BONNEVILLE POWER ADMINISTRATION

Northwest HVAC Sales & Trends 2016 – 2021

Executive Summary

January 2023

Report Overview

This report presents BPA's analysis of Northwest heating, ventilation, and air conditioning (HVAC) supplier sales data for 2016–2021. Included is a description of the sales data's coverage of the total Northwest HVAC market and analysis results including the annual efficiency mix estimates for residential heating and cooling equipment sold in the Northwest region. The sales data represent submittals from 14 suppliers to the Northwest Energy Efficiency Alliance (NEEA) and their contractor, D+R International (D+R).[1]

The Bonneville Power Administration (BPA) and NEEA conduct this sales data collection effort to obtain robust information on the regional HVAC market by leveraging NEEA and D+R's existing relationships with regional HVAC suppliers. This effort has been ongoing for five years. NEEA and D+R augment the data by matching equipment model numbers to equipment efficiency attributes from the Air-Conditioning, Heating, and Refrigeration Institute certification database.

The resulting analyses provide regional efficiency mix information for major residential heating and cooling equipment, help the region understand year-over-year trends in sales volume for different technologies, and inform standard practice baselines. BPA uses the analysis results to inform market modeling efforts, specifically to estimate efficiency levels and annual sales growth rates for residential HVAC technologies installed in Northwest homes. This marks the second year of tracking and reporting variable-speed heat pump (VSHP) sales. The data set provides limited regional insights into commercial HVAC sales.

Finally, to understand HVAC sales as comprehensively as possible, BPA and Cadeo (the research team) also analyzed room air conditioner sales data obtained from NEEA's retail product portfolio (RPP).

Data Sources

- HVAC sales data spanning six years from a subset of Northwest HVAC suppliers, collected by NEEA.
- Regional HVAC sales data from the Heating, Air Conditioning and Refrigeration Distributors International (HARDI), accessed through NEEA's subscription.
- Interviews conducted in 2021 with 27 Northwest HVAC market participants and observers.[2]
- Room air conditioner sales from NEEA's RPP that collects data directly from retailers.
- Equipment sales estimates from BPA's 2016 – 2021 Residential HVAC Market Model.[3]

[1] In total, D+R collected data from 15 suppliers, but one supplier did not provide sufficient data to properly characterize equipment sales or efficiency.
[2] Cadeo Group, "2020–2021 HVAC Market Research Interview Summary," July 2021, https://www.bpa.gov/-/media/Aep/energy-efficiency/momentum-savings/bpa-hvac-market-actors-interview-findings-2020-2021.pdf.
[3] BPA (Bonneville Power Administration), "Residential HVAC Northwest Market Model," August 2022, https://www.bpa.gov/-/media/Aep/energy-efficiency/momentum-savings/2016-2021-res-hvac-market-model-report.pdf.

Market Coverage of Supplier Sales

From this latest round of data collection, NEEA received sales data from 14 suppliers, an increase of three from the previous round. These suppliers include all the known residential suppliers and most of the companies that handle both residential and light commercial equipment.[4] This section provides a qualitative description of the sales data's coverage of the total Northwest HVAC market. BPA's residential market model identifies four key technologies in homes: central air conditioners, gas furnaces, air source heat pumps, and ductless heat pumps. This section discusses coverage of these four residential technologies in detail.

TABLE 01

Participating and Known HVAC Suppliers in the Northwest

Market	Known Suppliers	Participating Suppliers	Increase in Participating Suppliers from Last Round
Residential	3	3	▲ 2
Commercial	8	0	0
Residential and Commercial	20	11	▲ 1
Total	**31**	**14**	**▲ 3**

Sector Coverage

The data set represents a mix of regional and national suppliers including those that serve both the residential and light commercial sector. Table 1 shows that NEEA recruited two additional residential suppliers this round, covering all known residential-only suppliers. Commercial-sized equipment accounts for roughly 3% of the reported sales in this data set and is likely a small portion of the overall commercial HVAC market. NEEA plans to continue reaching out to commercial suppliers to increase knowledge about this sector.

