2016 Residential Heating Ventilation and Air Conditioning

MARKET RESEARCH AND MOMENTUM SAVINGS REPORT

Bonneville
POWER ADMINISTRATION

JUNE 2016

EXECUTIVE SUMMARY

This report details the research team's methodology and results to estimate Momentum Savings from residential heating, ventilation, and air conditioning (HVAC) units in Bonneville Power Administration (BPA) territory and the Pacific Northwest region between 2010 and 2014. The report also contains a market characterization defining the current state of the residential electric HVAC market in the Northwest region.

APPROACH

The findings in this report are based on sales data, interviews, discussions with BPA staff, and analysis of secondary data. The sales data comprises sales of all types of equipment—more than 200,000 unit sales in total—from five HVAC distributors in the Northwest. Depending on the product, the sales data collected accounts for 10% to 90% of product sales in the Northwest HVAC market. The 11 interviews with key players in the HVAC supply chain include wholesale distributors, manufacturer representatives, large mechanical or HVAC contractors, and HVAC engineers. Secondary data sources informing the market and Momentum Savings research include but are not limited to the Northwest Power and Conservation Council's Sixth Regional Power Plan, the Air Conditioning, Heating, and Refrigeration Institute (AHRI), and the 2011 Single Family and Manufactured Homes Residential Building Stock Assessments (RBSA).

MORE THAN
200,000
UNIT SALES

10% to 90%
of product sales in the Northwest HVAC market

11
interviews with key players in the HVAC supply chain

The research team estimated Momentum Savings using the Four Question Framework (described in detail in Figure 11 on page 15). Questions 1 and 2 define the residential HVAC market in terms of number of units installed in the marketplace each year within the product categories covered by this analysis. Questions 3 and 4 present the methods for quantifying Momentum Savings, including calculating the total energy consumption in the baseline and actual market scenarios and defining the program savings achieved in the HVAC market. Together, the results of the Four Questions enable the research team to estimate Momentum Savings in the residential HVAC market.

The main body of the report contains more detail on the methodology the team used to calculate Momentum Savings as well as characterize the market.

MARKET OVERVIEW

Our research on efficiency trends in the Northwest residential HVAC markets indicates that sales of high-efficiency HVAC equipment are not taking off on their own, especially sales of high-efficiency ducted HVAC equipment. However, the research team identified several possible strategic opportunities for efficiency programs to consider. The market research and sales data covering the period from 2010 through 2014 shows that:

1. THE INDUSTRY IS EXCITED ABOUT DUCTLESS.

The HVAC industry is excited about ductless, and it's creating changes in the structure of the U.S. HVAC market. Manufacturers are strategically positioning themselves to gain market shares in the United States. Distributors report strong growth in sales of this equipment in the Northwest, but sales have a way to go before they surpass the sales of ducted equipment.

2. HIGH-EFFICIENCY HVAC SALES MAY NEED A BOOST.

The majority of traditional residential air conditioners and heat pumps sold are at or near the federal minimum efficiency levels. The average efficiency of units sold from 2010 to 2014 increased only slightly over that time frame. This market may need help to jump-start the shift to today's world of high-efficiency HVAC products.

3. THE SUPPLY CHAIN AFFECTS RESIDENTIAL DECISION-MAKING.

The residential HVAC supply chain is consolidated at manufacturing and distribution. Most equipment sold in the region is sold through only a few key distributors. In contrast, the contractors and builders are very fragmented, with hundreds of different contractors installing equipment across the region. Contractors tend to recommend equipment that is readily available, cost-competitive, and familiar.

MARKET INTELLIGENCE FOR PROGRAM PLANNERS AND MANAGERS

The research team identified several possible strategic opportunities for efficiency programs that may help boost efficiency in the HVAC market.

1. CONSIDER OPPORTUNITIES TO EXPAND THE TARGET AUDIENCE TO INCLUDE DISTRIBUTORS.

Distributors play a very important role in both the residential and commercial HVAC decision and supply chains. Engaging distributors is a good way to make a big impact on the HVAC market while only touching a few market actors, as the distributor network is more consolidated than contractors and end-users.

2. LOOK INTO THE BEST WAYS TO SUPPORT DISTRIBUTORS IN PROMOTING AND STOCKING EFFICIENT EQUIPMENT.

This approach could include education, training, spifs for salespeople, or incentives to reduce the cost of higher-efficiency equipment. For both residential and small commercial, encouraging distributors to stock efficient units is especially important to help the failed equipment market become more efficient. When end-users experience a sudden HVAC failure, they need a quick replacement and may settle for what is in stock and readily available. Because of the long life and high cost of HVAC equipment, most end-users do not replace their equipment until it fails or is near the end of its life. Therefore, the opportunity for efficiency programs to influence customers in their decision to install efficient equipment is rare. Encouraging distributors to stock more efficient equipment is critical to leveraging the failed equipment decision opportunity.

3. SUPPORT DISTRIBUTORS IN DISSEMINATING THE MESSAGE ABOUT EFFICIENCY TO CONTRACTORS.

Distributors have close relationships with their contractor customers. Determine what distributors need from efficiency programs to sell more efficient equipment to contractors, and educate contractors on how to sell it to builders and end-users. This could include training for contractors and marketing collateral for contractors to provide to end users.

4. IDENTIFY HOW TO INFLUENCE THE NEW CONSTRUCTION MARKET.

In addition to distributors, builders play an important role in changing the efficiency mix of sales in the new construction market.Efficiency programs should learn more about their path to purchase new equipment, how to better engage with builders, and what will motivate them to install more efficient equipment.

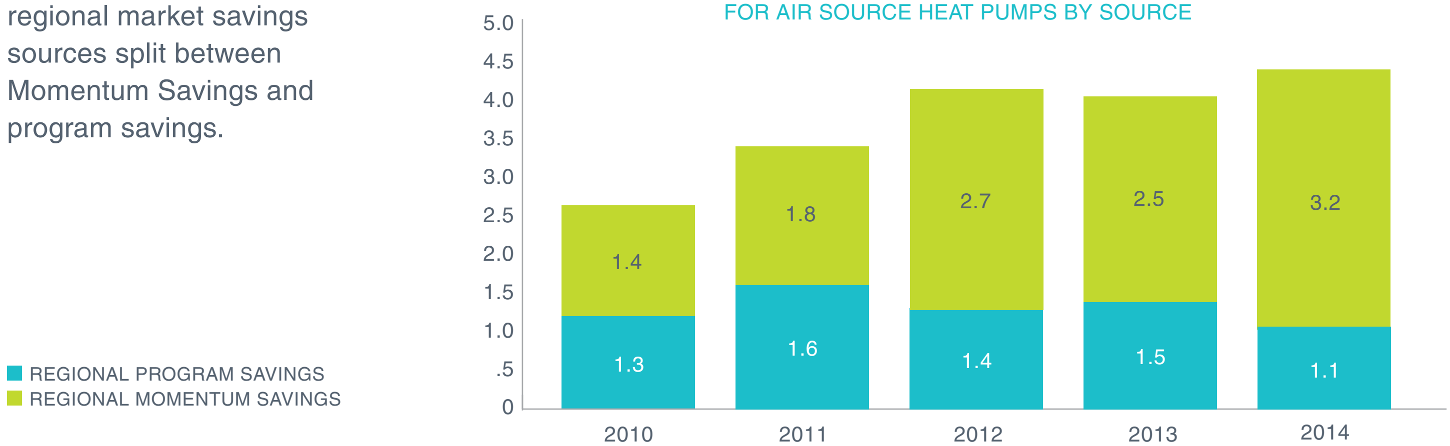
5. EMBRACE DUCTLESS BUT DON'T FORGET ABOUT THE MAJORITY OF THE MARKET WITH DUCTED SYSTEMS.

Ductless HVAC is an optimal, efficient technology for new construction and a variety of existing building applications but many buildings already have air ducts and may not want to go ductless. A concerted effort to improve the efficiency of ducted heat pumps in existing buildings could help capture a large volume of potential savings and complement the growing buzz around ductless equipment. This is an opportunity for energy-efficiency programs to help generate excitement about variable speed heat pumps with key players in the supply and decision chains.

DRAFT MOMENTUM SAVINGS RESULTS

Figure ES-1 shows the total regional market savings sources split between Momentum Savings and program savings.

FIGURE ES-1: TOTAL REGIONAL MARKET SAVINGS (AMW) FOR AIR SOURCE HEAT PUMPS BY SOURCE



The team learned from primary sales data collection efforts that the relative proportion of efficient and inefficient air source heat pump sales did not significantly change over the analysis period. Therefore, the efficiency mix of units sold is not a main driver of the Momentum Savings. The driving factors that determine Momentum Savings are:

1. THE RELATIVE PROPORTION OF CONVERSIONS VERSUS UPGRADES IN THE MARKET.
An air source heat pump replacing an electric forced air furnace (a conversion) yields much greater savings than an air source heat pump replacing another air source heat pump (an upgrade).

2. THE MARKET SIZE
Program savings remain relatively constant over the analysis period. As such, when the market size increases relative to program unit sales, Momentum Savings also increase.

3. QUALITY INSTALLATIONS.
For units sold into the market, the team assumes that contractors who install these units do not follow efficient commissioning, controls, and sizing (CC&S) practices. If the analysis team were to find that a certain percentage of contractors in the market outside of programs actually are following energy-efficient CC&S practices, Momentum Savings could increase.

4. PROGRAM SAVINGS
The team estimates Momentum Savings by subtracting program savings from the total market savings. Thus, the program savings directly influence Momentum Savings results. Gathering more detailed program data from BPA and regional IOUs will improve the estimation of Momentum Savings.

[1]HVAC Market Intelligence Report. https://www.bpa.gov/EE/Utility/research-archive/Documents/Momentum-Savings-Resources/2016_HVAC_Market_Intelligence_Booklet.pdf

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Introduction

In 2014, Bonneville Power Administration (BPA) contracted with Navigant Consulting, Inc. (Navigant) and Cadeo (the research team) and initiated this research project of the heating, ventilation, and air conditioning (HVAC) market to determine the extent to which Momentum Savings exist and to characterize the market.

Background

HVAC is a complex market with many important facets to be considered. It is also an important part of BPA's savings portfolio, accounting for slightly over one-quarter of the residential savings potential in the Northwest Power and Conservation Council's (the Council's) Seventh Power Plan. Thus, it is important that BPA understands the direction the industry is headed, how the supply and decision chains work, and the total market energy savings from HVAC equipment.

This was BPA's first research project attempting to characterize the entire HVAC market, meaning it was BPA's first time looking at the market's efficiency and how the market works beyond what is seen and known about efficiency programs in the Northwest. When the research team began this project, there were a lot of unknowns, but the team did not yet know what all the unknowns were. After nearly two years of research, the research team has learned a lot and also has a much better understanding of what it *does not know.* This report summarizes everything the research team learned from the initial research exploration into this market and highlights where data and information gaps remain.

Note that the research team identified several significant uncertainties that have a large effect on the Momentum Savings results as well as potential future actions to address the uncertainties. This report describes the key factors that drive Momentum Savings for residential HVAC and discusses these remaining uncertainties. To ensure that the results are robust, the savings will remain in draft status until the research team can fill in the key data gaps.

Objectives

The goal for this study was to deliver actionable insights based on recent HVAC market information, with a focus on ducted equipment. The study began with two major research objectives:

1. **Characterize the Market (see page 3).** The study sought to understand the market structure including the supply chain, how decisions are made, and equipment efficiency sales trends. As part of the study, the research team compiled a separate *HVAC Market Intelligence Report*,[1] delivered in April 2016, to provide program managers and planners immediate feedback on the current state of the HVAC market. This report provides an expanded methodology and more detailed sales data findings.

2. **Estimate Momentum Savings (see page 14).** The research team sought to develop a methodology and quantify Momentum Savings for the residential HVAC market. Momentum Savings are cost-effective savings that occur above the Council's Sixth Plan baseline and are neither incentivized by utility programs nor included in the Northwest Energy Efficiency Alliance's (NEEA's) net market effects. Momentum Savings have various drivers, including codes and

[1] *HVAC Market Intelligence Report*. https://www.bpa.gov/EE/Utility/research-archive/Documents/Momentum-Savings-Resources/2016_HVAC_Market_Intelligence_Booklet.pdf

standards (beyond those already captured in the Sixth Plan), baseline shifts, and general market transformation effects.

This study also provided an important opportunity to align BPA's data and analysis processes with its vision for regional HVAC efforts. Specifically, BPA envisions using market research and analytics to gather the market intelligence that regional program managers need to make effective and timely responses to changing market conditions. This will allow BPA to allocate ratepayer dollars for conservation acquisition in the most efficient way.

Organization of this Report

The remainder of the report includes two main sections that describe the details of the analysis' activities and discuss the sources of data:

- **Market Characterization:** This section discusses the methodology and findings from the research team's efforts to characterize and define the current state of the residential electric HVAC market in the Northwest. Findings include detailed sales data summaries by equipment type.
- **Momentum Savings Analysis:** Additionally, this report details the team's methodology and draft results to estimate Momentum Savings from residential ducted air source heat pumps in BPA territory and the Pacific Northwest region between 2010 and 2014.

Accompanying appendices provide additional information including a detailed description of the data collection tool, interview guides, and other relevant background material.

Market Characterization

This section describes the approach from efforts to characterize and define the current state of the residential electric HVAC market in the Northwest region. The section first describes the research methodology and then presents detailed aggregated HVAC distributor sales data and efficiency trends by technology. The *HVAC Market Intelligence Report*,[2] published in April 2016, provides key findings from the team's in-depth analysis of how the HVAC market operates in the residential market. The report also provides strategic opportunities for efficiency programs to consider how to improve overall HVAC market efficiency.

Methodology

The research team developed the key market characterization findings based on HVAC distributor sales data, a series of in-depth interviews with key market actors in the HVAC industry supply chain, secondary data, and discussions with BPA staff. This section provides more detail on the methodology for sales data collection and the approach for interviews with market actors and BPA program staff.

Sales Data Collection

The research team engaged with HVAC distributors and manufacturer representative firms between October 2014 and April 2015 to collect residential HVAC sales data in the Northwest. The sales data that the team collected feeds into both the HVAC market characterization findings as well as the Momentum Savings analysis. The team provided each contact with a detailed data collection template for numerous HVAC equipment types. The template had common size and efficiency categories for each equipment type, and the research team asked the contacts to populate the template with sales data from 2010 through 2014.

The research team designed the data collection template to be consistent with common size and efficiency categories used by the Consortium for Energy Efficiency (CEE), efficiency standard guidelines from the Department of Energy (DOE), and utility energy efficiency program requirements. Despite these efforts, many of the research team contacts found it very difficult to provide sales data in the requested format because they track by model number or brand category rather than efficiency. In general, it was easier for contacts to provide the team with residential sales data than commercial. Table 1 summarizes the responses to the research team's request for sales data.

[2] *HVAC Market Intelligence Report*. https://www.bpa.gov/EE/Utility/research-archive/Documents/Momentum-Savings-Resources/2016_HVAC_Market_Intelligence_Booklet.pdf

Table 1: Sales Data Collection Summary

Category	Responses
Contact populated tables as requested.	4
Contact provided extensive lists of model numbers, which the research team then manually matched to size and efficiency metrics using secondary research.	1
Contact provided regional sales totals as reported by the Air-Conditioning, Heating, and Refrigeration Institute (AHRI). The regional sales totals contained little or no information about equipment size and efficiency. The research team contacted AHRI and confirmed they do not track size and efficiency metrics.	1
Contact had ongoing interaction with the research team and had received the data collection template. In some cases, contacts had agreed to populate data template and participate in an interview but ultimately did not follow through.	8
Contact told the research team that the request was too laborious, or that it was not even possible for them to pull data from their records.	3
Contact stated they were not suited for the research team's request (i.e., they only sell controls or sell equipment to distributors).	2
Contacts did not respond to the team's request.	2

Sales Data Completeness

Table 2 summarizes the sales data collection status for each residential HVAC equipment type. The research team estimated the market share by comparing the number of units collected from the sales data to Air-Conditioning, Heating, and Refrigeration Institute (AHRI) regional shipment totals. For some equipment categories, the estimated market share is a range because the estimate represents several subcategories of equipment. For example, the estimated market share for the "Air Source Heat Pump" line item is 45%-60%.

The research team collected sales data for about 15,000 ductless heat pumps (DHPs) in 2014. The AHRI data reports a total of about 33,000 ductless units. Therefore, the sales data represents about 45% of the market (15,000/33,000) for DHPs. For split system ducted heat pumps, the same approach leads to a market share of 60%. To simplify Table 2, the research team presented a range of 45%-60% rather than separating the "air source heat pumps" technology into three line items (split system ducted, packaged ducted, and ductless). The AHRI data does not have the same level of granularity as the sales data with respect to system types, so the research team did their best to compare the collected sales data to the equivalent AHRI data.

Table 2: Summary of Residential Data Collected and Confidence in Use for Analysis

Target Sector	AHRI Equipment Type	Estimated Market Share of Collected Sales Data[1]
Residential	Air Source Heat Pumps	45%-60%
	Air Conditioners	15%-25%
	Residential Furnaces	10%-15%
	DHPs	10%-90%[2]
	Ductless Mini-Split Air Conditioners	10%-40%

Notes:
1. The research team has AHRI data for 100% of the residential market, but size and efficiency details are not as granular as sales data for all equipment types.
2. Data for DHPs includes NEEA data for 2013- 2015. NEEA estimates that their sales figures represent approximately 90% of the DHP market.

Sales Data Limitations

The sales data collected covered years 2010-2014, but distributors provided more complete datasets for the later years, 2013-2014. Therefore, readers should treat the sales trends for earlier years (2010-2012) with caution as they are not representative. Other limitations of the data include the following:

- The research team collected HVAC unit efficiency levels as ranges as opposed to discrete values. In some cases, more granular efficiency data would have allowed more in-depth analysis of efficiency trends.
- The research team did not collect data specific to variable speed heat pumps.
- The research team was not able to collect complete data for each equipment type for the entire region.

Interviews

The research team conducted 26 formal and informal interviews with 15 unique parties[3] between October 2014 and January 2015.[4] This included 21 interviews with HVAC distributors, facility solution firms, and engineering firms, and five interviews with utility and regional program staff. The team conducted all but two interviews by phone. The interviews informed the research team's finding on the residential HVAC market segmentation, supply chain and decision chain, recent market trends, and market actor experience with utility incentive programs. To further inform program opportunities and recommendations for the residential sector, Navigant conducted three additional interviews with BPA program staff in September 2015.

Secondary Data Analysis

The research team analyzed secondary data from a number of reports and sources including but not limited to:

[3] Eleven of the 15 interviewees were distributors, facility solutions firms, and engineering firms; the other four interviewees included utility and BPA program staff.
[4] The team used formal interview guides when speaking with the majority of market actors but also had informal follow-up conversations with interviewees to round out the HVAC market findings.

- Northwest Power and Conservation Council's Sixth Regional Power Plan
- Sales data from the AHRI
- 2011 Single Family and Manufactured Homes Residential Building Stock Assessments (RBSA)
- Consortium for Energy Efficiency (CEE) HVAC efficiency specifications
- Publications from the U.S. DOE and NEEA

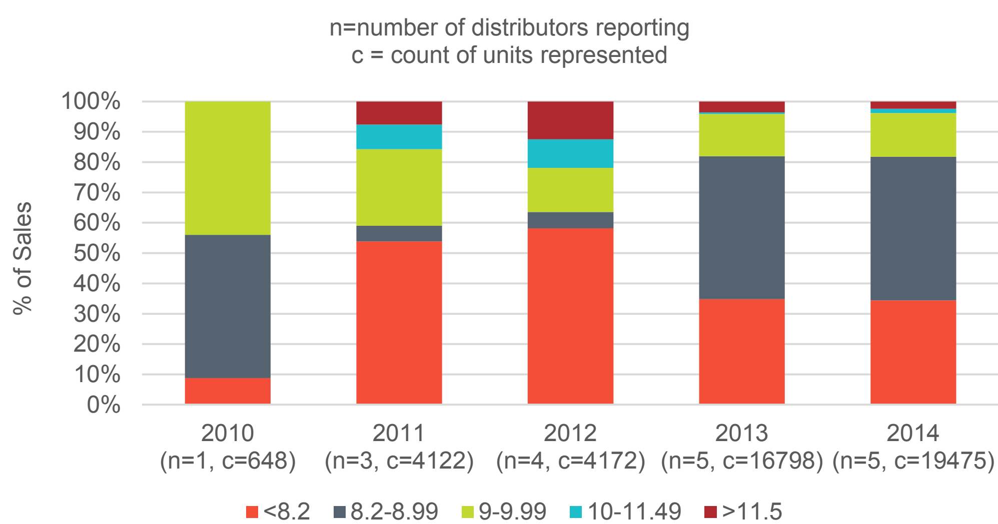
Detailed Sales Data Trends by Technology

The residential electric HVAC market primarily includes air source heat pumps and central air conditioners. Air conditioners provide cooling only, and heat pumps provide both heating and cooling. Each of these technologies can come in the form of a split system ducted unit, packaged ducted unit, or ductless unit. A split system is generally defined as having an outdoor condenser unit and an indoor evaporator fan coil that is paired with an indoor furnace (often gas) or an alternative form of heating supply (electric resistance, etc.). Packaged systems have the condenser and evaporator components in a single outdoor enclosure. For both split and packaged systems, the conditioned air is circulated via a duct system. The research team defines ductless systems in the Residential Ductless Mini-Split Systems section.

Residential Air Source Heat Pumps

Figure 1 shows the distribution of efficiency for split system air source heat pumps. Nearly half of the split system air source heat pumps sold in 2013 and 2014 were in the 8.2-8.99 Heating Seasonal Performance Factor[5] (HSPF) range, which exceeds the federal minimum of 7.7 HSPF. This trend is similar for packaged air source heat pumps (Figure 2).

