain low, and that significant barriers remain. In an emerging market such as the HPWH market in the Northwest, baseline sales infrequently *far* outpace incentivized sales, as produced by Panelists F – I.

Furthermore, compliance with standards rarely approaches 100 percent (an assumption or near-assumption of Panelists F – I). As with other standards such as Title 24 in California[10], consumers often find workarounds or simply do not comply. Even though this is a manufacturer standard, it is likely that end-users in baseline conditions would find a workaround (e.g., second hand electric storage water heaters, two smaller water heaters, investing in repairs as opposed to a new water heater, buying a Canadian water heater, etc.).

Since Panelists A – F did not believe that a second standard would influence baseline sales, we recommend that should the DOE implement a second federal standard (or standard update), the baseline forecast should be revisited for the time period immediately preceding the date the new standard takes effect, as well as all subsequent years' estimates. NEEA's impact on standards updates should be accounted for in separate research from baseline forecast research.

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[9] Heat Pump Water Heater Market Test Assessment, prepared by Evergreen Economics, Inc. for the Northwest Energy Efficiency Alliance, December 9, 2013. http://neea.org/docs/default-source/reports/northwest-heat-pump-water-heater-market-test-assessment.pdf?sfvrsn=6

[10] California's Title 24, otherwise known as The Energy Efficiency Standards for Residential and Nonresidential Buildings, are a set of codes that regulate residential and commercial building construction and retrofit. For more information: http://www.energy.ca.gov/title24/

Figure 36: Panelists A – E, Blended Average Forecasts by Tank Size and Tier, and Overall

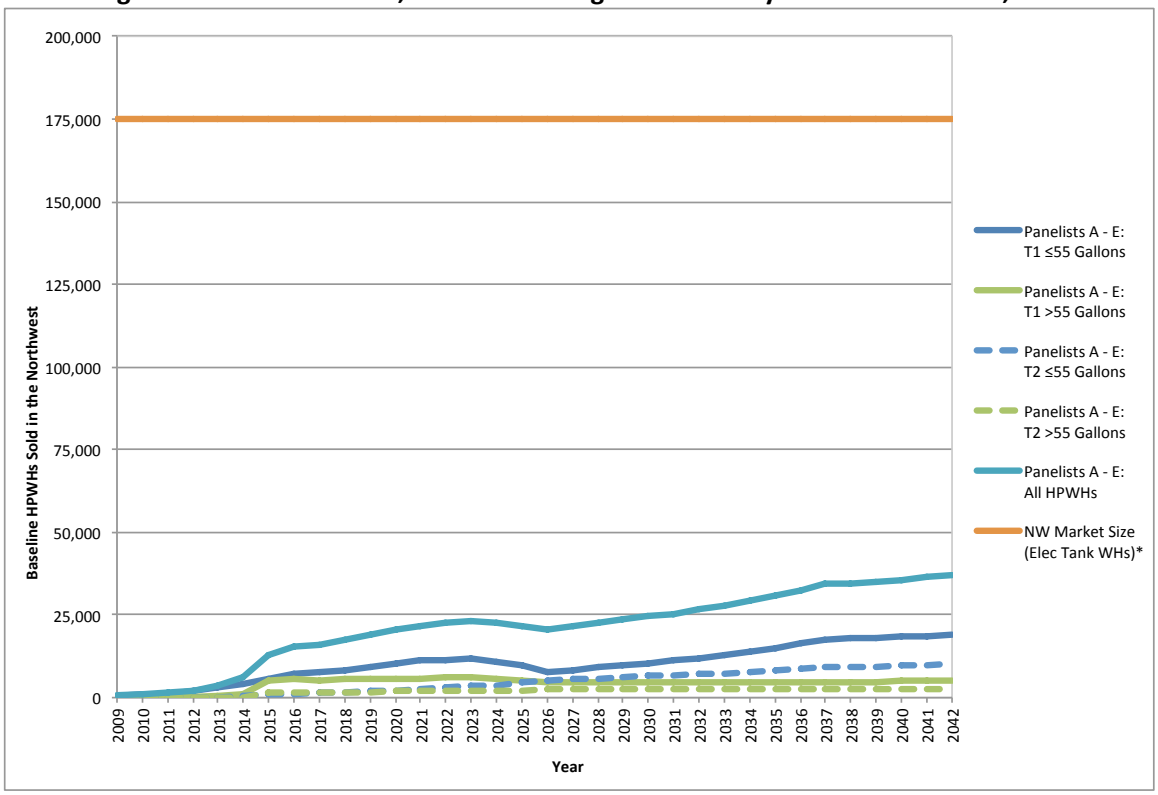
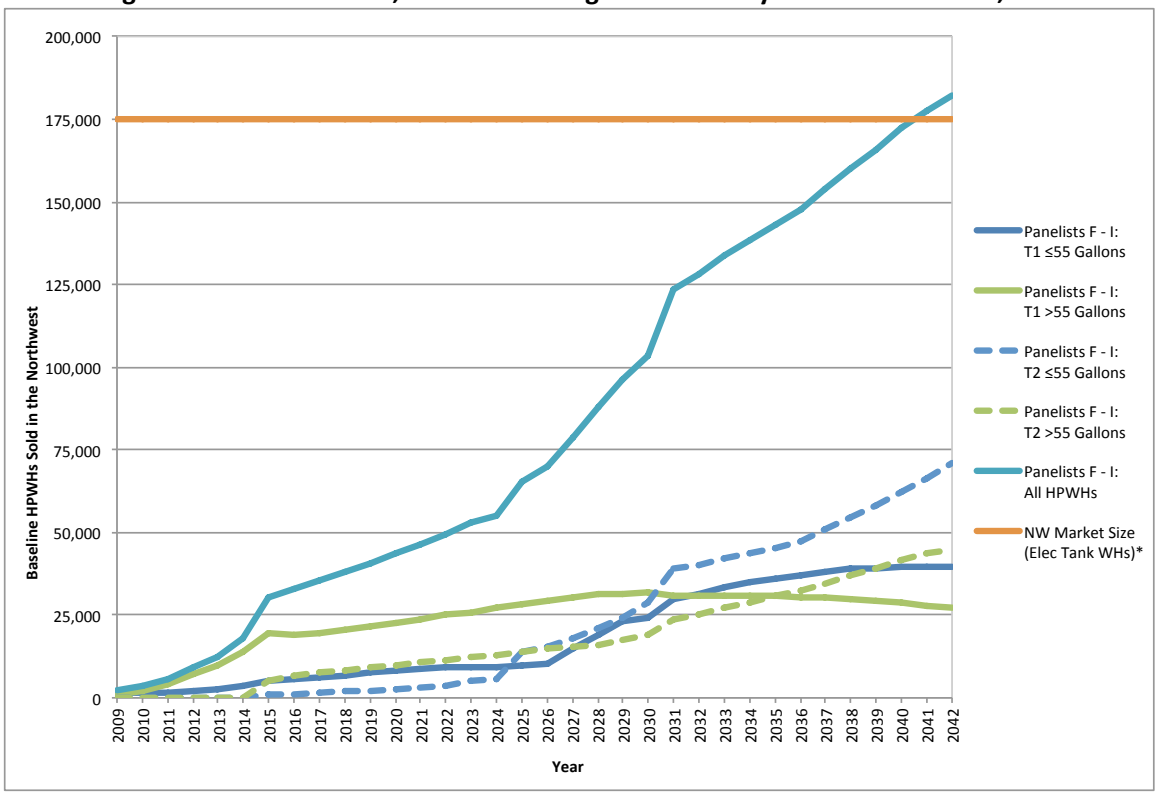