Geographic Coverage

Participating suppliers sell equipment into each state in the region. There are at least four reporting suppliers who sell the key residential HVAC technologies in each state. There is an underrepresentation of Idaho in the reported sales. The research team explains how they fill this gap with data from HARDI in the appended Data Analysis Memo.

Manufacturer Coverage

D+R identified the highest-sales manufacturers by analyzing HARDI data and verified that the top residential manufacturers appeared in the reported sales data.

[4] Three-phase HVAC equipment under 25 tons is generally considered light commercial equipment. To separate light commercial from residential, the research team identified sales as light commercial if the manufacturer rated the cooling capacity at over 60,000 British thermal units per hour (the equivalent of 5 tons).

Technology Coverage

Participating suppliers do not represent all sales in the region. BPA's Residential HVAC Market model produces technology-specific product flow estimates for the main residential technologies using a stock turnover model and various data sources.[5] Figure 1 shows a comparison of sales represented by participating suppliers versus estimated total sales calculated by the market model.

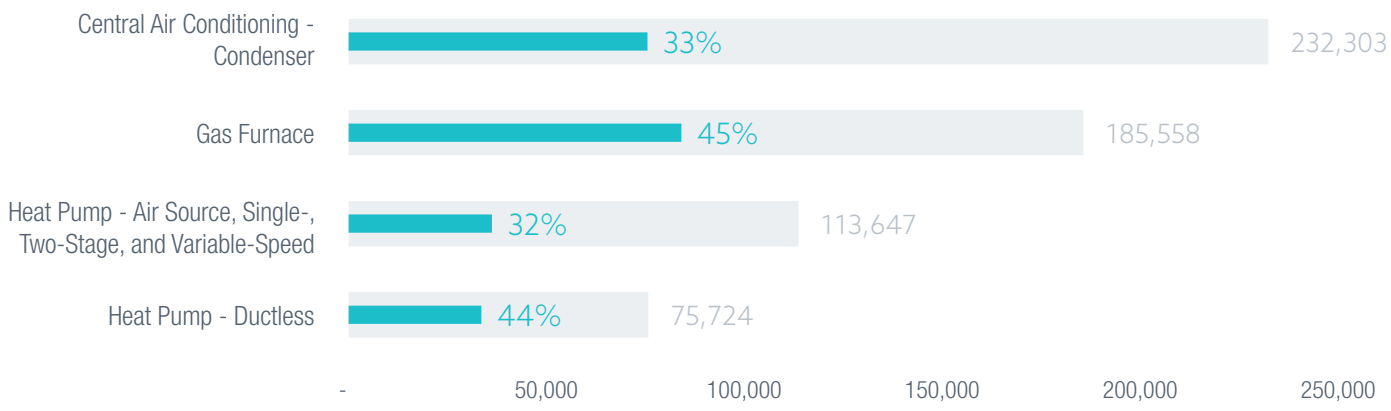
Out of the four key technologies, ductless heat pumps have the best coverage, with nearly all suppliers reporting sales for that technology and the highest number of reporting suppliers for each state. Reported ductless heat pump sales represent approximately 44% of the overall Northwest market, likely the result of NEEA's long-standing engagement with ductless heat pump suppliers.

Gas furnaces are similarly well-represented at approximately 45% of the overall Northwest market. Reported sales for air-source heat pumps (ASHPs) and central air conditioning (CAC) systems represent between 32% and 33%, respectively, of the overall Northwest market.

NEEA and D+R have successfully increased representation: the reported sales include 32% to 45% of estimated total residential sales for each of the four main residential technologies. Reported sales for the previous round accounted for roughly 25% to 45% of total sales.