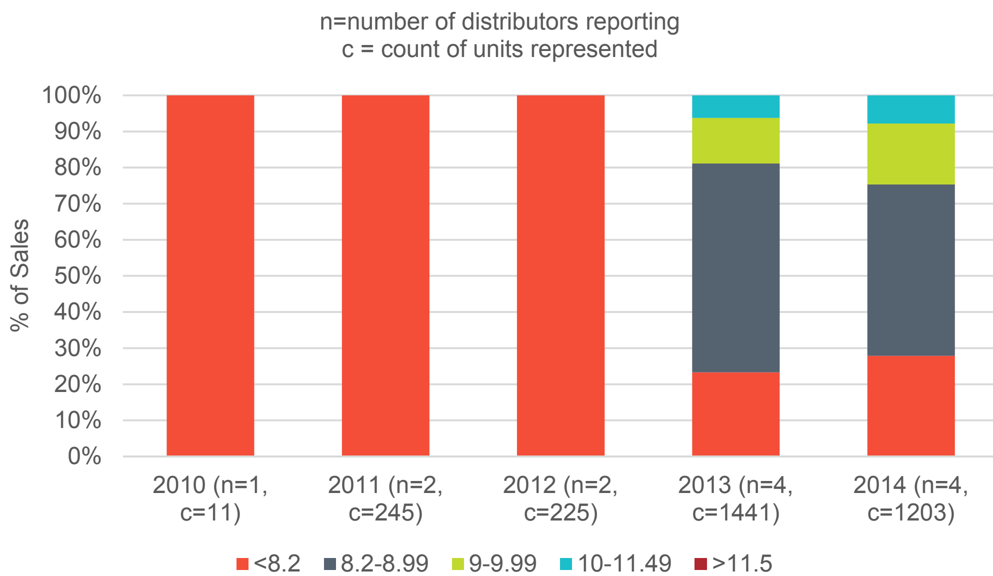
Figure 1: Residential Split System Air Source Heat Pump Sales by HSPF Category



Source: HVAC distributor sales data, collected from October 2014 through April 2015

[5] The heating seasonal performance factor is a measure of a heat pump's efficiency in heating mode. A higher HSPF means the unit operates at higher efficiency.

Figure 2: Residential Packaged Air Source Heat Pump Sales by HSPF Category

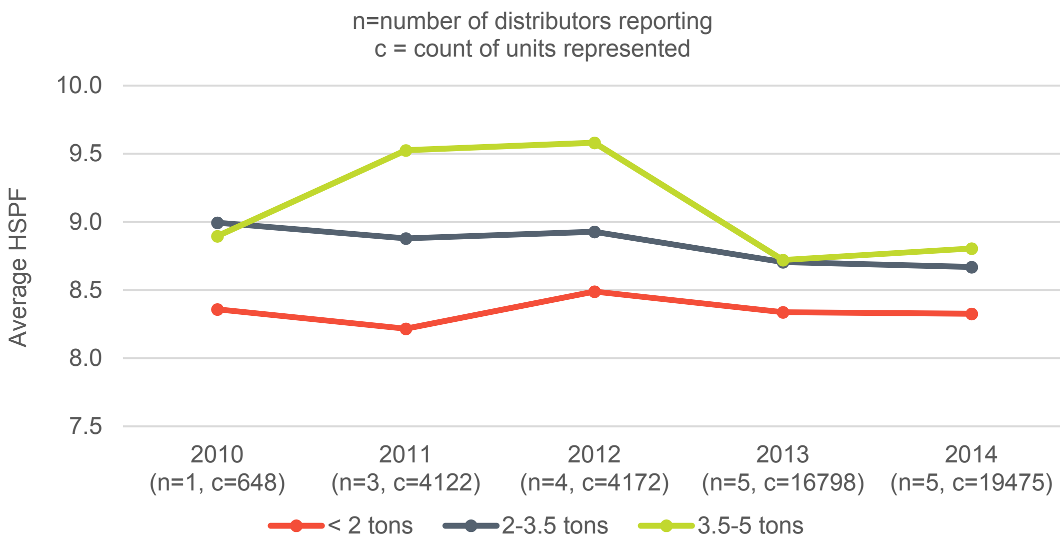


Source: HVAC distributor sales data, collected from October 2014 through April 2015

Another way of visualizing the efficiency trends of the sales data is to compare the average HSPF and Seasonal Energy Efficiency Ratio[6] (SEER) values from the sales data for each year. Figure 3 and Figure 4 show the heating efficiency trends from 2010 through 2014 for residential split system and packaged heat pumps, respectively. The research team collected far more data points for 2013 and 2014, but overall the data shows a fairly flat trend in heating efficiency during that time range.

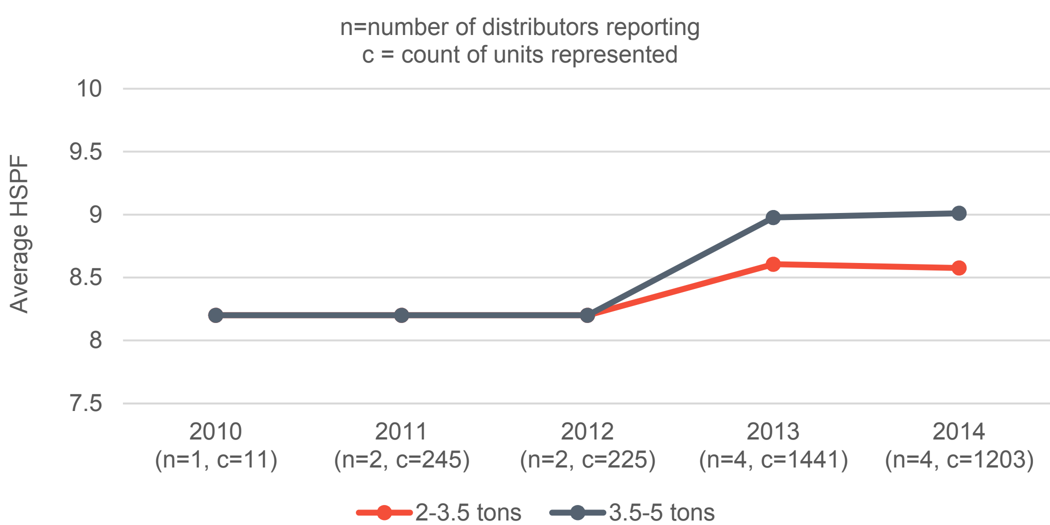
[6] The heating seasonal performance factor is a measure of a heat pump's efficiency in heating mode. A higher HSPF means the unit operates at higher efficiency.

Figure 3: Average Heating Efficiency (HSPF) of Residential Split System Air Source Heat Pumps



Source: HVAC distributor sales data, collected from October 2014 through April 2015

Figure 4: Average Heating Efficiency (HSPF) of Residential Packaged Air Source Heat Pumps



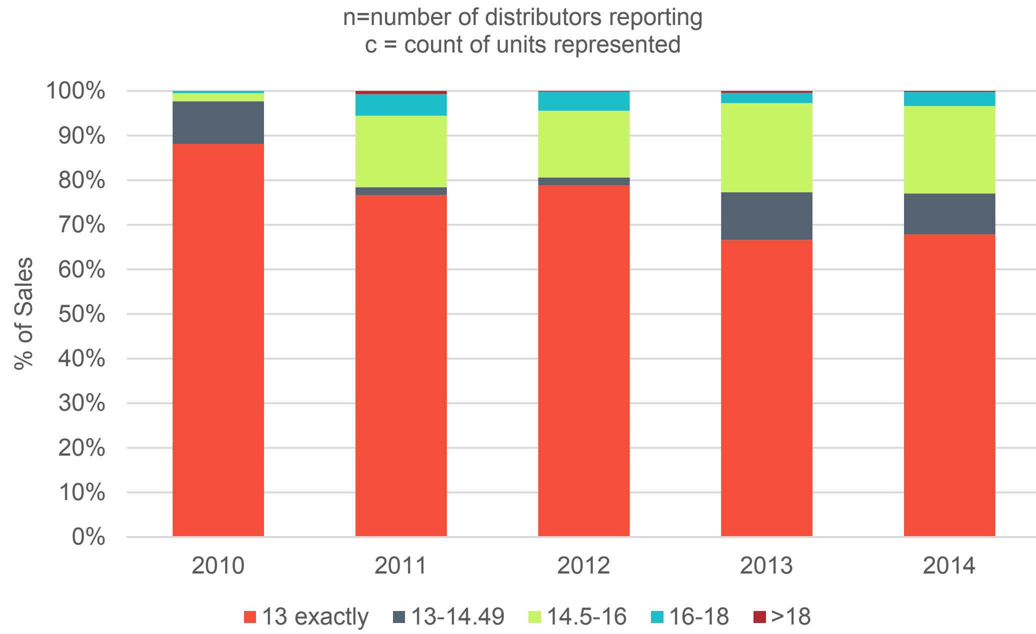
Note: Efficiency trends for <2 ton systems were not included due to lack of data for this capacity.

Source: HVAC distributor sales data, collected from October 2014 through April 2015

Residential Air Conditioners

Figure 5 shows the distribution of efficiency for split system air conditioners. Between 2010 and 2014, on average, 75% of split system air conditioners represented by the sales data were the federal minimum SEER 13.[7] During the same time period, on average, 20% of residential split system air conditioners represented by the sales data were between a SEER 14.5 and a SEER 16, and less than 1% were greater than SEER 18.

Figure 5: Residential Split System Air Conditioner Sales by SEER Category

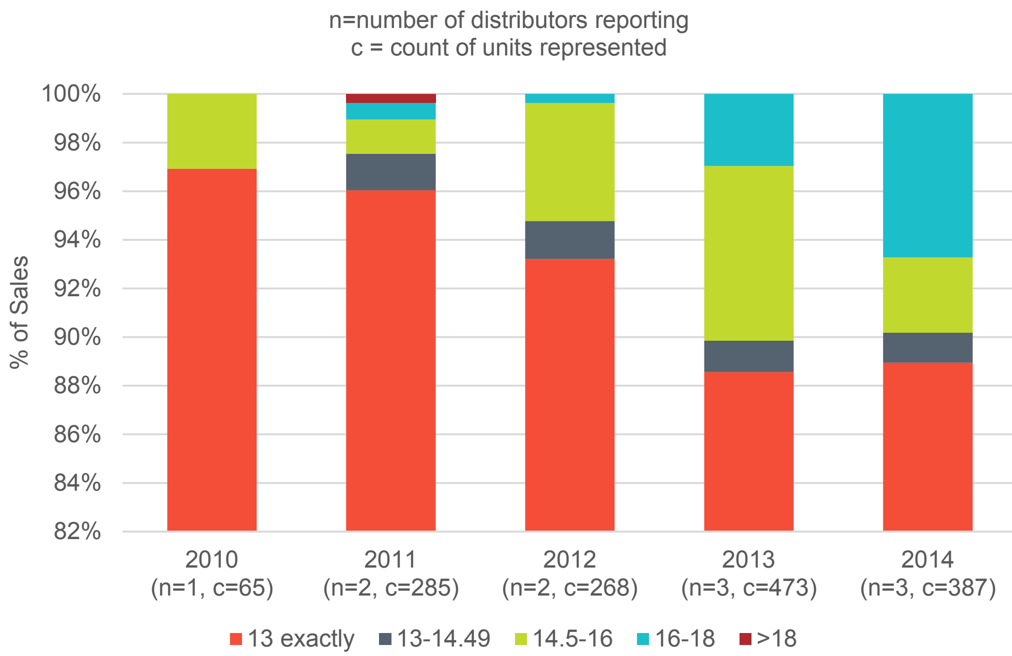


Source: HVAC distributor sales data, collected from October 2014 through April 2015

[7] The federal standards for SEER 13 efficiency have been in place since 2006.
http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/75

Figure 6 provides the distribution of sales for residential packaged air conditioners, and shows a similar trend to split systems. About 90% or more of the packaged units sold were at the federal minimum efficiency of SEER 13.

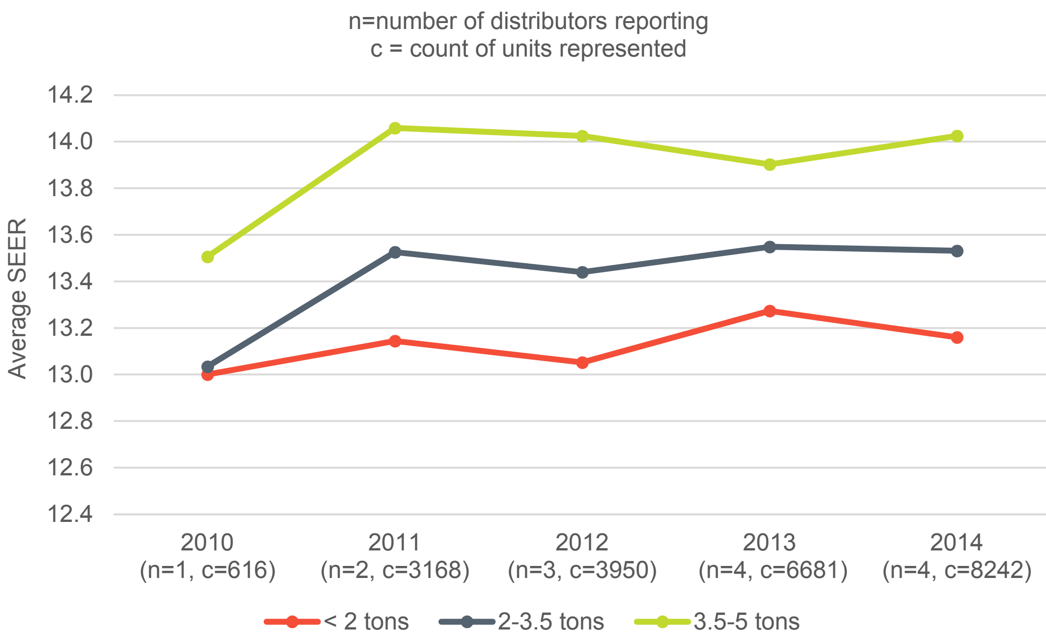
Figure 6: Residential Packaged Air Conditioner Sales by SEER Category



Source: HVAC distributor sales data, collected from October 2014 through April 2015

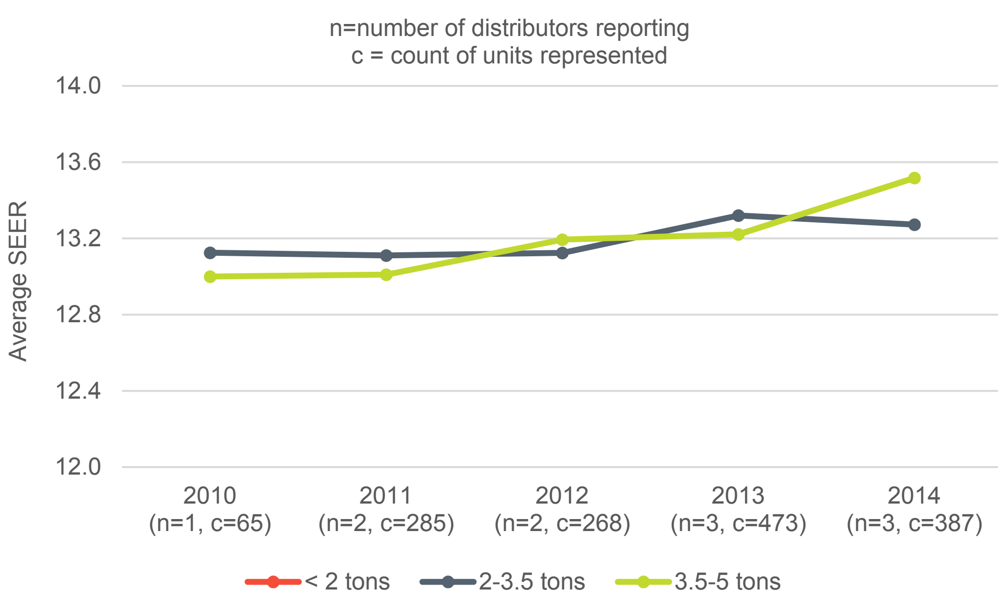
Figure 7 and Figure 8 show the weighted average SEER value by size category for residential split system and packaged air conditioners, respectively. For split systems, sales of larger sized split systems tended to be more efficient than smaller units. However, the average efficiency did not change by much from year to year in any given size category. For packaged units, the efficiency did not generally relate to unit size. Figure 8 does seem to show a small trend toward increasing efficiency between 2010 and 2014, although the data is not conclusive because the research team collected fewer data points for the early years of this range.

Figure 7: Average Efficiency (SEER) of Residential Split System Air Conditioners (weighted by sales)



Source: HVAC distributor sales data, collected from October 2014 through April 2015

Figure 8: Average Efficiency (SEER) of Residential Packaged Air Conditioners (weighted by sales)



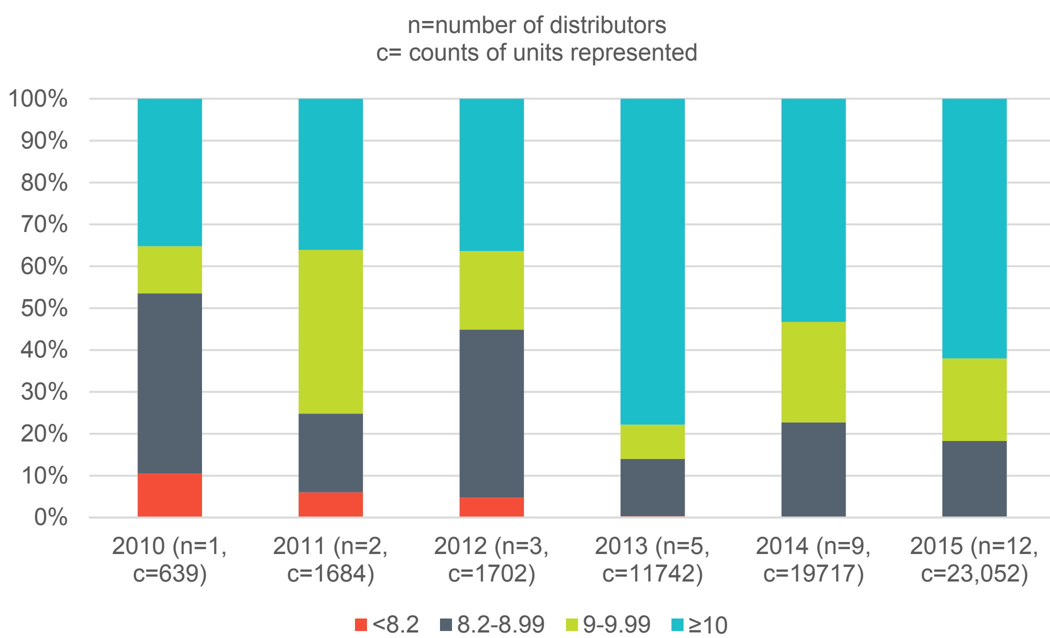
Source: HVAC distributor sales data, collected from October 2014 through April 2015

Residential Ductless Mini-Split Systems

An exciting trend in the residential HVAC market is the emergence of ductless technology. These systems have been prevalent in Asia and Europe for some time but are just recently beginning to penetrate the U.S. market. Ductless mini-splits have a single outdoor condenser unit and individual indoor evaporator units located throughout the home. Instead of circulating conditioned air though a duct system like traditional units, the ductless mini-splits circulate refrigerant through low-profile tubing, or “lines,” to each evaporator. Some benefits of ductless technology include zonal heating and cooling, and reduced energy losses through duct leakage.

Figure 9 shows the efficiency distribution of ductless mini-split heat pumps. A large portion of DHP sales was in the HSPF ≥10 range, especially starting in 2013. Figure 10 shows that about 40% of ductless mini-split air conditioner sales are greater than SEER 18 efficiency. The majority of market actors interviewed by the research team indicated they expect the sales of ductless systems to grow rapidly over the next several years, and they expect these sales to displace sales of traditional split system and packaged units. This suggests that the trend of higher efficiency ductless units shown in Figure 9 and Figure 10 is likely to offset a portion of the standard efficiency ducted trend Figure 1 through Figure 4 shows.

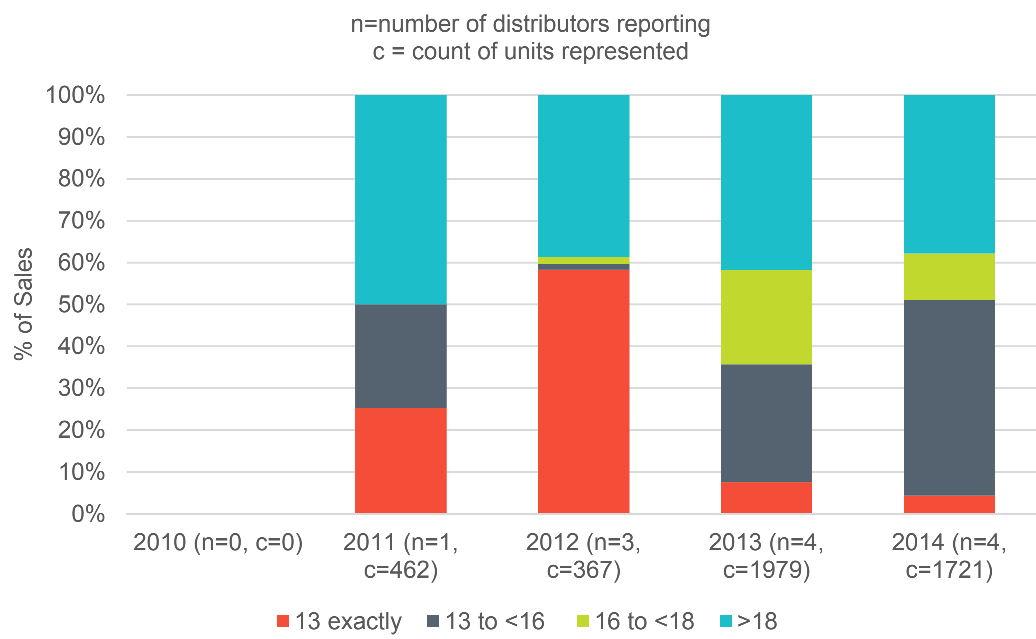
Figure 9: Efficiency Distribution (HSPF) of Ductless Mini-Split Heat Pumps



Note: The research team received more granular efficiency levels for DHP sales data with HSPF ≥10. However, the efficiency levels for distributor sales data do not align with efficiency levels for the NEEA data. As a result, the research team grouped sales data for all DHPs with HSPF ≥10 into one efficiency category.