Figure 37: Panelists F – I, Blended Average Forecasts by Tank Size and Tier, and Overall



Memorandum

Oct. 30, 2014

TO: Christopher Frye, Senior Manager, Research and Evaluation; Stephanie Rider, Senior Manager, Market Planning

FROM: Christina Steinhoff, Planning Analyst III; Jill Reynolds, Initiative Manager; Dave Kresta, Product Manager

CC: Anu Teja, Senior Project Manager, Market Research and Evaluation; Lis Saunders, Senior Manager Stakeholder Relations; Becca Yates, Marketing and Communications Manager

SUBJECT: Heat Pump Water Heater Baseline Response

Evergreen Economics provided NEEA with a baseline forecast of Heat Pump Water Heater (HPWH) sales through 2042.[1] The forecast shows the sales expectations of industry experts by using a Delphi panel. This memo explains how NEEA incorporated the baseline forecast into its Net Market Effects savings forecast.

Background

Net Market Effects is savings not counted as Baseline or through a local program[2] (Figure 1). NEEA forecasts Net Market Effects using a market share forecast multiplied by an estimate of annual sales of electric water heaters. The difference between this forecast minus local programs[3] and minus the baseline is Net Market Effects when multiplied by a savings rate.

Figure 1: The Use of the Baseline Study

Applying the results of the baseline study to this calculation results in negative Net Market Effects for some products because the Baseline exceeds the Total Regional Savings. Data on regional electric water heater sales is not available. As a result, some panelists estimated 175,000 annual sales in the Northwest and

[1] Evergreen Economics. Dec. 6, 2013. NEEA Heat Pump Water Heater Baseline Research.

[2] Local programs are programs run by utilities, the Bonneville Power Company, or the Energy Trust of Oregon.

[3] NEEA also deducts the baseline share of Local program units to avoid double counting baseline.

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allowed the share of large tanks to grow.[4] Others created their own estimate. Meanwhile, NEEA estimates fewer annual sales and does not allow the tank-size mix to change over time.[5] As a result, the panelist's baseline sales forecast at times exceeds NEEA's sales forecast for large tanks.

Method to Apply the Baseline Study Results

The Heat Pump Water Heater Initiative team supports using the Baseline Study; however, the team agreed to force the baseline units equal to the actual sales when they exceed the actual sales. This is the most straightforward approach to incorporating the results of the study without reporting negative Net Market Effects because of inconsistencies in forecasting assumptions. NEEA will re-evaluate this approach as it collects more sales data.

[4] Derived from Verinnovation Inc. Jan. 16, 2012. 2011 Water Heater Market Update.

[5] Currently, NEEA assumes consumers replace their electric water heater every 15 years. The stock— number of electric water heaters—comes from the Residential Building Stock Assessment. The measure life comes from the Regional Technical forum.