FIGURE 01

Reported Residential Sales as a Percentage of Total Estimated Residential Sales (2021)[6]



Market Channel Coverage

The data set does not include big-box retail and online sales. This exclusion could be a gap, particularly for ductless heat pumps. Market actors interviewed in 2021 indicated that installers and homeowners could increasingly be turning to retail and online sales channels for these units over traditional HVAC suppliers. In addition, some interviewees estimated online ductless heat pump sales as "low," while others estimated online sales at between 10% and 20% of the overall sales. NEEA continues to investigate this potential gap in retail sales and explore ways to gain visibility into retail HVAC trends.

[5] BPA (Bonneville Power Administration), "Residential HVAC Northwest Market Model," August 2022, https://www.bpa.gov/-/media/Aep/energy-efficiency/momentum-savings/2016-2021-res-hvac-market-model-report.pdf.

[6] The total estimated residential sales values from the BPA Residential HVAC Market Model only include DHP units serving as primary heating systems, while the collected sales data does not differentiate and therefore likely includes DHPs serving as both primary and secondary heating systems. For a more accurate comparison, the estimated DHP sales value used in Figure 1 was scaled up from the market model value based on an estimate that 20% of all DHP sales are serving secondary systems. This estimate was based on analysis of the 2016 Residential Building Stock Assessment (RBSA) published by the Northwest Energy Efficiency Alliance (NEEA). https://neea.org/resources/rbsa-ii-combined-database.

Reported Sales Data

The sales data presented in **Table 2** are supplier-reported sales data, extrapolated to fill temporal and geographic gaps. For a more in-depth discussion of analysis and extrapolation processes, please see the Data Analysis Memo appended to this document. The region can use the data presented in this table to review the total volumes of reported sales by technology and to assess the year-over-year change in reported sales volumes. This table is not an indication of total market sales. The previously referenced BPA residential market model estimates total market sales. The research team identified all units though the outdoor model numbers provided by suppliers.

COVID Impacts on Sales

Total residential sales are continuing to trend upward during the years impacted by COVID. Anecdotally, based on NEEA conversations with suppliers and manufacturers, supply chain issues may influence the product efficiency mix being sold in the region. Though knowing what sales would have been like without COVID is impossible, the efficiency trends generally followed previous years' tendencies of efficiency gains.

TABLE 02

Extrapolated Sales Volume[7] by Technology

Technology	Sector	2016	2017	2018	2019	2020	2021
Central Air Conditioning (CAC) – Condenser	R	32,093	39,920	48,897	56,666	62,450	75,499
Gas Furnace	R	46,719	54,997	60,099	63,744	71,803	84,056
Heat Pump – Air Source, Single- and Two-Stage	R	19,091	21,614	22,107	24,261	25,668	27,686
Heat Pump – Air Source, Variable-Speed	R	1,556	3,270	3,170	3,337	4,948	8,576
Heat Pump – Air Source, Variable-speed	C	100	182	199	213	NA	NA
Heat Pump – Single Packaged	R	548	658	796	758	684	565
Heat Pump – Ductless	R	18,717	23,356	26,294	24,724	31,148	33,599
Variable-Speed Mini-Split and Multi-Split Air Conditioning	R	1,203	1,279	970	1,131	1,132	1,170
Gas Packaged Unit	C	1,957	2,386	2,920	2,764	2,558	2,410
CAC – Single Packaged	R	NA	NA	170	147	211	201
Heat Pump – Packaged Terminal	C	NA	669	1,290	1,303	NA	393
CAC – Packaged Terminal	C	NA	142	245	NA	NA	NA
Variable Refrigerant Flow	C	NA	NA	170	137	NA	264
Unitary Large Equipment	C	886	1,086	2,016	2,095	1,921	1,658

[7] Extrapolated sales do not represent all sales into the region. Supplier-reported sales are corrected to fill temporal gaps in reporting and geographic gaps in suppliers. See the Data Analysis Memo for an explanation of the extrapolation process.