Source: HVAC distributor sales data, collected from October 2014 through April 2015, for years 2010 through 2013. NEEA for years 2014 and 2015.

Figure 10: Efficiency Distribution (SEER) of Ductless Mini-Split Air Conditioners



Note: The research team did not receive any data for 2010.

Source: HVAC distributor sales data, collected from October 2014 through April 2015

Market Characterization Findings

The *HVAC Market Intelligence Report*[8], published in April 2016, provides an in-depth characterization of the residential and commercial HVAC market. The booklet highlights how the market works, what the industry is excited about, a summary of efficiency trends in select equipment sales (using the same sales data as presented in this report), and provides insights into opportunities for our programs to consider how to boost efficiency in the market.

[8] *HVAC Market Intelligence Report*. https://www.bpa.gov/EE/Utility/research-archive/Documents/Momentum-Savings-Resources/2016_HVAC_Market_Intelligence_Booklet.pdf

Momentum Savings Analysis

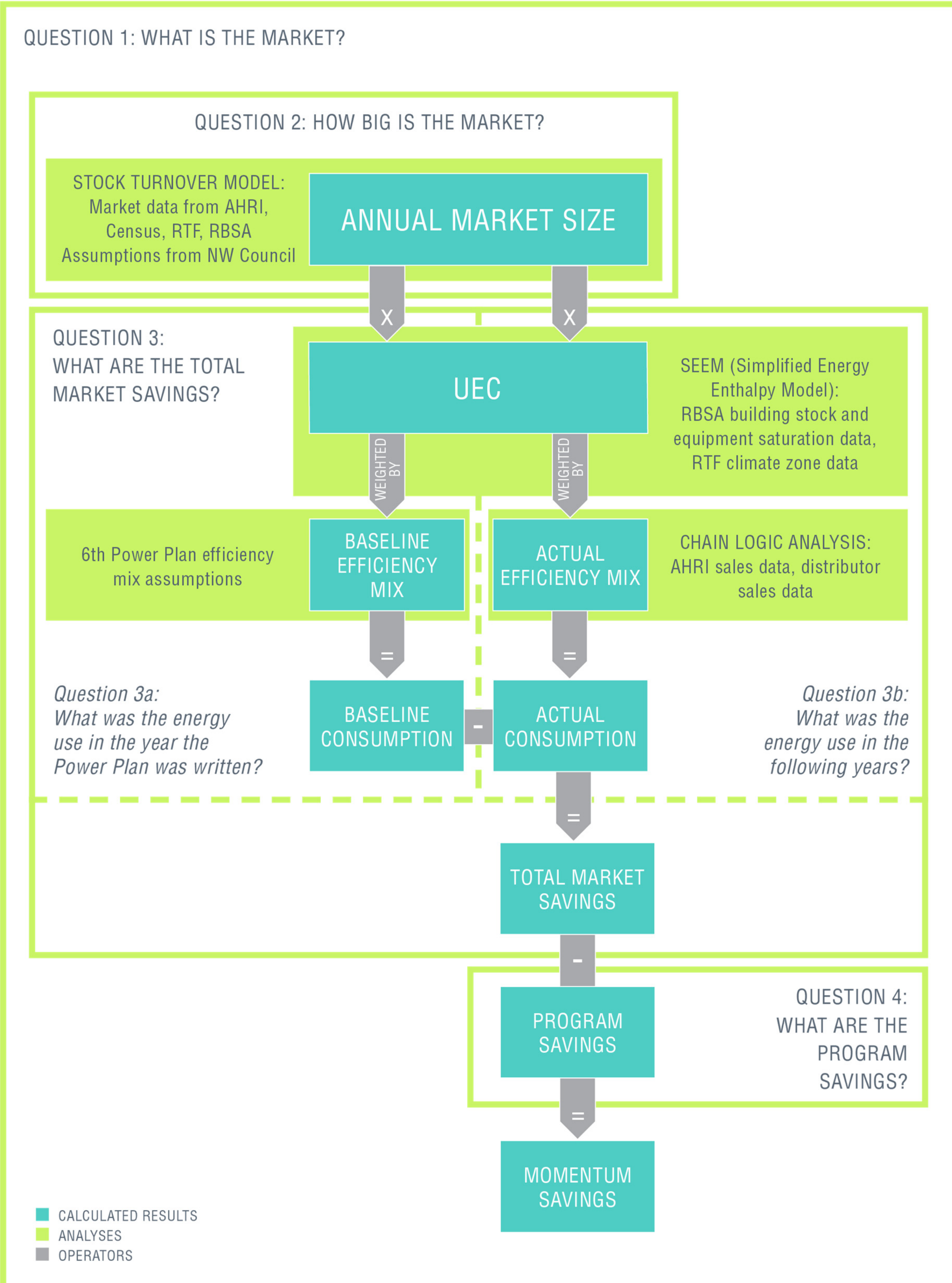
This section describes in detail the draft results of the research team's estimation of Momentum Savings from residential air source heat pumps in BPA territory and the Pacific Northwest region between 2010 and 2014. Note that these results will remain in draft status until some key data gaps can be filled by the research team (discussed in more detail in the Driving Factors section). The Methodology and Results section presents the research team's detailed technical methods for estimating Momentum Savings using the Four Question Framework, and documents the key technical decisions the research team made during the analysis. The "Driving Factors" section describes the steps the research team used to calculate the total energy consumption in the baseline and actual market scenarios (Question 3 of the Four Question Framework). It also defines the program savings achieved in the HVAC market (Question 4). Finally, the "Opportunities for Future Research" provides the research team's recommendations for improving future estimates of Momentum Savings in the residential HVAC market.

Methodology and Results

The Four Question Framework organizes this section. Questions 1 and 2 define the residential HVAC market in terms of number of units installed in the marketplace each year within the product categories covered by this analysis. Questions 3 and 4 present the methods for quantifying Momentum Savings, including calculating the total energy consumption in the baseline and actual market scenarios and defining the program savings achieved in the HVAC market. Together, the results of the Four Questions enable the research team to estimate Momentum Savings in the residential HVAC market.

Figure 11 shows the overall calculation of Momentum Savings, including the three key components for calculating consumption for the baseline and actual market scenarios: annual market size, unit energy consumption (UEC), and efficiency mix. Note that the values for annual market size and UEC remain constant for both scenarios and the only difference will be the efficiency mix within the HVAC market.

Figure 11: Overview of Momentum Savings Methodology



Source: Navigant analysis

Question 1: What is the market?

The research team defined the market for this analysis as newly installed ducted air source heat pumps in single family and manufactured homes. The defined market excludes measures that impact energy use after heat pump installation, such as improvements to building shell characteristics, HVAC distribution systems, tune-ups of existing HVAC systems, or HVAC control systems. The geographic scope of this analysis is Regional Technical Forum (RTF) heating zones 1, 2, and 3 in the Northwest region. The analysis encompasses the entire four-state Northwest region, including areas served by utilities other than BPA.

Table 3 presents the specific set of air source heat pumps included in this analysis. These measures cover two scenarios as defined by the Northwest Power and Conservation Council (the Council) Sixth Power Plan (Sixth Plan):

- **Conversion measures.** Newly installed air source heat pumps replacing older, less efficient technology of a different type (e.g., conversion from an electric furnace to a heat pump).
- **Upgrade measures.** New air source heat pump installations that replace a less efficient technology with a more efficient version of the same type (e.g., a new air source heat pump replacing an older, less efficient air source heat pump).

Table 3: HVAC Conversion and Upgrade Scenarios Within Scope of Analysis

Conversion of	Converted to	In the context of	With efficiencies of
Electric forced-air furnace w/ central air conditioning	New air source heat pumps	Single family homes, manufactured homes	HSPF[9] 7.7/SEER 13; HSPF 8.5/SEER 14; HSPF 9.0/SEER 14; HSPF 9.5/SEER 14; HSPF 10.0/SEER 14; HSPF 10.5/SEER 14; HSPF 11.5/SEER 14 (variable capacity)
Electric forced-air furnace w/o central air conditioning			
Retired existing heat pump	New air source heat pumps	Single family homes, manufactured homes	HSPF 8.5/SEER 14; HSPF 9.0/SEER 14; HSPF 9.5/SEER 14; HSPF 10.0/SEER 14; HSPF 10.5/SEER 14; HSPF 11.5/SEER 14 (variable capacity)

Source: Navigant analysis of Sixth Power Plan data

[9] Heating Seasonal Performance Factor (HSPF)

Key Decisions

- The research team assumed that all HVAC units sold in the region are “lost opportunity” measures, or only those units sold to replace faulty or “burnt out” units.[10] This assumption is consistent with the Sixth Plan.
- The research team did not quantify Momentum Savings from DHPs, as NEEA recently undertook an effort to quantify these savings.[11]
- The research team modeled the permutations of products and efficiencies where *substantial* distributor shipment data indicates that the product is applicable to the region. The research team’s Sales Data Results Memo explains the details of distributor shipment data, and how the data led the team to conclude that the units in Table 3 account for a significant portion of HVAC regional electricity consumption.

Question 2: How big is the market?

The research team defines the **annual market size** as the number of units sold per year, for each year of the analysis (2010-2014), for each combination of:

- HVAC unit type (as outlined in Table 3)
- Housing type (single family or manufactured homes)

The team developed a **stock turnover model** to determine annual market size for each of the combinations described above. Key data for this model includes distributor sales data collected by the research team, sales data provided by the AHRI,[12] historical and forecast housing data from the Northwest Power and Conservation Council (the Council),[13] climate zone data technology allocation data from 2011 Single Family and Manufactured Homes RBSA,[14,15] regional stock saturation data from the 1992 Pacific Northwest Residential Energy Survey (PNWRES92)[16] and RBSA, and estimated measure life data from the U.S. DOE Energy Conservation Standards Rulemaking Engineering Analysis for heat pumps and furnaces.[17]

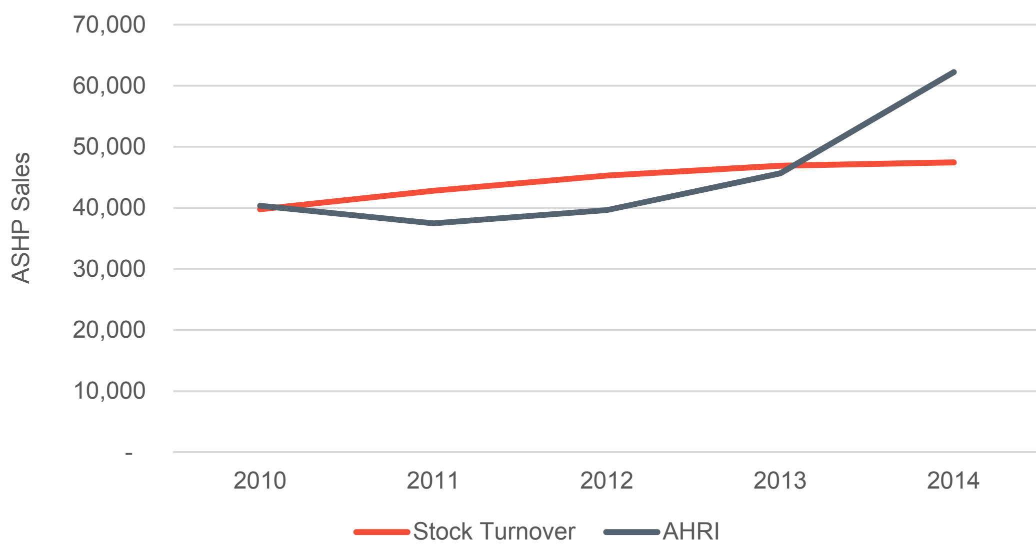
The team’s stock turnover model is similar to the stock turnover models developed to estimate market size for BPA’s Appliance Standards Momentum Savings project[18]. As with the Appliance Standards Model, the HVAC Stock Model starts by using the 1992 and 2011 stock saturations to develop a linear trend for each technology[19] and housing type. Specific to the HVAC Stock Model, the team also

[10] Lost-opportunity resources can only be technically or economically captured during a limited window of opportunity, such as when a building is built or an industrial process is upgraded.
[11] For more information on NEEA’s work in this area, see https://neea.org/docs/default-source/reports/ductless-heat-pump-market-continues-to-increase-dhp-mper-4.pdf?sfvrsn=12
[12] AHRI represents 95% of the total heat pumps sold in the region. These data are comprehensive in market coverage, but limited to the extent that the reports present aggregated data; AHRI provides sales data in terms of units sold, not capacity (tons, kW, or BTUs), and much of the data are aggregated by unit type and efficiency level.
[13] Northwest Power and Conservation Council Sixth Power Plan Supply Curve Files: Residential Supply Curve Housing and Appliance Units
[14] ’2011 Residential Building Stock Assessment: Single-Family Characteristics and Energy Use’, NEEA, September 18, 2012
[15] ‘Residential Building Stock Assessment: Manufactured Homes Characteristics and Energy Use’, NEEA, January 30, 2013
[16] The 1992 Pacific Northwest Residential Energy Survey – Phase I, Book 2: Item-by-Item Cross tabulations, Volume C: Pacific Northwest Region
[17] DOE Furnaces and Boilers 2007 Final Rule, Technical Support Document Chapter 8: Lifecycle Cost Analysis, Table 8.3.3 Furnace and Boiler Lifetimes Used in the LCC Analysis.
[18] Available at: https://www.bpa.gov/EE/Utility/research-archive/Documents/Appliance_Standards_Report.pdf
[19] This includes electric forced air furnaces, gas forced air furnaces, and ducted air source heat pumps. While the savings in this analysis are derived from air source heat pumps, both types of furnaces were modeled to estimate the portion of electric forced air furnaces that were converted to ducted heat pumps.

developed an estimate of the equipment saturation in new construction over the same time period to reflect changing preferences and availability of technology.

The team applied these trends to the housing stock and new construction figures, respectively, to arrive at estimates of the installed stock and shipments to new construction in each year from 1980 to 2015. The models then estimate the replacement shipments and other new installations in each year of the analysis by examining how the stock turns over and how it grows[20]. Stock turnover is a function of the estimated useful life of the equipment. For air source heat pumps, the team calibrated the model by changing the air source heat pump useful life so the model results would match the total shipments estimated from AHRI and distributor sales data. Figure 12 presents a comparison of the AHRI market data and the stock model estimates. As shown in the figure, the stock turnover model is calibrated to the average AHRI shipments across the analysis period. Though the model does not exactly match shipments in any given year, this calibration process provided the research team a reasonable level of confidence that the stock turnover model effectively represents reality.

Figure 12: Comparison of AHRI Market Data and Stock Turnover Model Output



Source: Navigant analysis of AHRI data, using results of the Stock Turnover Model

The model assumes that HVAC equipment is shipped, put into service, and remains in the installed stock for its estimated useful life after which it is retired and replaced. Whether or not each system is replaced with a similar piece of technology is a function of the stock saturation's trajectory, with the assumption that if stock is growing, like technology is replaced with like technology, and if it is shrinking, some fraction of retired systems are replaced with a different technology.

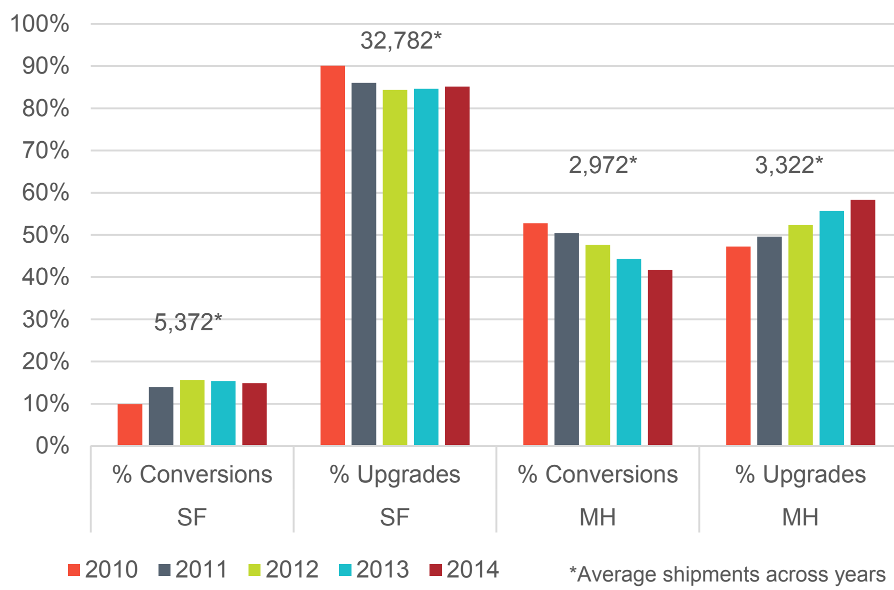
An upgrade occurs when ducted heat pumps are retired and replaced with a new ducted heat pump. A conversion occurs when electric forced air furnaces (FAF) are retired and replaced with either a ducted heat pump or a gas forced air furnace. To determine which technology is replacing electric forced air furnaces, the team determined the total electric forced air furnace conversions and subtracted out the portion that the team estimated converted to gas. The team based this estimate on the rise of gas forced air furnace saturation in existing homes.

[20] If, in a given year, the installed stock grows by more than the number of units shipped to new construction, the model assigns this growth in units to the existing housing stock.

The estimated number of ducted heat pump upgrades and conversions from electric forced air furnaces to ducted heat pumps in each year of the analysis period (2010 – 2014) were then imported into the HVAC Momentum Savings model where they were combined with UEC data from the residential Simplified Energy Enthalpy Model (SEEM) weighted by climate zone allocations from RBSA. See Figure 13 for the estimates of ducted heat pump upgrades and conversions in single family and manufactured homes in each year of the analysis.

The analysis results presented in Figure 13 indicate that, on a percentage basis, there are many more conversions in the manufactured home context relative to the single family context. This is primarily due to the higher prevalence of electric forced air furnaces in manufactured homes. However, in absolute terms, there are significantly more shipments in both categories in the single family sector, due to the larger market size for single family homes in the region. The number of upgrades in manufactured homes increases over the analysis period, driven by an increase in the saturation of air source heat pumps in these homes. Note that within each home type, the percentage of conversions and upgrades sum to 100% in each year, indicating that all air source heat pump shipments can be characterized as either a conversion or upgrade.

Figure 13: ASHP Installed as Conversions or Upgrades by Home Type



Source: Navigant analysis using results of the Stock Turnover Model

Key Decisions

Key decisions made by the research team while developing the stock turnover model include the following:

- **Adjust AHRI estimates of market size to reflect a portion of ducted heat pumps sold into multifamily and small commercial applications.** The analysis team received data from AHRI representing all sales in the heat pump market, regardless of where end users ultimately installed the heat pumps. DOE analysis indicates that 93% of heat pumps are installed in residential locations, and 7% are installed in small commercial buildings[21]. The analysis team assumed that 3% of the residential heat pumps are installed in multifamily contexts (such as attached townhomes), leaving 90% of all AHRI sales installed in homes of interest (single family and manufactured homes).

- **Calibrate the ducted heat pump model shipments to the adjusted AHRI data by changing the measure life.** The overall number of shipments in a given year is the sum of shipments to new construction, system conversions, and replacements of existing stock. The number of replacements in any year is a function of the estimated useful life of the equipment – following the logic that a shorter useful life increases annual replacements as the stock turns over more frequently. The team calibrated the model by changing the useful life of ducted heat pumps such that the total sales from 2010 to 2014 matched the total sales in the same period as estimated using the AHRI data. The team opted for one aggregate calibration in lieu of year-to-year adjustments for the sake of simplicity, recognizing the natural variability in sales data.

- **Model HVAC equipment at the housing sector level in the stock model, then allocate the stock and shipments to each climate zone in the HVAC Momentum Savings model.** The team first explored developing individual stock turnover models for the equipment in each climate zone. The primary vs. secondary classification issue in RBSA complicated the issue, resulting in different overall numbers of ducted heat pumps depending on if RBSA classified them as primary heating/cooling equipment or secondary heating/cooling equipment. The selected approach remedies this issue.

- **Include all heat pumps, regardless of primary/secondary classification.** Based on a thorough review of RBSA data, there appear to be two types of 'secondary' heat pumps: those where people assert they primarily heat with wood, and those that are 'secondary' to another heat pump (e.g. if a house has zonal heating/cooling). The team identified 20 secondary units in the RBSA dataset, 15 of which were secondary to wood and five of which were secondary to other heat pumps. In discussing this with David Baylon of Ecotope (a primary author of the RBSA), the team believes the latter arrangement essentially behaves like a primary heat pump and so should be counted as one unit, and the former is a negligible quantity. Furthermore, the analysis is simulating the HVAC UEC values using the RTF Phase I and Phase II SEEM calibrations, which account for the interaction between wood heat and electric heat.

- **Develop forecasts for new construction saturations of each technology separate from the forecasts of stock saturations.** This analysis sought to improve upon previous stock turnover modeling methodologies, which made the simplifying assumption that new construction saturation was equal to stock saturation. The team knows this to not be true as the very nature of increasing stock almost assuredly requires higher saturation in new construction. The team opted to develop independent estimates of new construction saturations because this subtle change in methodology has profound impacts on the balance of upgrades and conversions.

- **Assume the electric forced air furnace conversions transition to either gas forced air furnaces or to ducted heat pumps.** Earlier iterations of this analysis assumed that retirements of electric forced air furnaces, which were not replaced by another forced air furnace, constituted a conversion to a ducted heat pump. In actuality, they may be converted to gas forced air furnaces, ducted heat pumps, or other technologies entirely. For the simplicity of modeling, the team assigned conversion of electric forced air furnaces to either gas forced air furnaces or

[21] U.S. DOE. 2011-06-08 Furnace and Central Air Conditioners and Heat Pump National Impact Analysis Spreadsheet (Energy Efficiency) and Furnace Installation Analysis Worksheet http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0011-0011

ducted heat pumps as these represent the two dominant heating technologies, which leverage existing duct infrastructure in homes.

After defining the scope of the analysis (Question 1) and estimating market size (Question 2), the research team calculated the total market savings (Question 3).

Question 3: What are the total market savings?

Total market savings are equal to the difference between baseline consumption and actual consumption. Questions 3a and 3b enable the estimation of total market savings by calculating the total energy consumption for both the baseline and actual market scenarios, respectively.

Question 3a: What was the energy use when the Power Plan was written?

The research team estimated **baseline consumption** using four inputs:

- Annual market size (estimated previously in Question 2)
- HVAC UEC for each HVAC measure combination included in Table 3
- Baseline efficiency mix (the share of total sales occurring in each efficiency level as assumed by the Sixth Plan)
- Climate zone (geographic heating zones 1, 2, or 3 as established by the RTF)

The research team estimated the **HVAC UEC** values using the residential **SEEM**. The team modeled UEC estimates separately for each efficiency level of a given measure.[22] The team developed SEEM models for this analysis instead of using deemed savings values from the RTF for two reasons. First, the models allowed the team to isolate energy savings associated with only the HVAC unit, as the RTF-deemed values also include significant savings from commissioning, controls, and sizing (CC&S) installation practices. Second, the RTF deemed values do not include the variety of efficiency ratings observed in market data.

Estimating Measure-Level UEC

The following steps illustrate an example of the UEC modeling using an air source heat pump (ASHP) HSPF 8.5 HVAC type/efficiency combination.

1. **Set up the SEEM model.** The team assumes all ASHP units shipped in the market are installed in the typical home scenarios of the SEEM model (192 for single family homes, 321 for manufactured homes).
2. **Run the SEEM model.** The team runs a SEEM simulation for each of the applicable characteristic homes, using the same HVAC unit type/efficiency combination (in this case, ASHP HSPF 8.5).
3. **Apply characteristic home weights.** The characteristic home weights indicate the region-wide prevalence of each of the typical homes, as determined by the RBSA. This will develop a weighted UEC for ASHP HSPF 8.5 in a composite home, which is the weighted average UEC of all homes in the region.
4. **Apply climate zone weights.** The team applies the RTF established climate zone weights by home to each of the SEEM scenarios. This results in the typical UEC of an ASHP HSPF 8.5 in a single composite home in each climate zone. Subsequent application of climate zone weighting factors generates regional UEC values for the ASHP HSPF 8.5 unit.

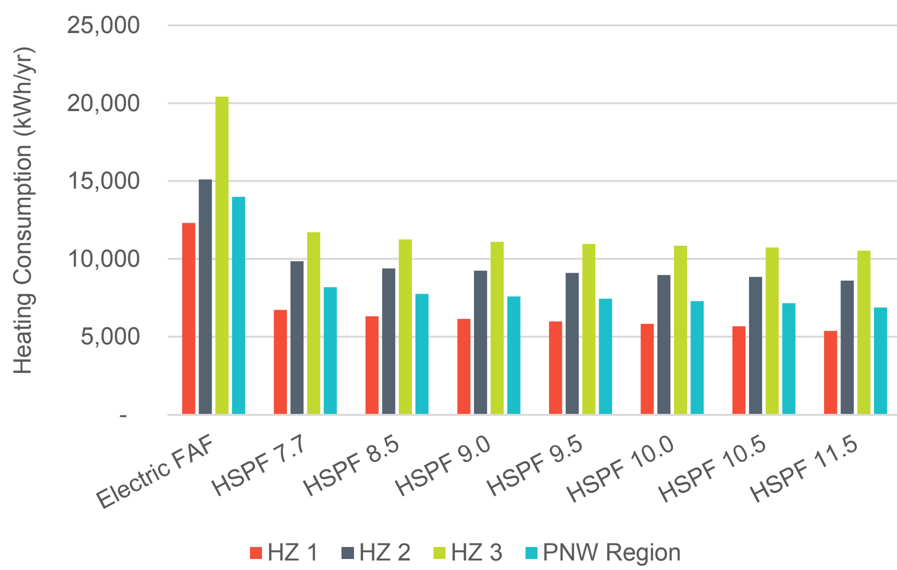
The research team used a multi-step process to develop UEC values that accurately reflect the diversity of home types and climate zones in the Northwest region. The single-family SEEM model used 192 different "characteristic scenarios" developed by the RTF from RBSA data that

[22] SEEM, written by Ecotope, was developed by and for the Council and NEEA. SEEM is used to estimate conservation measure savings for regional energy utility policy planners.

represent typical homes in the region.[23] Each scenario is a different energy simulation, which resulted in a new UEC output. The research team simulated all scenarios for all units listed in Table 3. The team then applied home characteristic and climate zone weighting factors to SEEM model results in order to arrive at an estimated UEC for each HVAC efficiency in each climate zone, as well as region-wide weighted UECs. See the text box titled “Estimating Measure-Level UEC” for an illustration of how the research team used the SEEM model to estimate UEC for a specific efficiency level.

Figure 14 shows the UEC for single family homes converting from electric FAF to air source heat pump (ASHP) as an example output from this process. Figure 14 compares the UEC values in each climate zone by unit type and efficiency and shows the relative energy consumption between unit types and climate zones. Table 4 presents the discreet UEC values displayed in Figure 14. Note that there is a large difference between FAF UEC and ASHP UEC, signifying that a conversion saves significantly more energy than an upgrade. This is a main driver of the analysis results, discussed further below.

Figure 14: UEC Values (kWh/yr.) for Single Family Homes Eligible for Conversions, by Efficiency Level and Climate Zone



Source: Navigant analysis using SEEM 97 and RBSA data

[23] 192 is the maximum number of applicable models. For certain HVAC units only a subset of the models were applicable. For example, no model with electric baseboard heat was used to simulate heat pump savings, since that would imply a case of switching from decentralized to centralized heating. The same approach was used for manufactured homes, except there are 321 distinct models in that case.

Table 4: UEC Values (kWh/yr.) for Single Family Homes Eligible for Conversions, by Efficiency Level and Climate Zone

Single Family Homes: Conversions				
Heating Zone	**HZ 1**	**HZ 2**	**HZ 3**	**PNW Region**
Electric FAF	12,306	15,105	20,426	**13,983**
HSPF 7.7	6,720	9,851	11,709	**8,180**
HSPF 8.5	6,307	9,391	11,244	**7,747**
HSPF 9.0	6,144	9,241	11,099	**7,590**
HSPF 9.5	5,984	9,101	10,965	**7,439**
HSPF 10.0	5,827	8,967	10,843	**7,293**
HSPF 10.5	5,673	8,841	10,730	**7,151**
HSPF 11.5	5,371	8,609	10,530	**6,881**

Source: Navigant analysis using SEEM 97 and RBSA data

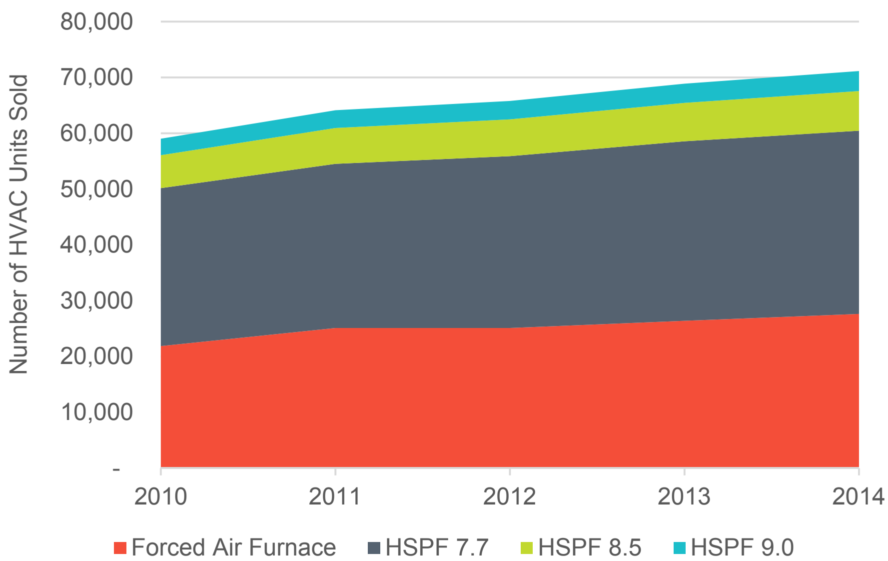
The research team then used the UECs to calculate baseline consumption according to the assumed **baseline efficiency mix** as documented in the Sixth Plan. The efficiency mix is the distribution of sales across the spectrum of least efficient (code minimum) to most efficient (highest efficiency in the market). The Sixth Plan assumed the following baseline efficiency mixes:

- Conversions: 85% of the natural retirements of electric forced air furnaces are replaced with the same type of electric forced air furnace, 10% are converted to HSPF 8.5 air source heat pumps, and 5% are converted to HSPF 9.0 air source heat pumps[24]
- Upgrades: 85% of the natural retirements of air source heat pumps are replaced with HSPF 7.7, 10% HSPF 8.5, and 5% HSPF 9.0 (all air source heat pumps)

[24] In other words, the Sixth Plan assumes a “current practice” baseline where 15% of forced air furnaces are replaced with heat pumps when they wear out, but the remaining 85% are not converted to a different technology.

Using this information and the total market size from Question 2, the team calculated the number of units in each efficiency tier within the total market. These results are show in Figure 15, aggregated by housing type (single family and manufactured) and installation type (conversions and upgrades). The units sold increases over the analysis period as a function of the growth in market size. The relative portion of units in each efficiency tier (the efficiency mix) remains consistent across all years for the base case.

Figure 15: Total Units Sold by Efficiency Level – Base Case



Source: Navigant analysis of Sixth Power Plan Data

Finally, the research team estimated the baseline consumption for each year of the analysis by multiplying the annual market size by the weighted UEC estimate as shown in Equation 1.

Equation 1: Baseline Consumption Calculation by Building Type and HVAC Type

$$\text{Baseline Consumption} = \text{Market Size} \times \text{UEC}_{\text{Weighted by baseline efficiency mix}}$$

Using this equation, the team calculated the baseline total market consumption in each year, shown in Table 5. The baseline consumption increases over the analysis period as a function of the growth in market size.

Table 5: Baseline Market Consumption by Year (aMW)

2010	2011	2012	2013	2014
62.4	69.0	70.4	73.8	76.2

Source: Navigant analysis of Sixth Power Plan Data and results of the Stock Turnover Model

Key Decisions

Key decisions made by the research team which impact the baseline consumption include the following:

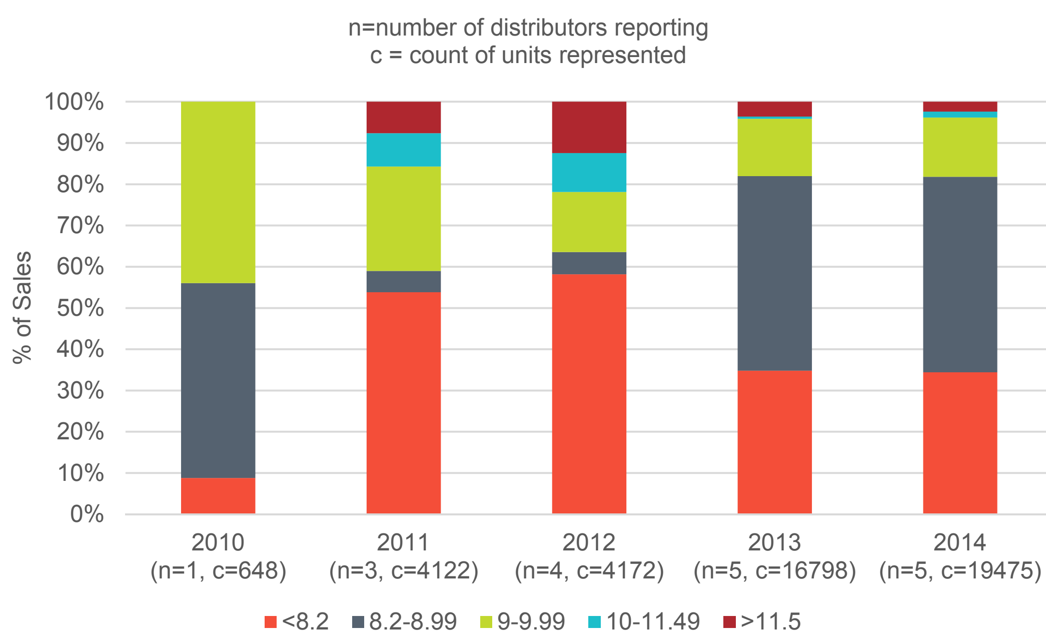
- The team used the SEEM modeling platform to develop UEC values, as it is well-vetted by the RTF and applied widely throughout the Northwest region.

- The team followed the RTF approach for developing regional building characteristics from the RBSA as inputs to SEEM. The team also remained consistent with the RTF approach for weighting the results of these model runs, as these weights have been applied to other analyses conducted by the RTF in the region.
- The team used the RTF-approved SEEM calibration multipliers to discount the results of the SEEM models[25].
- The team did not use the exact UEC values from the Sixth Plan. Instead, the team applied the Sixth Plan efficiency mixes to new UEC values, which were calculated using the updated version of SEEM (SEEM 97).

Question 3b: What was the energy use in the following years?

Actual consumption is calculated using the same basic equation as in the baseline consumption calculation. The only factor that varies between the two calculations is the **actual efficiency mix**, estimated using sales data from distributors. The actual consumption calculation uses the estimate of annual market size calculated in Question 2 and the UEC calculated in Question 3a. In the actual market scenario, the team weights the UEC for each measure by the actual efficiency mix as estimated in this step of the analysis. Figure 16 and Figure 17 show the relevant market data that informed this analysis, as well as the number of distributors and unit counts for each year. Note that the number of distributors and unit counts increase in recent years, due to better data availability from distributors.

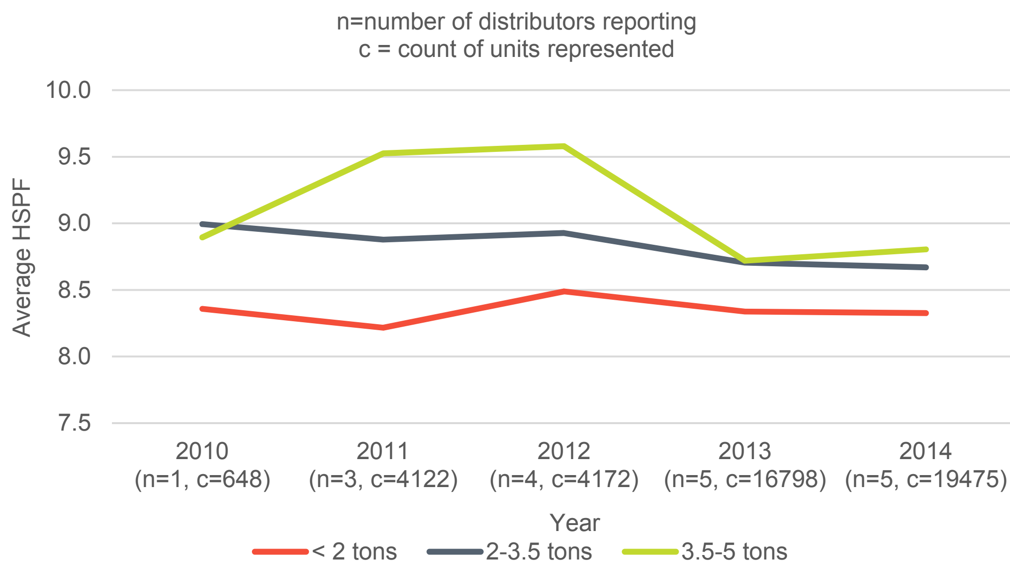
Figure 16: Residential Split System Air Source Heat Pump Sales by HSPF Category



Source: Navigant analysis of distributor reported sales data

[25] The Phase 1 and Phase 2 calibration multipliers were developed after extensive analysis and discussion by members of the RTF to account for observed discrepancies between residential billing analyses and SEEM outputs. These calibration multipliers “true up” the results of SEEM to be more reflective of actual residential energy consumption data in the region.

Figure 17: Average Heating Efficiency of Residential Split System Air Source Heat Pumps



Source: Navigant analysis of distributor reported sales data

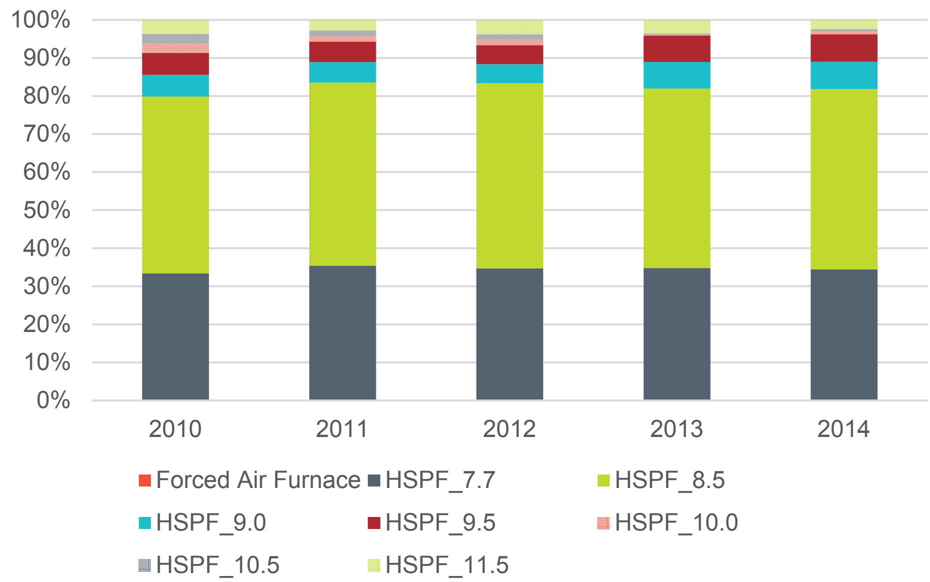
The research team estimated the actual efficiency mix for each year of the analysis using these distributor sales data. The team extrapolated information known about part of the market to the entire market. Depending on the year, the team surveyed between 2% and 45% of the total estimated market (Table 6) The results of the analysis were estimates of the percentage of all HVAC units sold at each efficiency level across the spectrum of least efficient (code minimum) to most efficient (highest available efficiency). The research team multiplied these percentages (collectively known as the actual efficiency mix) by the UEC estimation from Question 3a to create a single, weighted average UEC estimate for all HVAC units sold in the actual market scenario.

Table 6: Estimated Portion of Market Represented by Distributor Surveys

Total Units Shipped (AHRI and Stock Model)	37,140	39,012	40,650	42,478	43,504
Total Units Surveyed (Distributor Surveys)	648	4,122	4,172	16,798	19,475
Estimated Portion of Market Surveyed (%)	2%	11%	10%	40%	45%
Number of Distributor Companies Reporting	1	3	4	5	5

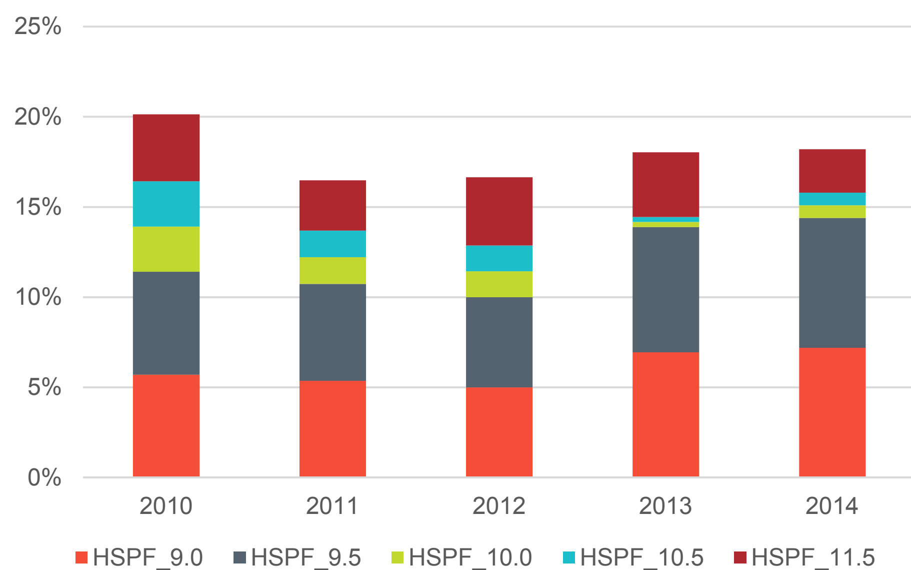
Figure 18 shows the normalized air source heat pump efficiency distributions, for all efficiency tiers, derived from distributor shipment data. The majority of units are in the two lowest efficiency tiers (HSPF 7.7 and 8.5), and the relative proportions of shipments in each tier do not vary significantly over time. Figure 19 shows the same data for the higher efficiency tiers at or above HSPF 9.0. While the data do show some variability at this level of detail, the research team concluded that this variance may not represent real significant market trends, as four out of five distributors surveyed were unable to provide data spanning the entire analysis period.