Residential Insights

- ASHP
- DHP
- Gas Furnace
- CAC
- Room AC
- 2023 Standards

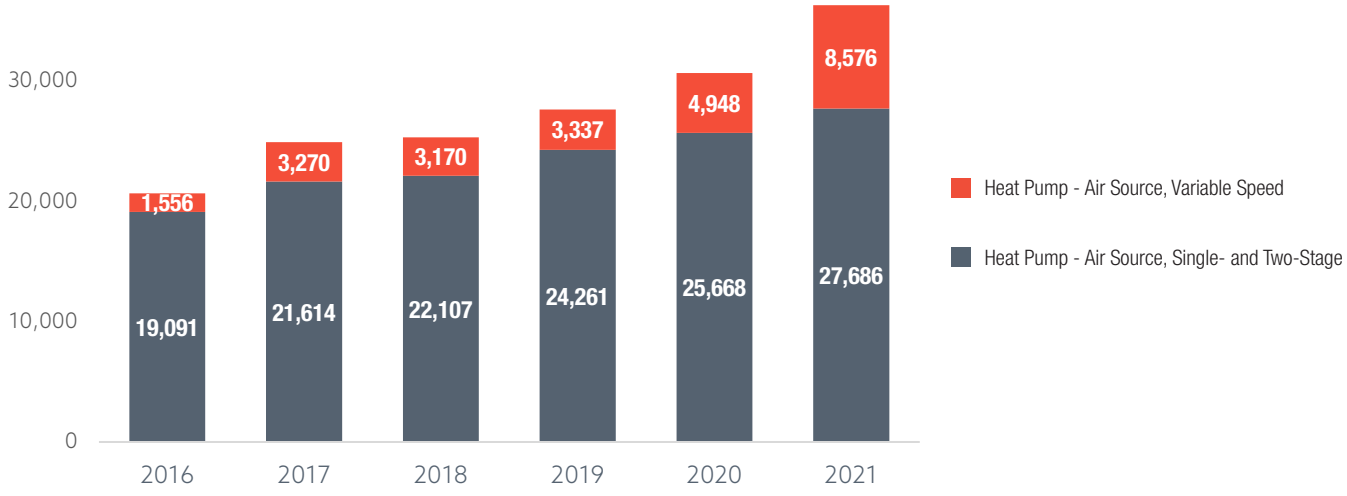
This section reviews insights specific to five technologies. The ASHP section starts with general trends across single-stage, two-stage and variable speed ASHPs and then discusses variable-speed ASHPs specifically. The discussion then moves to ductless heat pumps (DHPs), followed by insights regarding gas furnaces, CAC systems, and room air conditioners (ACs). The final section gives an overview of 2023 standards updates.

ASHPs Single-Stage, Two-Stage, and Variable-Speed

ASHPs are an important technology for energy efficiency efforts because they can provide high efficiency electric heating along with centralized cooling. Reported sales of ASHPs increased significantly in 2021 (18%). Although there were moderate increases in the sales of single- and two-stage units, the big bump of increased sales comes from VSHPs. VSHP sales rose 73% in 2021—a large bump in growth rate over the previous two years. **Figure 2** shows the annual extrapolated sales volumes for ASHPs.

ASHPs show a moderate but steady increase in efficiency. The lowest heating seasonal performance factor (HSPF) tiers are sold less and less while the VSHP portion has grown significantly. Although VSHP units have a range of HSPF values, modeling shows that VSHPs consume less energy than the highest HSPF tier of single and two-stage ASHPs.[8] Similarly, the cooling efficiency of ASHPs is on an upward trend, with VSHPs replacing lower seasonal energy efficiency ratio (SEER) units. **Figures 3 & 4** show the results for ASHP heating and cooling efficiency mixes. The Federal standards are rising in January 2023, and so the lowest performers for both heating and cooling will be eliminated. See the Updated Standards in 2023 section for more information about these changes.

FIGURE 02 Extrapolated Sales Volumes - ASHPs



[8] BPA (Bonneville Power Administration), "Residential HVAC Northwest Market Model," August 2022, https://www.bpa.gov/-/media/Aep/energy-efficiency/momentum-savings/2016-2021-res-hvac-market-model-report.pdf.