Figure 18: Actual Market Efficiency Mix of Air Source Heat Pumps – Upgrade Case



Source: Navigant analysis of distributor reported sales data

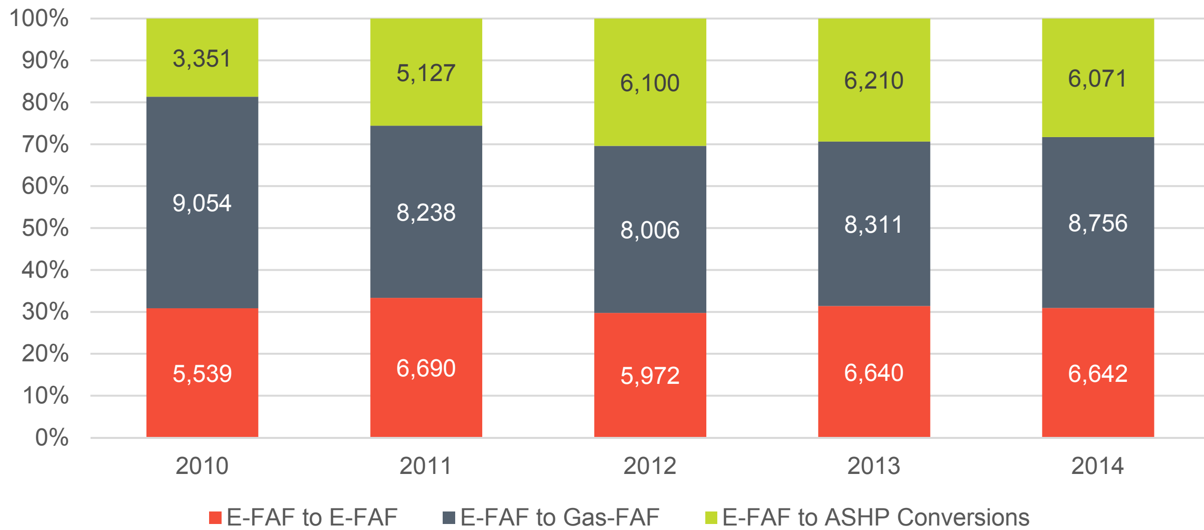
Figure 19: High Efficiency Air Source Heat Pumps as a Percentage of Total Market Shipments – Upgrade Case



Source: Navigant analysis of distributor reported sales data

The upgrade scenario represents a homogeneous market (e.g. ASHP replacing other ASHP), so the team applied the efficiency distributions to the ASHP market size at face value. To represent the efficiency distribution in the conversion case, the research team needed to estimate the size of the natural replacement market for electric forced air furnaces, and assume that a certain percentage of forced air furnaces are not being converted to air source heat pumps. Of those not being converted to air source heat pumps, they are replaced by the same type of electric forced air furnaces, or converted to gas forced air furnaces (and are removed from consideration in this analysis). The team derived these percentages by comparing the market size for electric forced air furnaces and air source heat pumps, as calculated by the calibrated stock turnover model (described in more detail under Question 2). This analysis, shown in Figure 20, indicated that 70% to 85% of forced air furnaces retiring in any given year are not converted to heat pumps. The team believes that the growth in electric forced air furnace to air source heat pump conversions between 2010 and 2012 is due to economic recovery from the recession in 2009.

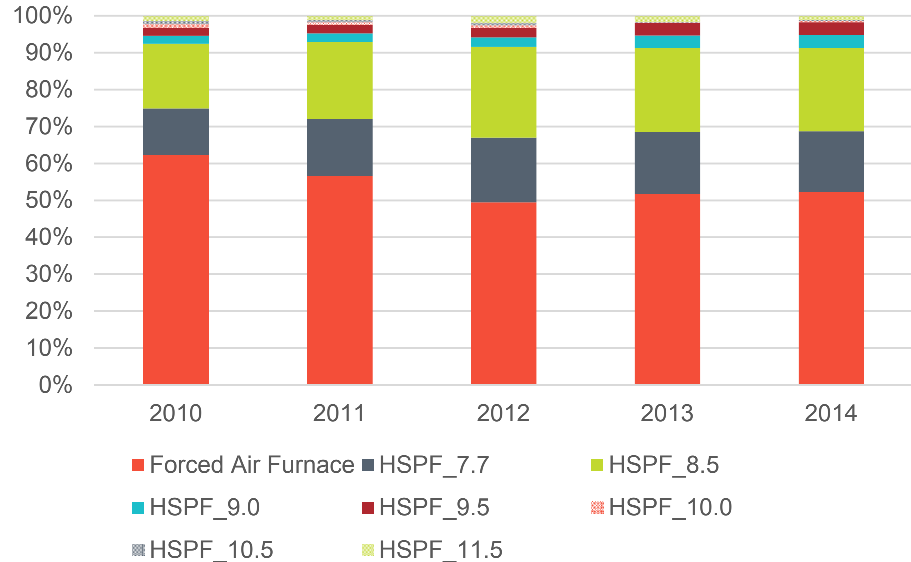
Figure 20: HVAC Unit Types Estimated to be Replacing Forced Air Furnaces in Single Family Homes



Source: Navigant analysis using results of the Stock Turnover Model

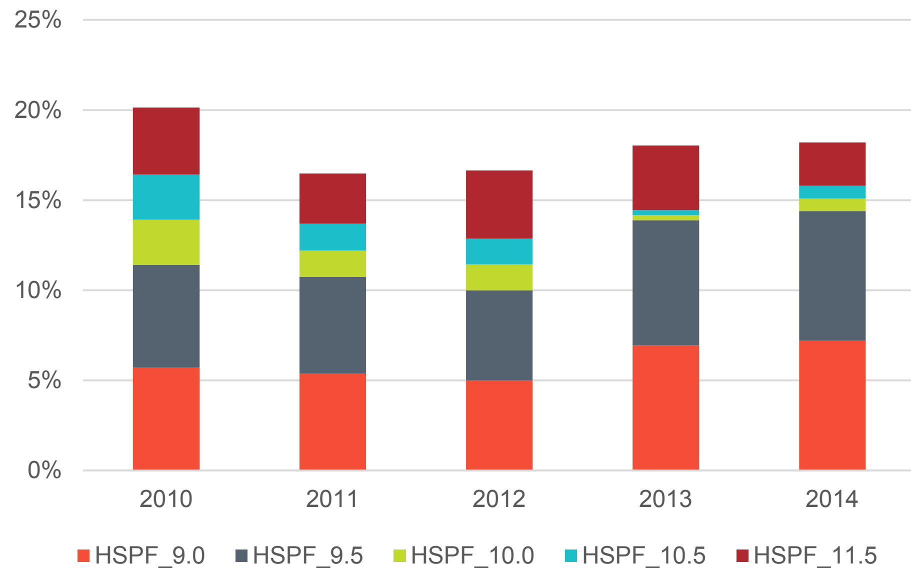
The team determined the electric forced air furnace contribution to the efficiency mix as the number of electric forced air furnaces shipped each year, divided by the total electric market size. The total electric market size is the sum of the forced air furnaces not converted to a different unit type (E-FAF to E-FAF), and those that converted to other electric heat (E-FAF to ASHP Conversions). Therefore, the gas units are not considered when developing the efficiency mix. Figure 21 shows the actual market efficiency mix for the conversion scenario, a portion of which remains electric FAF. The majority of units are replaced with new forced air furnace (i.e., are not converted). Of those that are converted, most are converted to air source heat pumps in the lower efficiency tiers (HSPF 7.7 and 8.5). The team believes that the relative proportion of conversions increases between 2010 and 2012 because of economic recovery after the 2009 recession. Figure 22 shows the same data for the higher efficiency tiers at or above HSPF 9.0. While the data does show some variability at this level of detail, the research team concluded that this variance may not represent real significant market trends, as four out of five distributors surveyed were unable to provide data spanning the entire analysis period.

Figure 21: Actual Market Efficiency Mix of Forced Air Furnaces and Air Source Heat Pumps – Single Family Conversion Case



Source: Navigant analysis of distributor reported sales data

Figure 22: High Efficiency Air Source Heat Pumps as a Percentage of Total Market Shipments – Single Family Conversion Case



Source: Navigant analysis of distributor reported sales data

Finally, the research team estimated actual consumption for each year of the analysis by multiplying the annual market size by the actual efficiency mix-weighted UEC estimate as shown in Equation 2. Table 7 shows the results of this calculation.

Equation 2: Actual Consumption Calculation, by Building Type and HVAC type

$$\text{Actual Consumption} = \text{Market Size} \times \text{UEC}_{\text{Weighted by actual efficiency mix}}$$

Table 7: Actual Market Consumption by Year (aMW)

2010	2011	2012	2013	2014
59.7	65.5	66.3	69.8	71.9

Source: Navigant analysis of distributor reported sales data and results of the Stock Turnover Model calibrated to AHRI data.

Key Decisions

The research team made one key decision when analyzing distributor sales data: some distributors only provided data for a subset of years in the analysis period. Therefore, the analysis team used the trends present in the data provided by each distributor to project sales by efficiency forward or backward to smooth trends and fill gaps in the data. Table 6 provides annual detail on the number of distributors reporting, the number of shipments reported by all distributors, and the portion of the total market surveyed.

Total Market Savings

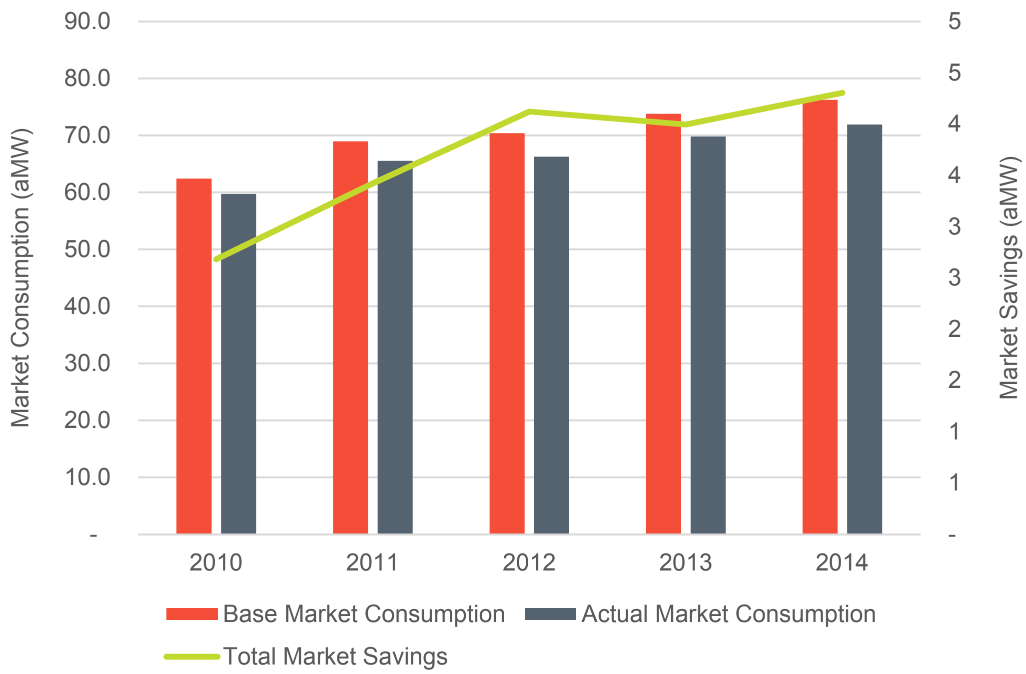
To conclude the analysis in Questions 3a and 3b and arrive at total market savings, the team calculated the difference between baseline consumption and actual consumption as shown in Equation 3.

Equation 3: Total Market Savings Calculation

$$\text{Total Market Savings} = \text{Actual Energy Consumption} - \text{Baseline Energy Consumption}$$

Figure 23 shows the baseline and actual market consumption, calculated in Questions 3a and 3b on the primary axis, and the total market savings on the secondary axis. Total savings increase over time, primarily driven by growth in the market. The relative difference between baseline and actual market consumption does not change significantly over time. The implication is that growth in the total market size, rather than increasingly efficient mix of air source heat pumps, increases total market savings over time.

Figure 23: Baseline Market Consumption, Actual Market Consumption, and Total Market Savings (Secondary Axis) in aMW



Source: Navigant analysis of Sixth Power Plan data, distributor reported sales data, and results of the Stock Turnover Model

The final step in the analysis is determining the regional program savings relative to the Sixth Plan baseline.

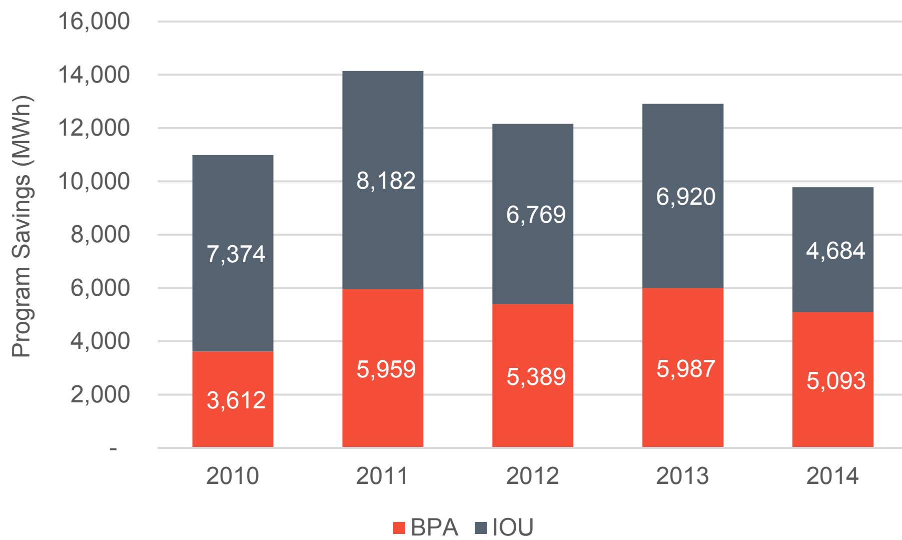
Question 4: What are the program savings?

Question 4 concerns the final variable in the Momentum Savings equation: program savings. Momentum Savings, by definition, exclude electricity savings achieved through efficiency programs in the region. The research team developed estimates of programmatic savings from program data provided by BPA and investor-owned utilities.

However, to subtract these programmatic savings from the total market savings, the team first measured both values against the same baseline. Regional program administrators report program savings measured against customized baselines from local evaluations or RTF deemed savings values. These baselines are constantly changing over time, and vary throughout the analysis period. In contrast, the total market savings analysis described earlier measures savings against the Sixth Plan baseline—a fixed baseline that often differs from those baselines used to evaluate program savings. For this reason, the research team could not use program savings as-reported without first recalculating the program savings against the Sixth Plan baseline. To accomplish this, the analysis used measure counts from the program data[26] and UEC values as defined in Question 3 to estimate programmatic savings against the Sixth Plan baseline, consistent with the estimation of total market savings.

The research team calculated program savings for each efficiency level by subtracting the actual UEC for that efficiency level (as calculated from program unit efficiencies) from the baseline efficiency mix-weighted UEC (from the Council baseline), then multiplying the result by the total number of program measures. This is the same procedure used to calculate total market savings under Question 3, except the team substituted program unit quantities as the market size. Furthermore, consistent with the Sixth Plan, the team assumed that any conversion facilitated by the program would have an 85% chance of not converting without the influence of the program. Figure 24 shows the results of this analysis, separated into BPA program savings and other Investor Owned Utility (IOU) program savings.

Figure 24: Program Savings by Year (MWh)



Source: Navigant analysis of BPA and IOU HVAC program savings data

Key Decisions

Key Decisions made by the research team include the following:

- Because each IOU uses a different baseline to report program savings, the team decided that the best way to measure program savings against the Council baseline would be to collect data on unit type, quantity, installation context, and efficiency level, and re-calculate program savings using the SEEM UEC values derived from Question 3.
- Lacking a reliable source of data on IOU program activity, the research team decided to survey IOU representatives to request the appropriate data to determine regional program savings. While there were still gaps in the data received from IOU program administrators, these data proved sufficient to calculate savings from this analysis.

[26] The research team requested detailed program participation data, including fields for HVAC unit type, building type, and unit quantity for units incentivized directly through regional utility programs from 2010-2014. Where there were gaps in the program data from investor-owned utilities (IOUs), the team applied assumptions based on BPA program data to the missing IOU program data. The team structured the analysis such that new IOU data can be easily incorporated as it becomes available.

Calculating Momentum Savings—Draft Results

Momentum Savings are equal to the difference between total market savings and program savings as shown in Equation 4. The total market savings encompass the entire four-state Northwest region, including areas served by utilities other than BPA. Likewise, program savings include all programs in the region, not only BPA programs.

Equation 4: Momentum Savings Calculation

Momentum Savings = Total Market Savings – Program Savings

Figure 25 shows the sources of total market savings, split between Momentum Savings and program savings. Table 8 shows the two sources of total market savings in average megawatts (aMW) and as a percentage of total market savings.

Figure 25: Sources of Total Market Savings (aMW) for Air Source Heat Pumps

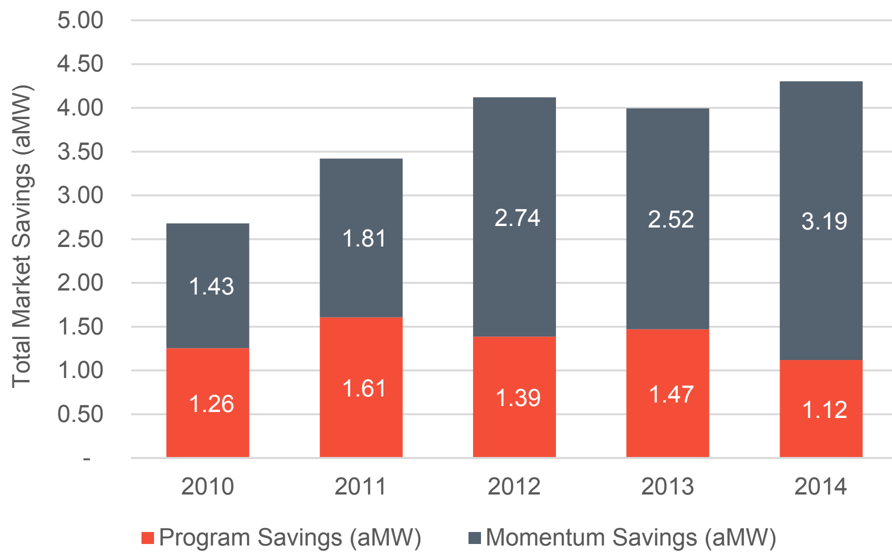


Table 8: Sources of Total Market Savings (aMW and % of Total Market Savings)

	2010	2011	2012	2013	2014
Program Savings (aMW)	1.26	1.61	1.39	1.47	1.12
Momentum Savings (aMW)	1.43	1.81	2.74	2.52	3.19
Program Savings (% of Total Market)	47%	47%	34%	37%	26%
Momentum Savings (% of Total Market)	53%	53%	66%	63%	74%

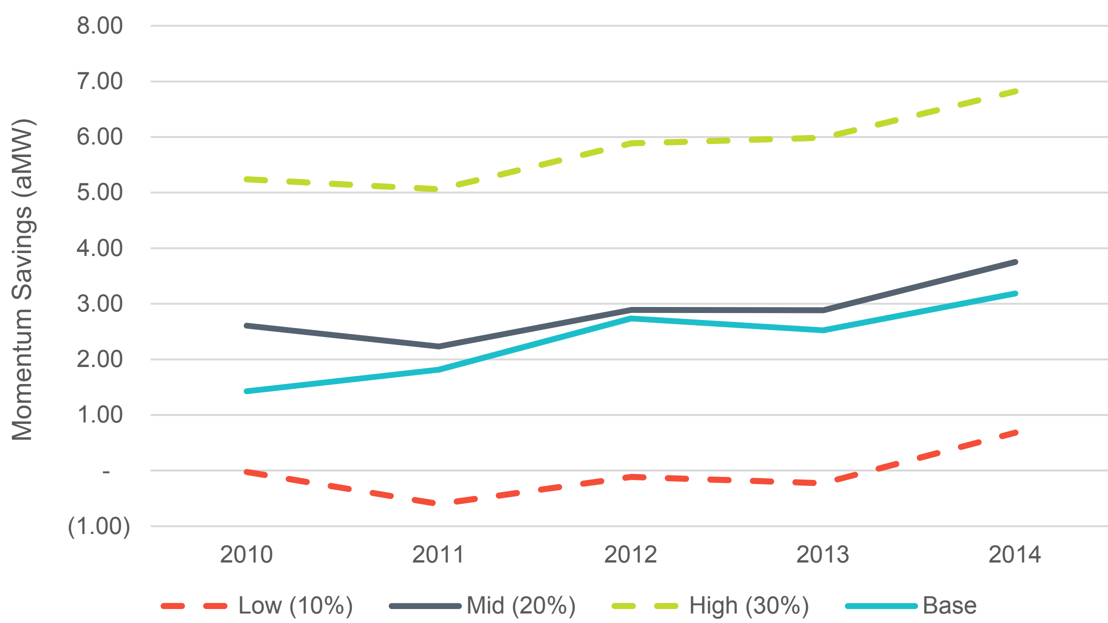
Driving Factors

Throughout the analysis, the research team identified several significant uncertainties that have a large effect on the analysis results, as well as potential future actions to address the uncertainties. This section describes the key factors that drive Momentum Savings for residential HVAC, and discusses the model's remaining uncertainties.

Conversions vs. Upgrades

The number of ASHP units installed as conversions from electric forced air furnaces, relative to upgrades from other ASHP is a main driver of Momentum Savings, and one of the largest uncertainties in the analysis. A conversion from an electric forced air furnace to a heat pump yields much greater savings than an upgrade from a less efficient heat pump to a more efficient heat pump. As shown back in Figure 14, there is a large decrease in UEC between FAF and ASHP, but only incremental decreases in UEC between lower efficiency ASHP and higher efficiency ASHP. Figure 26 shows the sensitivity of Momentum Savings to this assumption.

Figure 26: Momentum Savings as a Function of the Percentage of ASHP Units Installed as Conversions (aMW)



The team determined the number of conversions and upgrades based on assumptions about electric FAF and ASHP stock saturations, derived from RBSA and the 1992 Pacific Northwest Residential Energy Survey (PNWRES92)[27] data. Specifically, the team assumed diminishing saturation of electric FAF indicated a conversion to ASHP. This simplifying assumption does not account for scenarios of switching from decentralized to centralized HVAC systems, installing ASHP as a secondary system, or switching from gas furnaces to ASHP. Obtaining more data on the installation context of ASHP would help the research team refine this assumption.

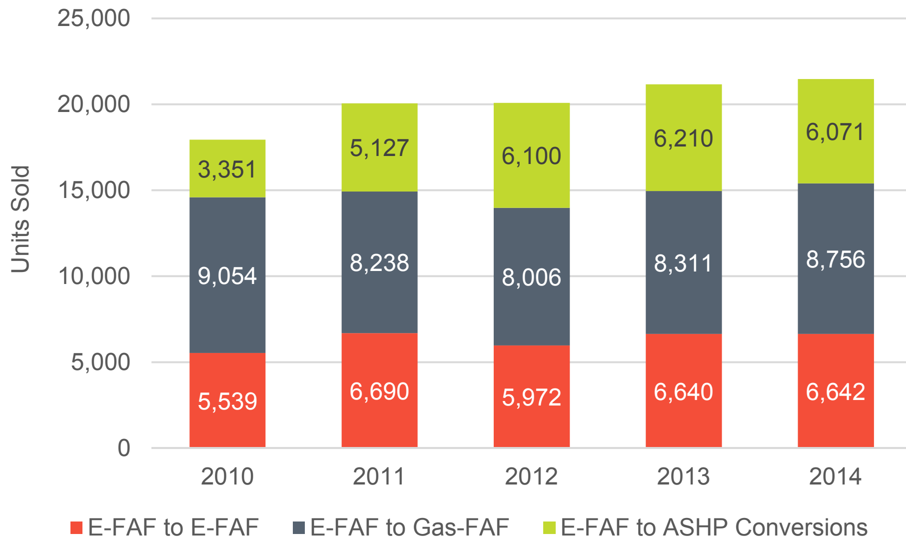
The number of conversions from electric forced air furnaces to air source heat pump increases throughout the analysis period. This increase is a result of the increasing market size in the stock turnover model. Because electric forced air furnaces have a 21 year measure life[28], a large growth in the stock from 1989 to 1993 yields an increasing number of natural retirements between 2010 and 2014. Figure 27 shows the number of heat pumps and electric and gas force air furnaces shipped in each year. Between 2010 and 2011, there is a 53% increase in conversions of electric forced air furnaces to air source heat

[27] The 1992 Pacific Northwest Residential Energy Survey – Phase I, Book 2: Item-by-Item Cross tabulations, Volume C: Pacific Northwest Region

[28] DOE Furnaces and Boilers 2007 Final Rule, Technical Support Document Chapter 8: Lifecycle Cost Analysis, Table 8.3.3 Furnace and Boiler Lifetimes Used in the LCC Analysis.

pumps. The team has identified this as a key driving factor for the model results, and suggests more research is necessary to validate this increase.

Figure 27: HVAC Unit Types Replacing Electric Forced Air Furnaces (Units Sold)



Source: Navigant analysis of AHRI data, using results of the Stock Turnover Model

Market Size

The quantity of heat pumps sold in the Pacific Northwest is a key determinant of Momentum Savings. If the market size increases relative to program unit sales, Momentum Savings also increase. During the analysis period (2010-2014), the market for residential HVAC units increased, as shown in Figure 12. Historical data indicates this increase in market size is a function of the economic recovery from the housing crisis in 2008-2009. As described in Question 2, the team used a variety of data sources to inform the stock turnover model, which calculates market size. Aligning the various data sources required several assumptions outlined under “Key Decisions” in Question 2. The research team should continue to seek data to inform these considerations, and refine the estimate of market size.

Quality Installations

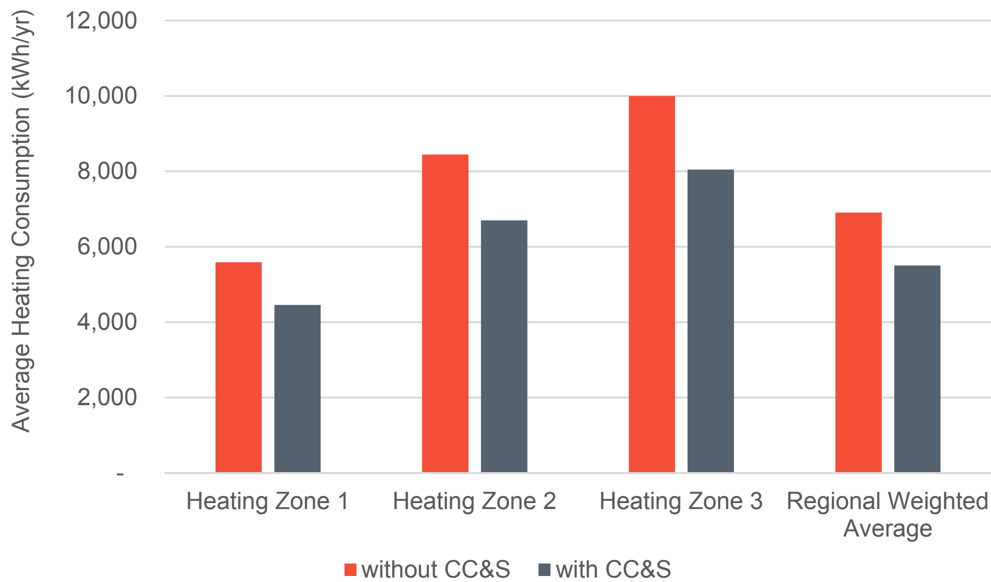
Quality installation—also known as CC&S—is an important factor that impacts the efficiency of HVAC equipment. Energy efficiency programs require HVAC equipment to have proper CC&S to be eligible for incentives. As such, the analysis team assumed that contractors install all program units using proper CC&S. Conversely, for all other units sold into the market, the team assumes that contractors who install these units do not follow proper CC&S practices (therefore, units installed outside of programs have lower savings).

This is a conservative assumption consistent with the Council baseline and RTF proceedings. However, if the analysis team were to find that a certain percentage of contractors in the market outside of programs actually are following proper CC&S practices, Momentum Savings could increase.

To test the significance of CC&S on the per unit energy consumption, the research team simulated two different versions of SEEM, one with and without CC&S. As shown in Figure 28, the addition of proper

CC&S results in approximately a 20% decrease in annual heating consumption averaged across all HSPF efficiency levels considered in the analysis.

Figure 28: Comparison of Average per Unit Heating Consumption with and without CC&S (kWh/yr.)



Source: Navigant analysis using SEEM 97

Program Savings

As described in the methodology section under Question 4, the research team must measure all the regional program savings against the Sixth Plan baseline to enable an "apples to apples" comparison of programmatic and Momentum Savings. In order to calculate the program savings, the research team requested detailed program tracking data from utilities across the region. Although the research team received a lot of well-documented program data from utilities across the Pacific Northwest, including the IOUs, in some cases, regional energy efficiency program managers were unable to provide full detailed data on their residential HVAC programs.

Table 9 summarizes the data gaps in each program savings data request. In this table, "Yes" means the program data was complete and used in the analysis, "Most" means the research team interpreted portions of the data and used them in the analysis, and "No" means the data field was not obtained from the program records. In cases where gaps were present in the data, the research team projected the values from known data sources. For example, all IOUs were unable to provide the housing type (single family or manufactured homes) in which the unit was installed. The analysis team assumed that the split between single family and manufactured homes was the same as the split present in the BPA data, and applied those percentages to IOU program data accordingly.

Table 9: Summary of Program Data Completeness

Service Territory	Program Year	Measure Name Clear	Quantity	Efficiency	Housing Type	Years Data Covers
BPA	Yes	Yes	Yes	Yes	Yes	2010-2014
Avista	Yes	Yes	Yes	Most	No	2010-2014
Energy Trust of Oregon	Yes	Most	Yes	Most	No	2010-2014
Idaho Power	Yes	No	Yes	Yes	Yes	2010-2014
PacifiCorp (ID and WA)	Yes	Yes	Yes	No	No	2010-2014
Puget Sound Energy	Yes	Most	Yes	Most	No	2010-2014

Source: Navigant analysis of BPA and IOU program data

Acquisition of more detailed program data may increase or decrease Momentum Savings, depending on if the data decreases or increases program savings respectively.

Future Research Opportunities

This section presents the research team's recommendations to BPA for future data collection and analysis that could improve the estimation of residential HVAC Momentum Savings. The research team developed these recommendations upon completion of the Momentum Savings analysis in late 2015. At the time of this report's publication (June 2016), BPA is in the process of exploring how to gather primary data on installation context and more robust sales data.

Table 10 summarizes each opportunity according to the following criteria:

- **Impact on results:** the estimate of how the research opportunity may impact the Momentum Savings estimates, based on the highest and lowest expected outcomes from the research. Research topics with greater uncertainty generally yield a higher impact.
    - Low: likely to affect Momentum Savings results by <10%
    - Medium: could potentially affect Momentum Savings results by 10-20%
    - High: could potentially affect Momentum Savings results by greater than 20%
- **Effort:** the estimate of expected level of effort required to adequately investigate the opportunity.

- **Overall ranking:** The analysis team ranked the research opportunities according to overall importance, taking into account expected level of effort and model sensitivities.

Table 10: Summary of Opportunities for Future Research

Opportunity	Overall Ranking	Impact	Level of Effort
Survey of HVAC installation contractors	1	High	****
Enhancing program savings data from BPA and IOUs	2	Low	*
Enhance sales data	3	Medium	**
Calculating HVAC cooling savings	4	Medium	***
Calculating DHP Momentum Savings	5	High	***

Survey HVAC Installation Contractors

Impact on results: High

Effort: ****

After developing the model, it became clear that installation context is a main driver of the results. More data on the breakdown of installations between single family, manufactured homes, conversions, upgrades, multifamily, and small commercial establishments would greatly reduce the uncertainty in the current model. The team could interview HVAC installation contractors in order to obtain more details regarding these factors. These interviews would have the added benefit of informing the team about the prevalence of fuel switching in the market, as well as quality installation practices outside of utility programs.

The team ranked this opportunity as the first priority due to how sensitive the results of the model are to the installation context assumptions, even though the team estimates it to be the highest level of effort opportunity.

Enhance Program Savings Data from BPA and IOUs

Impact on results: Low

Effort: *

As mentioned above, the program data obtained from BPA and regional IOUs was partially incomplete. In the future, the research team could develop simple, streamlined annual data requests to specific contacts at each IOU. In return, BPA could provide HVAC market characterization data and program opportunities to participating IOUs. BPA would need to determine to what extent IOU program managers would value this market characterization, and what types of data they would be interested in.

The team ranked this opportunity as the second priority, as it requires a relatively low level of effort and will ensure that future HVAC Momentum Savings analyses use all available program data.

Enhance Sales Data

Impact on results: Medium

Effort: **

The research team was fortunate enough to receive sales data representing a summary of the entire Pacific Northwest HVAC market according to AHRI from one of the distributor interviewees. However, more context would improve this data significantly. How much of the market does AHRI really characterize? Should the stock turnover model precisely match AHRI data, or be slightly lower due to distribution of units to commercial spaces? Does AHRI collect more detailed information on heating efficiencies?

Enhancing sales data may involve establishing relationships with AHRI to obtain more context for their data, subscribing to other regional HVAC data acquisition services, such as Heating, Air Conditioning and Refrigeration Distributors International (HARDI), dedicating time to establishing ongoing relationships with regional distributors, or some combination of these approaches. The team is in the process of assessing the various options to choose the best approach.

The team ranked this opportunity as the third priority. Depending on the results, this could have a substantial impact on Momentum Savings estimates. However, the level of effort required for obtaining more market data is uncertain, as it may require more primary data collection or a subscription service.

Calculate HVAC Cooling Savings

Impact on results: Medium

Effort: ***

The research team did not estimate cooling savings in this analysis for three reasons:

- Cooling savings are a small (yet growing) portion of residential HVAC electricity use in the region
- Examining heating HVAC functionality simplified development of the stock turnover model, as ASHP were only replacing FAF, not potentially replacing central air conditioners
- Homes that did not previously have cooling that install ASHP for the cooling functionality can result in negative savings

In the future, the team could develop a methodology for estimating the cooling savings and accounting for these complications. The team ranked this opportunity as the fourth priority, as it would be relatively resource-intensive to execute.

Coordinate with NEEA to Calculate DHP Momentum Savings

Impact on results: High

Effort: ***

This analysis did not estimate Momentum Savings from DHP technology. As the regional HVAC market for DHP accelerates, this will be an important market to characterize and track, both for program design opportunities and potential Momentum Savings. Subsequent analyses should coordinate with NEEA to consider DHP in residential HVAC Momentum Savings.

The team ranked this opportunity as the fifth priority, as it may require a significant effort and the NEEA already developed estimates for DHP Momentum Savings.

Appendix A: Determining the Sixth Plan Baseline

What is the Sixth Plan baseline and why does it matter?

As part of regional integrated energy resource planning efforts, the Northwest Power and Conservation Council (the Council) develops periodic Power Plans every 5-7 years. These plans consider regional conservation potential. To measure conservation potential, the Council determines baseline levels of efficiency thought to already exist in the market and against which to measure all future energy savings for the duration of the current plan. The time frame for this analysis (2010-2014) is during the Council's Sixth Power Plan (Sixth Plan). As such, the research team investigated this Power Plan to determine the baseline against which to measure total market savings, program savings, and momentum savings.

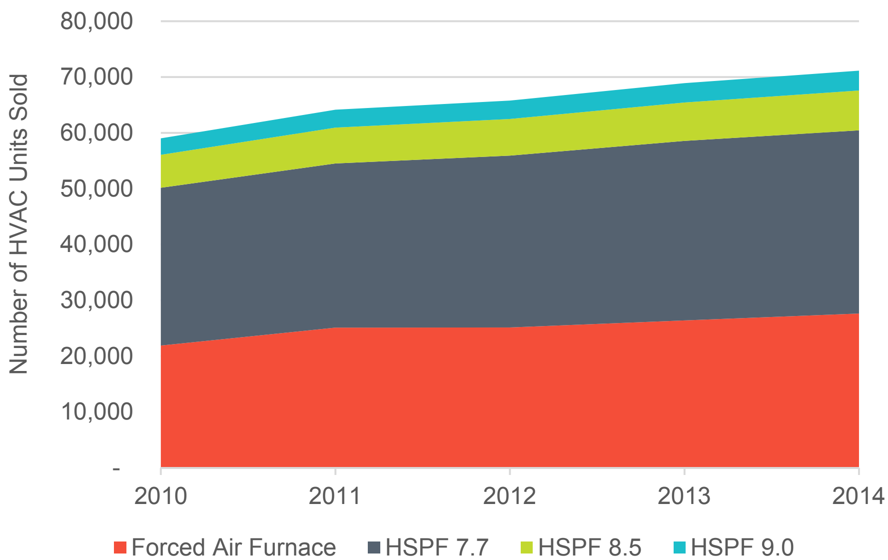
As noted in this report, the research team used the **baseline efficiency mix** as documented in the Sixth Plan to calculate baseline market consumption. The efficiency mix is the distribution of sales across the spectrum of least efficient (code minimum) to most efficient (highest efficiency in the market). The Sixth Plan assumed the following baseline efficiency mixes for the conversion and upgrade scenarios:

- **Conversions.** Eighty-five percent of the natural retirements of electric forced air furnaces are replaced with the same type of electric forced air furnace, 10% are converted to Heating Seasonal Performance Factor (HSPF) 8.5 air source heat pumps, and 5% are converted to HSPF 9.0 air source heat pumps.[29]
- **Upgrades.** Eighty-five percent of the natural retirements of air source heat pumps are replaced with HSPF 7.7, 10% HSPF 8.5, and 5% HSPF 9.0 (all air source heat pumps). Installations of heat pumps in new construction are considered an upgrade.

[29] In other words, the Sixth Plan assumes a "current practice" baseline where 15% of forced air furnaces are replaced with heat pumps when the furnaces wear out, but the remaining 85% are not converted to a different technology.

Using this information and the total market size from Question 2, the team calculated the number of units sold per year in each efficiency tier within the total market. Figure 29 shows these results aggregated by housing type (single family and manufactured) and installation type (conversions and upgrades). The units sold increases over the analysis period as a function of the growth in market size. The relative portion of units in each efficiency tier (the efficiency mix) remains consistent across all years for the base case.

Figure 29: Total Units Sold by Efficiency Level – Base Case



Source: Navigant analysis of Sixth Plan data

The research team used this information, combined with unit energy consumption values, to calculate the baseline energy consumption. The team then subtracted the efficient consumption from the baseline consumption to calculate total market savings, as detailed in the report methodology. Without this important calculation of the baseline market, the team would have no basis for quantifying total market savings, program savings, or Momentum Savings. The remainder of this appendix details how the research team derived the baseline efficiency mix from evidence in the Sixth Plan spreadsheets.

How did the team determine the baseline efficiency mix?

Close examination of the spreadsheets used to develop the Sixth Plan led the research team to derive the two efficiency mixes in the upgrade and conversion cases. After reading the Sixth Plan documents and the Council's conservation supply curve spreadsheets, the team determined that the information useful for ascertaining the baseline is in the spreadsheet titled "PNWResSpaceConditioningCurve_6thPlanv1_8.xls" on the "Applicability Data Base" tab.[30] Column J of this tab contains the baseline information.

Column J is "Current Market Saturation." This refers to the portion of the total market for each measure that the Council assumes to be efficient irrespective of program intervention throughout the Sixth Plan forecast period. The Council considers current market saturation when defining the baseline, as regional electric service providers cannot claim savings from installations of efficient HVAC units that the Council

[30] This spreadsheet, along with other Sixth Plan documentation, is available on the Council's website: https://www.nwcouncil.org/energy/powerplan/6/supply-curves

assumes occur irrespective of any utility interventions. Using the same example as earlier, if the current market saturation of the HSPF 8.5 heat pump is 10%, the Council assumes 10% of electric forced air furnaces retiring in a given year will convert to HSPF 8.5 heat pumps, irrespective of utility program intervention. In other words, the baseline efficiency mix assumes that 10% of sales replacing electric forced air furnaces in any given year will be HSPF 8.5 heat pumps.

Figure 30 is a screenshot from the Sixth Plan supply curve showing the current market saturation for manufactured home HVAC conversions from electric forced air furnaces to air source heat pumps of HSPF 8.5 and HSPF 9.0. As the figure shows, the market saturation for HSPF 8.5 units is 10%, and the market saturation for HSPF 9.0 units is 5% (the repetition of rows denotes different climate zones).

Figure 30: Sample of Current Market Saturation for HVAC Conversions in Manufactured Homes

	A	J
123	Measure	Current Market Saturation
124	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 8.5/SEER 14	10%
125	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 8.5/SEER 14	10%
126	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 8.5/SEER 14	10%
127	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 8.5/SEER 14	10%
128	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 8.5/SEER 14	10%
129	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 8.5/SEER 14	10%
130	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 8.5/SEER 14	10%
131	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 8.5/SEER 14	10%
132	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 8.5/SEER 14	10%
133	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 9.0/SEER 14	5%
134	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 9.0/SEER 14	5%
135	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 9.0/SEER 14	5%
136	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 9.0/SEER 14	5%
137	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 9.0/SEER 14	5%
138	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 9.0/SEER 14	5%
139	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 9.0/SEER 14	5%
140	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 9.0/SEER 14	5%
141	Existing Manufactured Home HVAC Conversion - Convert Electric FAF w/CAC to HSPF 9.0/SEER 14	5%

Conversion to HSPF 8.5 or 9.0 are the only two options considered in the Sixth Plan. As such, an electric forced air furnace can be replaced by a heat pump that is *either* HSPF 8.5 or 9.0 but not both. This consideration enables the research team to derive the baseline efficiency mix as a percentage of the total market for electric forced air furnace conversions. In this case, 85% of the natural retirements of electric forced air furnaces are replaced with the same type of electric forced air furnace, 10% are converted to HSPF 8.5 air source heat pumps, and 5% are converted to HSPF 9.0 air source heat pumps.[31] This baseline applies to both single family and manufactured homes.

[31] In other words, the Sixth Plan assumes a "current practice" baseline where 15% of forced air furnaces are replaced with heat pumps when they wear out, but the remaining 85% are not converted to a different technology.

A similar logic applies to upgrades of code minimum efficiency air source heat pumps (HSPF 7.7) to more efficient heat pumps. As seen in Figure 31, the plan assumes that 85% of the natural retirements of air source heat pumps are replaced with HSPF 7.7, 10% HSPF 8.5, and 5% HSPF 9.0 (all air source heat pumps).