FIGURE 03

ASHP Cooling Efficiency Mix

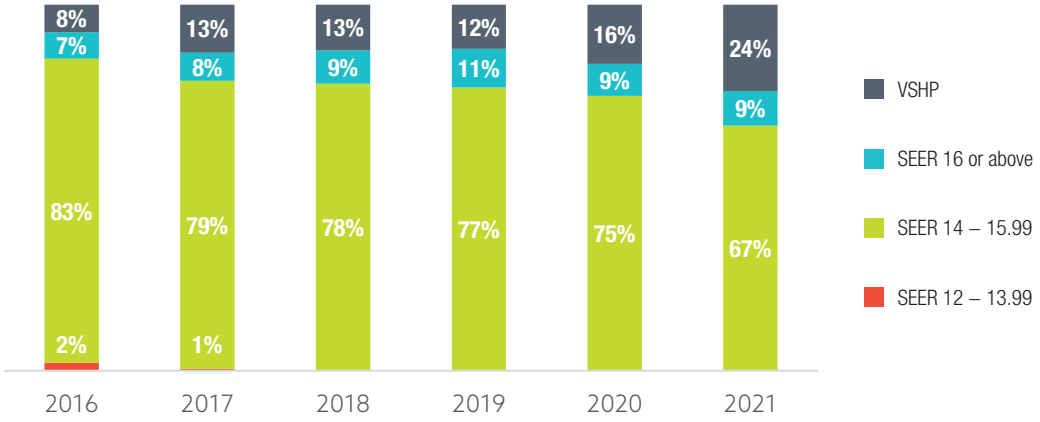
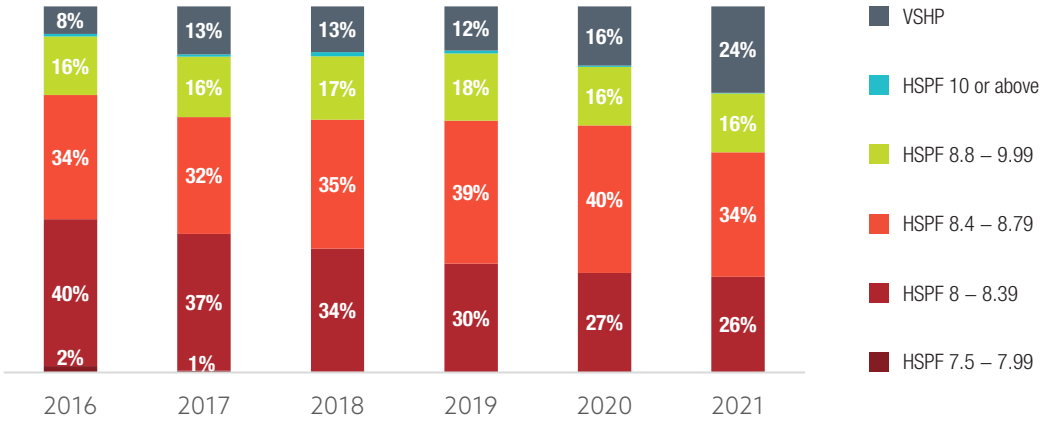