Figure 31: Sample of Current Market Saturation for HVAC Upgrades in Manufactured Homes

3	Measure	Current Market Saturation
343	Existing Manufactured Home HVAC Upgrade - Updgrade to HSPF 9.0/SEER 14 Heat Pump	5%
344	Existing Manufactured Home HVAC Upgrade - Updgrade to HSPF 9.0/SEER 14 Heat Pump	5%
345	Existing Manufactured Home HVAC Upgrade - Updgrade to HSPF 9.0/SEER 14 Heat Pump	5%
346	Existing Manufactured Home HVAC Upgrade - Updgrade to HSPF 9.0/SEER 14 Heat Pump	5%
347	Existing Manufactured Home HVAC Upgrade - Updgrade to HSPF 9.0/SEER 14 Heat Pump	5%
348	Existing Manufactured Home HVAC Upgrade - Updgrade to HSPF 9.0/SEER 14 Heat Pump	5%
349	Existing Manufactured Home HVAC Upgrade - Updgrade to HSPF 9.0/SEER 14 Heat Pump	5%
350	Existing Manufactured Home HVAC Upgrade - Updgrade to HSPF 9.0/SEER 14 Heat Pump	5%
351	Existing Manufactured Home HVAC Upgrade - Updgrade to HSPF 9.0/SEER 14 Heat Pump	5%
352	Existing Manufactured Home HVAC Upgrade - Upgrade to HSPF 8.5/SEER 14 Heat Pump &	10%
353	Existing Manufactured Home HVAC Upgrade - Upgrade to HSPF 8.5/SEER 14 Heat Pump &	10%
354	Existing Manufactured Home HVAC Upgrade - Upgrade to HSPF 8.5/SEER 14 Heat Pump &	10%
355	Existing Manufactured Home HVAC Upgrade - Upgrade to HSPF 8.5/SEER 14 Heat Pump &	10%
356	Existing Manufactured Home HVAC Upgrade - Upgrade to HSPF 8.5/SEER 14 Heat Pump &	10%
357	Existing Manufactured Home HVAC Upgrade - Upgrade to HSPF 8.5/SEER 14 Heat Pump &	10%
358	Existing Manufactured Home HVAC Upgrade - Upgrade to HSPF 8.5/SEER 14 Heat Pump &	10%
359	Existing Manufactured Home HVAC Upgrade - Upgrade to HSPF 8.5/SEER 14 Heat Pump &	10%
360	Existing Manufactured Home HVAC Upgrade - Upgrade to HSPF 8.5/SEER 14 Heat Pump &	10%

The research team identified all applicable Sixth Plan measures involving heat pump conversions or upgrades, in single family or manufactured homes, in all climate zones. The current market saturation assumptions follow a consistent logic for determining the efficiency distribution across all of these categories (85% least efficient, 10% HSPF 8.5, 5% HSPF 9.0). The team used this 85-10-5 logic to determine the baseline market consumption for calculating total market savings and recalculating program savings.

Appendix B: Recalculating Program Savings Against the Sixth Plan Baseline

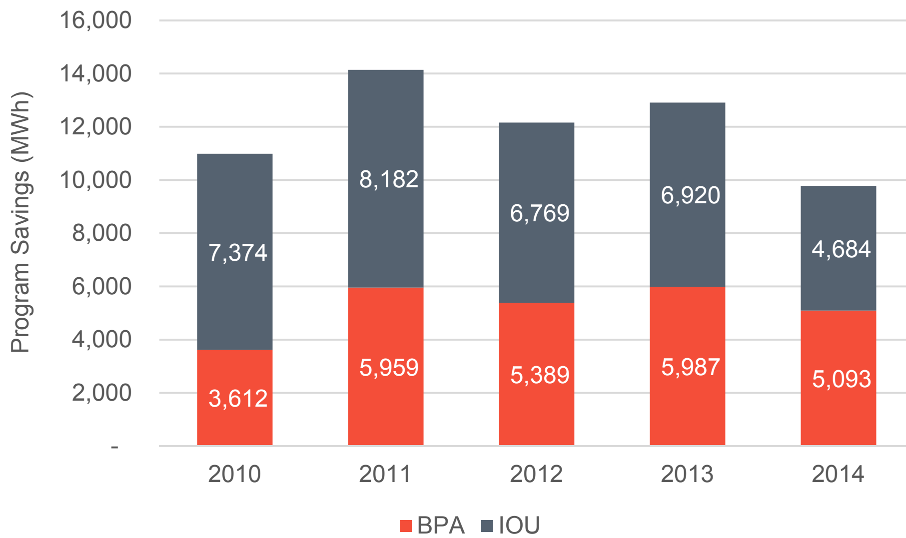
Question 4 concerns the final variable in the Momentum Savings equation: program savings. Momentum Savings, by definition, exclude electricity savings achieved through efficiency programs in the region. The research team developed estimates of programmatic savings from program data provided by BPA and Investor Owned Utilities (IOUs).

However, to subtract these programmatic savings from the total market savings, the team first measured both values against the same baseline. Regional program administrators report program savings measured against customized baselines from local evaluations or Regional Technical Forum (RTF) deemed savings values. These baselines are constantly changing over time and vary throughout the analysis period. In contrast, the total market savings analysis described earlier for Momentum Savings measures savings against the Sixth Plan baseline—a fixed baseline that often differs from those baselines used to evaluate program savings. For this reason, the research team could not use program savings as-reported without first recalculating the program savings against the Sixth Plan baseline. To accomplish this, the analysis used measure counts from the program data[32] and unit energy consumption (UEC) values as defined in Question 3 to estimate programmatic savings against the Sixth Plan baseline, consistent with the estimation of total market savings.

[32] The research team requested detailed program participation data, including fields for HVAC unit type, building type, and unit quantity for units incentivized directly through regional utility programs from 2010–2014. Where there were gaps in the program data from IOUs, the team applied assumptions based on BPA program data to the missing IOU program data. The team structured the analysis such that they can easily incorporate new IOU data as it becomes available.

The research team calculated program savings for each efficiency level by subtracting the actual UEC for that efficiency level from the baseline efficiency mix-weighted UEC (from the Council baseline), then multiplying the result by the total number of program measures. This procedure is the same process used to calculate total market savings under Question 3, except the team substituted program unit quantities as the "market size." Furthermore, consistent with the Sixth Plan, the team assumed that any conversion from forced air furnaces (FAF) facilitated by the program would have an 85% chance of not converting without the influence of the program. Figure 24 shows the results of this analysis, separated into BPA program savings and other IOU program savings.

Figure 32: Program Savings by Year (MWh)



Source: Navigant analysis of BPA and IOU HVAC program savings data

Program Data Completeness

As described in the methodology section under Question 4, the research team must measure all the regional program savings against the Sixth Plan baseline to enable an "apples to apples" comparison of programmatic and Momentum Savings. To calculate the program savings, the research team requested detailed program tracking data from utilities across the region. Although the research team received a lot of well-documented program data from utilities across the Pacific Northwest, including the IOUs, in some cases, regional energy efficiency program managers were unable to provide full detailed data on their residential HVAC programs.

Table 11 summarizes the data gaps in each program savings data request. In this table, "Yes" means the program data was complete and used in the analysis, "Most" means the research team interpreted portions of the data and used them in the analysis, and "No" means the data field was not obtained from the program records. In cases where gaps were present in the data, the research team projected the values from known data sources. For example, all IOUs except Idaho Power were unable to provide the housing type (single family or manufactured homes) in which the unit was installed. The analysis team assumed that the split between single family and manufactured homes was the same as the split present in the BPA data, and applied those percentages to IOU program data accordingly.

Table 11: Summary of Program Data Completeness

Service Territory	Program Year	Measure Name Clear	Quantity	Efficiency	Housing Type	Years Data Covers
BPA	Yes	Yes	Yes	Yes	Yes	2010-2014
Avista	Yes	Yes	Yes	Most	No	2010-2014
Energy Trust of Oregon	Yes	Most	Yes	Most	No	2010-2014
Idaho Power	Yes	No	Yes	Yes	Yes	2010-2014
PacifiCorp (ID and WA)	Yes	Yes	Yes	No	No	2010-2014
Puget Sound Energy	Yes	Most	Yes	Most	No	2010-2014

Source: Navigant analysis of BPA and IOU program data

Acquisition of more detailed program data may increase or decrease Momentum Savings, depending on whether the data decreases or increases program savings respectively.

Appendix C: Sales Data Collection Forms

Figure 33: Sales Data Collection Form for Furnaces (<225 kBtu/hr)

Furnaces (<225K btu/hr)

Please enter unit sales by year and efficiency.

Gas Furnace (Excluding Mobile Home Furnaces)					
	<225K BTU/h				
AFUE	2010	2011	2012	2013	2014
78% exactly					
78% to <82%					
82% to <90%					
90% to <95%					
>95%					
Total	0	0	0	0	0

Mobile Home Gas Furnaces					
	<225K BTU/h				
AFUE	2010	2011	2012	2013	2014
78% exactly					
78% to <82%					
82% to <90%					
90% to <95%					
>95%					
Total	0	0	0	0	0

Oil Furnace (Excluding Mobile Home Furnaces)					
	<225K BTU/h				
AFUE	2010	2011	2012	2013	2014
78% exactly					
78% to <83%					
83% to <90%					
90% to <95%					
>95%					
Total	0	0	0	0	0

Mobile Home Oil Furnaces					
	<225K BTU/h				
AFUE	2010	2011	2012	2013	2014
78% exactly					
78% to <83%					
83% to <90%					
90% to <95%					
>95%					
Total	0	0	0	0	0

Electric Furnaces					
	<225K BTU/h				
	2010	2011	2012	2013	2014
Total					

Figure 34: Sales Data Collection Form for Furnaces (>225 kBtu/h)

Furnaces (>225K btu/hr)
Please enter unit sales by year and efficiency.

Gas-fired Furnace					
	>225K BTU/h				
Thermal Efficiency	2010	2011	2012	2013	2014
80% exactly					
80% to >82%					
82% to <90%					
>90%					
Total	0	0	0	0	0

Oil-fired Furnace					
	>225K BTU/h				
Thermal Efficiency	2010	2011	2012	2013	2014
80% exactly					
80% to >82%					
82% to <90%					
>90%					
Total	0	0	0	0	0

Electric Furnace					
	>225K BTU/h				
	2010	2011	2012	2013	2014
Total					

Figure 35: Sales Data Collection Form for Electric Air Handlers

Electric Air Handlers
Please enter unit sales by year and efficiency.

Air Handlers					
	>225K BTU/h				
	2010	2011	2012	2013	2014
Total					

Figure 36: Sales Data Collection Form for Single Phase Air Conditioners

Air Conditioners: Single Phase															
Please enter unit sales by year and efficiency and capacity.															
Split System Air Conditioners															
	2010			2011			2012			2013			2014		
SEER BIN	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons
13 exactly															
13-14.49															
14.5-16															
16-18															
>18															
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Single Package Air Conditioners with Gas Package or Electric Strip															
	2010			2011			2012			2013			2014		
SEER BIN	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons
13 exactly															
13-13.99															
14-14.99															
15-15.99															
>16															
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ductless Mini Split (AC only)															
	2010			2011			2012			2013			2014		
SEER BIN	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons
13 exactly															
13 to <16															
16 to <18															
>18															
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: For Single Package Air Conditioners with Gas Package or Electric Strip, respondents are asked to estimate the share of annual total that are gas packs, and the share of annual total going to the commercial sector.

Figure 37: Sales Data Collection Form for Single Phase Heat Pump

Heat Pumps: Single Phase

Please enter unit sales by year and efficiency and capacity.

Split System Heat Pumps

	2010			2011			2012			2013			2014		
HSPF BIN	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons
<8.2															
8.2-8.99															
9-9.99															
10-11.49															
>11.5															
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Single Package Heat Pumps

	2010			2011			2012			2013			2014		
HSPF BIN	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons
<8.2															
8.2-8.99															
9-9.99															
10-11.49															
>11.5															
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ductless Mini Split Heat Pumps

	2010			2011			2012			2013			2014		
HSPF BIN	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons
<8.2															
8.2-8.99															
9-9.99															
10-11.49															
>11.5															
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Please estimate the average number of heads per outdoor unit (for all 1-phase ductless mini-splits): ______ average # of heads per system.

Water Source Heat Pumps (assume Geo-type)

	2010			2011			2012			2013			2014		
HSPF BIN	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons	<2 tons	2-3.5 tons	>3.5 to 5 tons
Code Minimum															
Standard															
Premium															
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Respondents are asked to describe the typical "Standard" and "Premium" Efficiency (Rating or technology type).

Figure 38: Sales Data Collection Form for Three-Phase Air Conditioners

Air Conditioners: Three Phase

Please enter unit sales by year and efficiency and capacity.

Split Systems - Air Conditioners with Gas Heating Section

	2010					2011					2012					2013					2014				
SEER BIN	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons
13 exactly																									
13-14.49																									
14.5-16																									
16-18																									
>18																									
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Package Outdoor Systems - Air Conditioners with Gas Heating Section

	2010					2011					2012					2013					2014				
SEER BIN	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons
13 exactly																									
13-14.49																									
14.5-16																									
16-18																									
>18																									
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Split Systems - Air Conditioners with Electric Strip Heat

	2010					2011					2012					2013					2014				
SEER BIN	<8.5 tons	8.5 to	12.5 to <15	15 to <20	>20 tons	<8.5 tons	8.5 to	12.5 to <15	15 to <20	>20 tons	<8.5 tons	8.5 to	12.5 to <15	15 to <20	>20 tons	<8.5 tons	8.5 to	12.5 to <15	15 to <20	>20 tons	<8.5 tons	8.5 to	12.5 to <15	15 to <20	>20 tons
13 exactly																									
13-13.99																									
14-14.99																									
15-15.99																									
>16																									
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Package Outdoor Systems - Air Conditioners with Electric Strip Heat

	2010					2011					2012					2013					2014				
SEER BIN	<8.5 tons	8.5 to	12.5 to <15	15 to <20	>20 tons	<8.5 tons	8.5 to	12.5 to <15	15 to <20	>20 tons	<8.5 tons	8.5 to	12.5 to <15	15 to <20	>20 tons	<8.5 tons	8.5 to	12.5 to <15	15 to <20	>20 tons	<8.5 tons	8.5 to	12.5 to <15	15 to <20	>20 tons
13 exactly																									
13-13.99																									
14-14.99																									
15-15.99																									
>16																									
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ductless Mini Split (AC only)

	2010					2011					2012					2013					2014				
SEER BIN	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5 tons	8.5 to <12.5 tons	12.5 to <15 tons	15 to <20 tons	>20 tons
13 exactly																									
13 to <16																									
16 to <18																									
>18																									
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 39: Sales Data Collection Form for Three-Phase Heat Pump

Heat Pumps: Three Phase
Please enter unit sales by year and efficiency and capacity.

Split Systems - Heat Pump

	2010					2011					2012					2013					2014				
COP	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons
Code Minimum																									
Standard Efficiency																									
Premium Efficiency																									
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Single Package - Heat Pump

	2010					2011					2012					2013					2014				
COP	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5	12.5 to <15	15 to <20	>20 tons	<8.5ton	8.5 to <12.5	12.5 to <15	15 to <20	>20 tons
Code Minimum																									
Standard Efficiency																									
Premium Efficiency																									
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ductless Multi-Split - Heat Pumps

	2010					2011					2012					2013					2014				
COP	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons
Code Minimum																									
Standard Efficiency																									
Premium Efficiency																									
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Please estimate the average number of heads per outdoor unit (for all 3-phase ductless mini-splits): ______ average # of heads per system.

Water Source Heat Pumps

	2010					2011					2012					2013					2014				
HSPF BIN	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5 ton	12.5 to <15 tons	15 to <20 tons	>20 tons	<8.5ton	8.5 to <12.5	12.5 to <15	15 to <20	>20 tons	<8.5ton	8.5 to <12.5	12.5 to <15	15 to <20	>20 tons
Code Minimum																									
Standard Efficiency																									
Premium Efficiency																									
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Respondents are asked to describe the typical "Standard" and "Premium" Efficiency (Rating or technology type).

Figure 40: Sales Data Collection Form for VRF

VRF
Please enter unit sales by year, capacity, and efficiency.

AIR CONDITIONERS

Water Source VRF

	2010				2011				2012				2013				2014			
Efficiency	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K
Code Minimum																				
Standard Efficiency																				
Premium Efficiency																				
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Air Source VRF

	2010				2011				2012				2013				2014			
Efficiency	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K
Code Minimum																				
Standard Efficiency																				
Premium Efficiency																				
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

HEAT PUMPS

Water Source VRF

	2010				2011				2012				2013				2014			
Efficiency	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K
Code Minimum																				
Standard Efficiency																				
Premium Efficiency																				
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Air Source VRF

	2010				2011				2012				2013				2014			
Efficiency	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K	< 65K btu/h	>65K to <135K	>135K to 240K	>=240K
Code Minimum																				
Standard Efficiency																				
Premium Efficiency																				
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Respondents are asked to describe the typical "Standard" and "Premium" Efficiency (Rating or technology type) and the average number of heads per outdoor unit (for all VRF products).

Figure 41: Sales Data Collection Form for Boilers

Boilers

Please enter unit sales by year and efficiency and capacity.

Gas-fired hot water boiler

	2010				2011				2012				2013				2014			
AFUE	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M
Code Minumum																				
75% to 82%																				
82% to <90%																				
>90%																				
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Gas-fired steam boiler

	2010				2011				2012				2013				2014			
AFUE	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M
Code Minumum																				
75% to 80%																				
80% to >90%																				
>90%																				
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Electric hot water boiler

	2010				2011				2012				2013				2014			
	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M
Total																				

Oil -fired hot water boiler

	2010				2011				2012				2013				2014			
AFUE	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M
Code Minumum																				
75% to <84%																				
84% to <90%																				
>90%																				
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Oil -fired steam boiler

	2010				2011				2012				2013				2014			
AFUE	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M	<300K btu/h	300K to <1M	<1M to 2M	>2M
Code Minumum																				
75% to <82%																				
82% to <90%																				
>90%																				
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 42: Sales Data Collection Form for Chillers

Chiller Instructions
Please enter unit sales by year, efficiency, and capacity.

Air Cooled Chiller

	2010						2011						2012						2013						2014					
	<30 tons	30 to <60 ton	60 to <100 ton	100 to <200 ton	200 to <400 ton	>400 ton	<30 tons	30 to <60 ton	60 to <100 ton	100 to <200 ton	200 to <400 ton	>400 ton	<30 tons	30 to <60 ton	60 to <100 ton	100 to <200 ton	200 to <400 ton	>400 ton	<30 tons	30 to <60 ton	60 to <100 ton	100 to <200 ton	200 to <400 ton	>400 ton	<30 tons	30 to <60 ton	60 to <100 ton	100 to <200 ton	200 to <400 ton	>400 ton
Code Minimum																														
Standard Efficiency																														
Premium Efficiency																														
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Air Cooled: Centrifugal

	2010						2011						2012						2013						2014					
	<30 tons	30 to <60 ton	60 to <100 ton	100 to <200 ton	200 to <400 ton	>400 ton	<30 tons	30 to <60 ton	60 to <100 ton	100 to <200 ton	200 to <400 ton	>400 ton	<30 tons	30 to <60 ton	60 to <100 ton	100 to <200 ton	200 to <400 ton	>400 ton	<30 tons	30 to <60 ton	60 to <100 ton	100 to <200 ton	200 to <400 ton	>400 ton	<30 tons	30 to <60 ton	60 to <100 ton	100 to <200 ton	200 to <400 ton	>400 ton
Code Minimum																														
Standard Efficiency																														
Premium Efficiency																														
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Water Cooled Chiller (not Centrifugal)

	2010					2011					2012					2013					2014				
	<150 ton	150-300	300 to 500	500 to 1000	>1000	<150 ton	150-300	300 to 500	500 to 1000	>1000	<150 ton	150-300	300 to 500	500 to 1000	>1000	<150 ton	150-300	300 to 500	500 to 1000	>1000	<150 ton	150-300	300 to 500	500 to 1000	>1000
Code Minimum																									
Standard Efficiency																									
Premium Efficiency																									
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Water Cooled: Centrifugal

	2010					2011					2012					2013					2014				
	<150 ton	150-300	300 to 500	500 to 1000	>1000	<150 ton	150-300	300 to 500	500 to 1000	>1000	<150 ton	150-300	300 to 500	500 to 1000	>1000	<150 ton	150-300	300 to 500	500 to 1000	>1000	<150 ton	150-300	300 to 500	500 to 1000	>1000
Code Minimum																									
Standard Efficiency																									
Premium Efficiency																									
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Respondents are asked to please describe the typical "Standard" and "Premium" Efficiency (Rating or technology type)

Figure 43: Sales Data Collection Form for Unit and Duct Heaters

UNIT AND DUCT HEATERS
Please enter unit sales by year, efficiency and capacity.

UNIT HEATERS (gas)																				
	2010				2011				2012				2013				2014			
Thermal Efficiency	<= 100K btu/h	100k-200k btu/h	200k-300k btu/h	>300k btu/h	<= 100K btu/h	100k-200k btu/h	200k-300k btu/h	>300k btu/h	<= 100K btu/h	100k-200k btu/h	200k-300k btu/h	>300k btu/h	<= 100K btu/h	100k-200k btu/h	200k-300k btu/h	>300k btu/h	<= 100K btu/h	100k-200k btu/h	200k-300k btu/h	>300k btu/h
Code Minimum																				
<80%																				
80% to <82%																				
82% to <90%																				
>90%																				
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DUCT HEATERS/FURNACE (gas)																				
	2010				2011				2012				2013				2014			
Thermal Efficiency	<= 100K btu/h	100k-200k btu/h	200k-300k btu/h	>300k btu/h	<= 100K btu/h	100k-200k btu/h	200k-300k btu/h	>300k btu/h	<= 100K btu/h	100k-200k btu/h	200k-300k btu/h	>300k btu/h	<= 100K btu/h	100k-200k btu/h	200k-300k btu/h	>300k btu/h	<= 100K btu/h	100k-200k btu/h	200k-300k btu/h	>300k btu/h
Code Minimum																				
< 80%																				
80% to <82%																				
82% to <90%																				
>90%																				
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 44: Sales Data Collection Form for Packaged Terminal Air Conditioners and Heat Pumps

Packaged Terminal Air Conditioners and Heat Pumps

Please enter unit sales by year, efficiency, and capacity.

Packaged Terminal Air Conditioners					
STANDARD SIZE					
< 7 kBtuh	2010	2011	2012	2013	2014
EER 11.7 Exactly					
EER 11.7 - 12.3					
EER 12.4 - 13.0					
EER > 13.0					
7.1 - 15.0 kBtuh	2010	2011	2012	2013	2014
EER 9.3 Exactly					
EER 9.3 - 10.0					
EER 10.1 - 11.0					
EER > 11.0					
> 15 kBtuh	2010	2011	2012	2013	2014
EER 9.3 Exactly					
EER 9.3 - 10.0					
EER 10.1 - 11.0					
EER > 11.0					
Total	0	0	0	0	0

Packaged Terminal Air Conditioners					
NON STANDARD SIZE					
< 7 kBtuh	2010	2011	2012	2013	2014
EER 9.4 Exactly					
EER 9.4 - 10.0					
EER 10.1 - 11.0					
EER > 11.0					
7.1 - 15.0 kBtuh	2010	2011	2012	2013	2014
EER 7.7 Exactly					
EER 7.7 - 8.5					
EER 8.6 - 10.0					
EER > 10.0					
> 15 kBtuh	2010	2011	2012	2013	2014
EER 7.7 Exactly					
EER 7.7 - 8.5					
EER 8.6 - 10.0					
EER > 10.0					
Total	0	0	0	0	0

Packaged Terminal Heat Pumps					
STANDARD SIZE					
< 7 kBtuh (cooling)	2010	2011	2012	2013	2014
EER 11.9 Exactly					
EER 11.9 - 12.3, COP > 3.3					
EER 12.4 - 13.0, COP > 3.3					
EER > 13.0, COP > 3.3					
7.1 - 15.0 kBtuh (cooling)	2010	2011	2012	2013	2014
EER 9.5 Exactly					
EER 9.5 - 10.0, COP > 2.9					
EER 10.1 - 11.0, COP > 2.9					
EER > 11.0, COP > 2.9					
> 15 kBtuh (cooling)	2010	2011	2012	2013	2014
EER 9.5 Exactly					
EER 9.5 - 10.0, COP > 2.9					
EER 10.1 - 11.0, COP > 2.9					
EER > 11.0, COP > 2.9					
Total	0	0	0	0	0

Packaged Terminal Heat Pumps					
NON STANDARD SIZE					
< 7 kBtuh (cooling)	2010	2011	2012	2013	2014
EER 9.3 Exactly					
EER 9.3 - 10.0, COP > 2.7					
EER 10.1 - 11.0, COP > 2.7					
EER > 11.0, COP > 2.7					
7.1 - 15.0 kBtuh (cooling)	2010	2011	2012	2013	2014
EER 7.6 Exactly					
EER 7.6 - 8.5, COP > 2.5					
EER 8.6 - 10.0, COP > 2.5					
EER > 10.0, COP > 2.5					
> 15 kBtuh (cooling)	2010	2011	2012	2013	2014
EER 7.6 Exactly					
EER 7.6 - 8.5, COP > 2.5					
EER 8.6 - 10.0, COP > 2.5					
EER > 10.0, COP > 2.5					
Total	0	0	0	0	0

Appendix D: Interview Guides

Distributor Interview Guide

Contact Name:
Title:
Company Name:
Company Phone:
Company Address:
Today's Date & Time:
Attendees:
Notes:

Thank you for participating in the Inaugural Survey of Northwest HVAC Distributors!

I. **Introduction.**

About Us. *This interview is a critical component of a market research project aimed at learning how BPA can best deploy its resources to drive greater efficiency in the Northwest HVAC market. The insights you provide here into market trends, market niches, product mix, customer segments, and the distribution chain will help share future program investment in the region.*

To quickly get on the same page, by "Northwest," we mean: WA, OR, ID, and MT.

About you. *We understand distributors have highly variable service territories and may have parent companies or subsidiaries with various internal divisions, so it is important for us to understand the perspective you'll be providing today.*

a. What is your role within your company?
b. Please provide an overview of your company's role in the Northwest HVAC market. Consider any market segments or niches you specialize in, differentiated services, or specific geographical areas where you have a relatively strong presence.
c. How many branches in the Northwest does your company operate?
d. Do you have any central warehouses that serve your Northwest branches? How many?
e. What is your company's service territory?
f. What is your estimated market share among distributors in the Northwest by unitary sales? Do you expect that would be consistent across all four states?
g. Within the Northwest, do you think there are geographic differences in the accessibility of energy efficient HVAC options? For example, do consumers in both the residential and commercial sectors have the same choices with regards to efficiency by virtue of their location, or are they limited?
   If Yes:

        i. What specific areas do you think have better access to high efficiency options and why?
        ii. Which areas have worse access and why?

II. Programmatic and Non-Programmatic Activity

a. Does your company participate in any utility energy efficiency programs in the Northwest?
    i. If yes:
        1. Which one(s)?
        2. What could these programs do better? What is the biggest headache associated with these programs?
        3. Is there something these programs should do, but do not, to help drive sales of energy efficient equipment?
        4. Are there any specific efficient HVAC products not currently incentivized by utility programs that you would like to see incentivized?
b. What percentage of your above-minimum efficiency sales would you estimate do *not* go through utility incentive programs?
    i. Has that share changes in recent years?
c. Are there any specific product categories for which efficient products commonly do NOT go through programs?
d. What are some common reasons why customers might purchase high-efficiency products (other than utility incentives)?

III. Distribution Chain and Market Actors

a. Suppose we traced the origin of 100 newly installed residential HVAC units back to the original manufacturer:
    i. How many of those units would have been held at some point by a distributor like your company?
    ii. Is there ever a time when a manufacturer will ship residential products directly to a contractor (excluding manufacturer-owned distribution)? Consider new construction projects, etc.
        1. If yes, when and how many of those 100 units?
    iii. How many of those 100 units would flow through manufacturer-owned distribution vs. independent distributors?
    iv. Would any of those 100 units flow through retailers such as Sears, Costco, Lowe's or Home Depot? If any, are those also 'touched' by distributors at some point?
b. Let's move through the same thought experiment for "light commercial units" (under 25 tons in capacity?)
c. Lastly, let's move through the same thought experiment for large commercial units (above 25 tons in capacity?)
d. Please walk us through the most typical sales process (from the identification of the need for the equipment to its installation)? Who calls who? How does the process unfold? [Consider how the need is recognized, who makes the purchase decision, who influences it, etc.]
    i. Residential units.
    ii. Lite commercial units.
    iii. Large commercial units.
e. Do you purchase any units from parties other than manufacturers? (I.e., other larger distributors, etc.) If yes, what percentage of your unit purchases do ***not*** come directly from a manufacturer?
f. When do you have the greatest opportunity to influence what your customer purchases buy and how can you influence it?
g. Do contractors typically know what is in your inventory?
h. What happens if a contractor calls and asks for a product you do not have in stock?

i. How do you determine which products to stock? Who makes that decision? Do you need to achieve a certain turnover threshold in order to choose to stock a product? (i.e., 16 SEER AC?)

IV. Sales Trends

a. How has the market changed over the last 5 years? Do you expect these trends to continue and do you see any others developing?

b. Please estimate the breakout of your **commercial** sales by market segment as shown in the table below.

	% of Total Unit Sales	% of Total Revenue
Plan and Spec		
Design/Build		
Other?		
Total	**100%**	**100%**

c. Please estimate the breakout of your sales by reason for purchase.

Purchase Driver	**% share of units sales**		
	Residential	Lite Commercial	Large Commercial
Replacement (due to unit or system failure)			
Early Retirement/Retrofit			
New Construction			
Total	**100%**	**100%**	**100%**

a. With regards to residential units, do you have a sense for what percentage of the HVAC units your company sells end up in multi-family housing complexes as opposed to single family residences?

b. What macro factors correlate most directly with your overall sales volumes? (GDP growth, housing starts, consumer sentiment, credit markets, etc.)
   a. Residential
   b. Commercial

c. What are the fastest growing product categories for your business?

d. Have you seen any shifts in product mix due to the reduced federal incentives over the last few years?

e. How do you set sales targets and forecast sales volume (historical performance, GDP, population, building stock forecasts)? Over what time period are you issuing forecasts (monthly, quarterly, yearly?)

f. How do you measure sales performance and determine whether you have had a bad year or a good year? What is the monthly/quarterly/annual target you use for a benchmark against which to measure your sales performance?

g. Do you supply any contractors that specialize in serving particular sectors of the market, such as the agriculture sector?
   i. [If yes to agriculture] My colleague is conducting research for BPA to better understand ways to support energy efficiency in the agriculture sector. If you could

provide some names of contractors who serve the agriculture market specifically, that would be very helpful.

HVAC Engineer Interview Guide

Contact Name:	
Title:	
Company Name:	
Company Phone:	
Company Address:	
Today's Date & Time:	
Attendees:	
Notes:	

Thank you for participating in this Survey of Northwest HVAC Engineering Firms!

I. **Introduction.**

About Us. *This interview is a critical component of a market research project aimed at learning how BPA can best deploy its resources to drive greater efficiency in the Northwest HVAC market. The insights you provide here into the design elements, market trends, market niches, product mix, customer segments, and the distribution chain will help share future program investment in the region.*

To quickly get on the same page, by "Northwest," we mean: WA, OR, ID, and MT.

a. ***About you.*** *It is important for us to understand the perspective you'll be providing today. As we understand it, HVAC engineering firms like yours design specialized equipment or systems and services on custom or 'plan and spec' jobs.* Please provide an overview of your company's role in the Northwest HVAC market. Consider any market segments or niches you specialize in, differentiated services, or specific geographical areas where you have a relatively strong presence.
b. [If not clear from previous question] Please describe how your company fits into the HVAC equipment supply chain in the Northwest. We are particularly interested in any areas where your company is able to influence decision makers and/or the type and efficiency of the equipment that is sold.
c. What is your role in the company?
d. What is your company's service territory?

II. Design Process and Market Actors

a. Please walk us through the most typical sales or bidding process for a plan and spec type project (from the identification of the need for the equipment to its installation)? Who calls whom? How does the process unfold? [Consider how the need is recognized, who makes the purchase decision, who influences it, etc.]
b. Who is your company's "typical" customer or client when it comes to a custom HVAC spec job?
c. Do your typical clients tend to be the decision-makers at the building site, or do you typically work with someone who has been given a specific budget or design requirement to work with?

d. We would like to understand the types of design requirements or boundaries that your company is tasked to work with for a given plan and spec project. Please list and describe some of the key parameters that affect the equipment design that you submit during a bidding process. Examples may include: building specs or HVAC load, fixed cost, client's operating budget (i.e. energy costs), a well-defined payback period, efficiency criteria, etc.
e. During the bidding process for a plan and spec project, do your clients ever include efficiency criteria in their design requirements or do they rely on the engineering firm to select an appropriate efficiency?
f. How do the design engineers at your company stay informed about the latest options and technology with regards to energy efficient HVAC equipment?
g. Do you often present multiple options to your clients, such as systems with different efficiencies, or is it generally a single option for a given bid?
h. Is there much opportunity to influence a change in the spec'd equipment? For example, does your company attempt to upsell or encourage the customer to opt for a more efficient HVAC system?
i. When do you have the greatest opportunity to influence what your customer purchases and how can you influence it?
j. Is there anything BPA could do in order to support or enhance your ability to implement higher efficiency systems into the market?
k. In your opinion, do your clients typically have an understanding of how a more efficient HVAC system may save money in the long-run, or are they more focused on the upfront cost of the system?

III. Programmatic and Non-Programmatic Activity

a. The next few questions relate to utility energy efficiency programs. Although your company may not be directly involved with utility energy efficiency programs, it is possible that the equipment you design may be incentivized through some of these programs, so we would like your perspective.
   i. If yes:
      1. Can you describe what role, if any, utility energy efficiency programs play in your company's business?
      2. What could these programs do better? What is the biggest headache associated with these programs?
      3. Is there something these programs should do, but do not, to help drive sales of energy efficient equipment?
      4. Are there any specific efficient HVAC products not currently incentivized by utility programs that you would like to see incentivized?
b. What are some common reasons why customers might purchase high-efficiency products (other than utility incentives)?

IV. Sales Trends

a. How has the market changed over the last 5 years? Do you expect these trends to continue and do you see any others developing?
b. Please estimate the breakout of your design projects by reason for purchase.

Purchase Driver	% Sales Share	
	Small Commercial (<20tons)	Large Commercial
Replacement (due to unit or system failure)		

Early Retirement/Retrofit		
New Construction		
Total	**100%**	**100%**

c. If I defined “standard efficiency” HVAC equipment to mean that the efficiency rating just meets building code levels and “high efficiency” HVAC equipment to mean exceeding the building code efficiency requirements, what percentage of the equipment your company designs for the plan and spec market falls into each of the following:

	Small Commercial	Large Commercial
Standard Efficiency		
High Efficiency		
Total	**100%**	**100%**

d. To your knowledge, does any of your “commercial” equipment end up at multi-family residential housing complexes? If so, approximately what percentage?
e. What are the fastest growing product categories for your business?
f. Who are your main competitors?
g. Do you serve customers or clients in the agriculture sector?
    i. [If yes to agriculture] My colleague is conducting research for BPA to better understand ways to support energy efficiency in the agriculture sector. If you could provide some names of contractors you work with who serve the agriculture market specifically, that would be very helpful.

Northwest HVAC Contractor Interview Guide

Contact Name:	
Title:	
Company Name:	
Company Phone:	
Company Address:	
Today's Date & Time:	
Attendees:	
Notes:	

Thank you for participating in our HVAC market research effort!

I. **Introduction.**

About Us. *This interview is a critical component of a market research project aimed at learning how BPA can best deploy its resources to drive greater efficiency in the Northwest HVAC market. The insights you provide here into HVAC market trends, market niches, product mix, customer segments, and the distribution chain will help share future program investment in the region.*

To quickly get on the same page, by "Northwest," we mean: WA, OR, ID, and MT.

About you. *We understand large contractors may have highly variable service territories with regards to HVAC services, and may have parent companies or subsidiaries with various internal divisions, so it is important for us to understand the perspective you'll be providing today.*

a. What is your role within your company?
b. Please provide an overview of your company's role in the Northwest HVAC market. Consider any market segments or niches you specialize in, or specific geographical areas where you have a relatively strong presence.
c. How would you describe the goals of your company with regards to HVAC services? Is the focus more on sales, installation services, maintenance, etc.?
d. How would you describe your company's target customer?
e. How does your company build and maintain long-term relationships with customers?

II. Programmatic and Non-Programmatic Activity

a. Does your company participate in any HVAC utility energy efficiency programs in the Northwest?
    i. If yes:
        1. Which one(s)?
        2. How does participating in these utility HVAC programs impact your business? How so?
        3. What could these programs do better? What is the biggest headache associated with these programs?

4. Is there something these programs should do, but do not, to help drive sales of energy efficient equipment?

b. What percentage of your above-minimum efficiency HVAC equipment sales would you estimate do *not* go through utility incentive programs?
    i. Has that share changes in recent years?

c. Are there any specific HVAC product categories for which efficient products commonly do NOT go through programs?

d. If not because of utility incentives, why do your customers purchase above-minimum HVAC equipment product sales?

e. Are there any specific efficient HVAC products not currently incentivized by utility programs that you would like to see incentivized?

f. What, other than the provision of rebates, could BPA do to help you sell more efficient products?

III. Decision Making and Market Actors

a. Please walk us through the most typical HVAC sales process (from the identification of the need for the equipment to its installation)? Who calls who? How does the process unfold? [Consider how the need is recognized, who makes the purchase decision, who influences it, etc.]
    i. Lite commercial units.
    ii. Large commercial units.

b. [If not addressed above] How does your company typically generate leads for HVAC service or sales?

c. Does your business focus on "plan and spec" HVAC projects whereby a bidding process is used to meet specifications outlined by the customer or do you focus more on "design build" projects where your company plays a larger role in the decision making process for equipment?

d. As a contractor, who is your primary point of interaction regarding HVAC projects? Examples include: property owners/managers, energy manager, facilities personnel, plan and spec engineers, etc.

e. What are some driving factors for a customer to decide whether it is worth repairing existing HVAC equipment or replacing equipment altogether?

f. What types of data or HVAC equipment characteristics does your company use to encourage a customer to upgrade or replace their HVAC equipment? For example, do you provide customers with failure or pre-failure information to help drive decisions? If so, can you provide some examples?

g. How much influence do you have over what customers choose to buy? When do you have the greatest opportunity to influence what they buy and how can you influence it?

h. In what ways, if any, do you "upsell" or encourage customers to purchase higher efficiency equipment rather than standard efficiency?

i. In what ways, if any, do customers push back against purchasing higher efficiency equipment? Can you give examples of their reasons for pushing back?

j. Does your company offer services to monitor energy use before and after an HVAC upgrade?
    i. If yes: How do customers respond to energy monitoring?
    ii. If no: Do customers ask for this service?

k. Are most of your commercial projects driven by capital budget decisions, or do operating budgets and energy savings drive equipment upgrades?

l. What percentage of your units or equipment do you purchase from the following sources:
    1. Distributors:
    2. Manufacturers:
    3. Other (please specify):

m. Does your company serve the agricultural sector or does there tend to be separate contractors that specifically serve the agricultural sectors?

1. [If Yes] My colleague is conducting research for BPA to better understand ways to support energy efficiency in the agricultural sector. Would it be possible for her to contact you or can you provide me with the name of someone at your company that she may be able to contact?

IV. Equipment Sales Trends

a. How has the HVAC market changed over the last 5 years? Do you expect these trends to continue and do you see any others developing?
b. Please estimate the breakout of your HVAC equipment installations by reason for purchase.

Purchase Driver	% Share of Units	
	Light Commercial	Large Commercial
Replacement		
Early Retirement/Retrofit		
New Construction		
Total	**100%**	**100%**

c. To your knowledge, does any of your “commercial” equipment end up at multi-family residential housing complexes? If so, approximately what percentage?
d. What macro factors correlate most directly with your overall sales activity? (GDP growth, housing starts, consumer sentiment, etc.)
e. What are the fastest growing HVAC product categories in the market your experience?

Commercial Sales Offices and Manufacturer Representative Interview Guide

Contact Name:	
Title:	
Company Name:	
Company Phone:	
Company Address:	
Today's Date & Time:	
Attendees:	
Notes:	

Thank you for participating in this Inaugural Survey of Northwest HVAC Distributors, Commercial Sales Offices, and/or Manufacturer Representative firms!

V. **Introduction.**

About Us. *This interview is a critical component of a market research project aimed at learning how BPA can best deploy its resources to drive greater efficiency in the Northwest HVAC market. The insights you provide here into market trends, market niches, product mix, customer segments, and the distribution chain will help share future program investment in the region.*

To quickly get on the same page, by "Northwest," we mean: WA, OR, ID, and MT.

a. ***About you.*** *It is important for us to understand the perspective you'll be providing today. As we understand it, CSO's have well-defined territories and primarily sell large, specialized equipment and services on custom or 'plan and spec' jobs.* Please provide an overview of your company's role in the Northwest HVAC market. Consider any market segments or niches you specialize in, differentiated services, or specific geographical areas where you have a relatively strong presence.
b. [If not clear from previous question] Please describe how your company fits into the HVAC equipment supply chain in the Northwest. We are particularly interested in any areas where your company is able to influence decision makers and/or the type and efficiency of the equipment that is sold.
c. What is your role in the company?
d. What is your company's service territory?
e. Within the Northwest, do you think there are geographic differences in the accessibility of energy efficient HVAC options? For example, do consumers in both the residential and commercial sectors have the same choices with regards to efficiency by virtue of their location, or are they limited?
   If Yes:
   i. What specific areas do you think have better access to high efficiency options and why?
   ii. Which areas have worse access and why?

VI. Programmatic and Non-Programmatic Activity

a. The next few questions relate to utility energy efficiency programs. Although your company may not be directly involved with utility energy efficiency programs, it is possible that the equipment you sell may be incentivized through some of these programs, so we would like your perspective.
    i. If yes:
        1. Can you describe what role, if any, utility energy efficiency programs play in your company's business?
        2. What could these programs do better? What is the biggest headache associated with these programs?
        3. Is there something these programs should do, but do not, to help drive sales of energy efficient equipment?
        4. Are there any specific efficient HVAC products not currently incentivized by utility programs that you would like to see incentivized?

b. What are some common reasons why customers might purchase high-efficiency products (other than utility incentives)?

VII. Distribution Chain and Market Actors

a. What percentage of your equipment sales are shipped directly from the factory to the job site? What percentage do you hold in inventory? What percentage is shipped through a wholesale distributor?

b. Please walk us through the most typical sales process (from the identification of the need for the equipment to its installation)? Who calls who? How does the process unfold? [Consider how the need is recognized, who makes the purchase decision, who influences it, etc.]

c. Is there typically a bidding process involved with the projects that your company sells?
    i. If yes, what are the key factors that lead to winning the bid?
    ii. If yes, approximately what share of your equipment sales occur through a bidding process?
    iii. Is there much opportunity to influence a change in the spec'd equipment? For example, does your company attempt to upsell or encourage the customer to opt for a more efficient HVAC system?

d. Do you purchase any equipment from parties other than manufacturers? (I.e., other larger distributors, etc.) If yes, what percentage of your unit purchases do ***not*** come directly from a manufacturer?

e. When do you have the greatest opportunity to influence what your customer purchases and how can you influence it?

VIII. Sales Trends

a. How has the market changed over the last 5 years? Do you expect these trends to continue and do you see any others developing?

b. Please estimate the breakout of your sales by reason for purchase.

Purchase Driver	% Sales Share
	Large Commercial
Replacement (due to unit or system failure)	
Early Retirement/Retrofit	
New Construction	
Total	**100%**

c. To your knowledge, does any of your “commercial” equipment end up at multi-family residential housing complexes? If so, approximately what percentage?
d. What macro factors correlate most directly with your overall sales volumes? (GDP growth, housing starts, consumer sentiment, credit markets, etc.)
e. What are the fastest growing product categories for your business?
f. How do you set sales targets and forecast sales volume (historical performance, GDP, population, building stock forecasts)? Over what time period are you issuing forecasts (monthly, quarterly, yearly?)
g. How do you measure sales performance and determine whether you have had a bad year or a good year? What is the monthly/quarterly/annual target you use for a benchmark against which to measure your sales performance?
h. Do you supply any distributors that specialize in serving particular sectors of the market, such as the agriculture sector?
i. [If yes to agriculture] My colleague is conducting research for BPA to better understand ways to support energy efficiency in the agriculture sector. If you could provide some names of contractors who serve the agriculture market specifically, that would be very helpful.

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