FIGURE 04

ASHP Heating Efficiency Mix



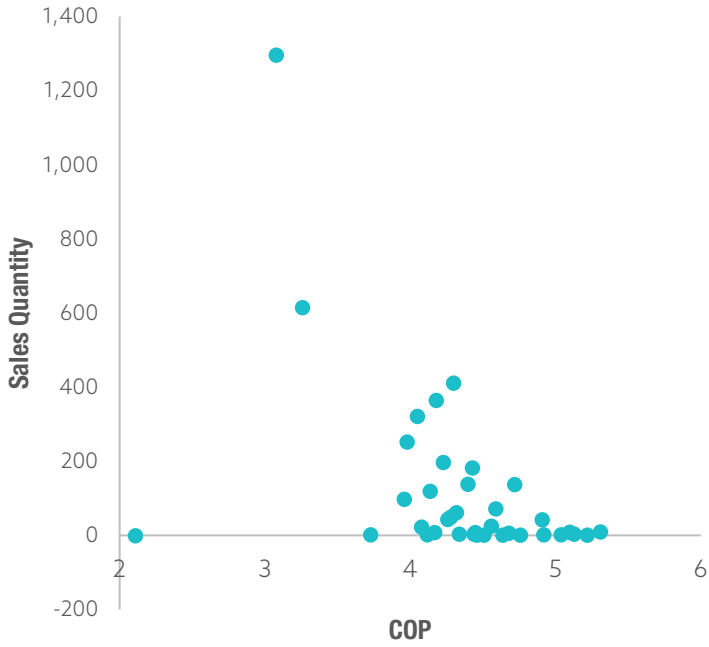
VSHPs

VSHPs are ASHPs with a variable-speed compressor. The inverter-driven compressor allows the heat pump to vary its capacity, typically making VSHPs more efficient than single- and two-stage ASHPs. VSHP sales jumped significantly in 2021. This technology now represents 24% of ASHP sales in the region.

Identifying VSHP in the Sales Data

The research team identified VSHP sales by referencing model numbers in reference lists for cold climate heat pumps from BPA,[9] the Energy Trust of Oregon,[10] and the Northeast Energy Efficiency Partnerships.[11] The research team also identified units through text searches of ASHP model descriptions (e.g., "VSP" or "VAR") and verified against model information.

FIGURE 05 VSHP COP at minimum capacity at 47°



NEEA research has shown that the coefficient of performance (COP) at low load is an important factor in determining life cycle costs for VSHPs.[12] **Figure 5** shows that many units sold in 2021 have a COP at 47 degrees Fahrenheit (°F) greater than 4.0, but a few models in the 3–3.25 range have high volume sales that bring down the weighted market average to 3.8.[13]

DHPs

DHPs, or mini-splits, use the same variable-speed compressor technology as VSHPs. DHPs, however, do not distribute air through ductwork. Distributors can sell DHPs with one or more indoor units. Each indoor unit ("head") contains a variable-speed fan that blows air directly into the conditioned room. The research team broke out DHPs from ASHPs because they are often used in different, typically smaller, applications.

DHP efficiency is following the trends of other heat pumps: higher efficiency units are replacing the lowest tiers. **Figure 6** shows the heating efficiency mix results for DHPs. Very few sales (below 2%) were in the lowest tier, while units in the HSPF 9 to 11 range continued to make up a bigger share of the market. Although DHP sales have increased significantly (81%) since 2016, their growth rate shifts year to year. In 2021, DHP sales increased by 8%. **Figure 7** shows the annual extrapolated sales volumes for DHPs.

[9] BPA, "DUCTED Inverter Driven Variable Speed Heat Pump (VSHP) Reference List," https://www.bpa.gov/-/media/Aep/energy-efficiency/residential/residential-ptcs-essentials/Ducted-Variable-Speed-Heat-Pump-Reference-List.xlsx; version dated 5/9/22.
[10] Energy Trust of Oregon, "Qualifying Extended Capacity Heat Pumps," October 1, 2022, https://www.energytrust.org/wp-content/uploads/2020/05/ECHP-QPL.pdf.
[11] NEEP (Northeast Energy Efficiency Partnerships), "NEEP's Cold Climate Air Source Heat Pump List," https://neep.org/heating-electrification/ccashp-specification-product-list; accessed through NEEA's subscription. Dated 8/16/22.
[12] NEEA (Northwest Energy Efficiency Alliance), "Variable Speed Heat Pump Product Assessment and Analysis," https://neea.org/resources/variable-speed-heat-pump-product-assessment-and-analysis.
[13] The research team was only able to identify COP values for approximately 52% of all VSHP sales.

DHPs

FIGURE 06

DHP Heating Efficiency Mix

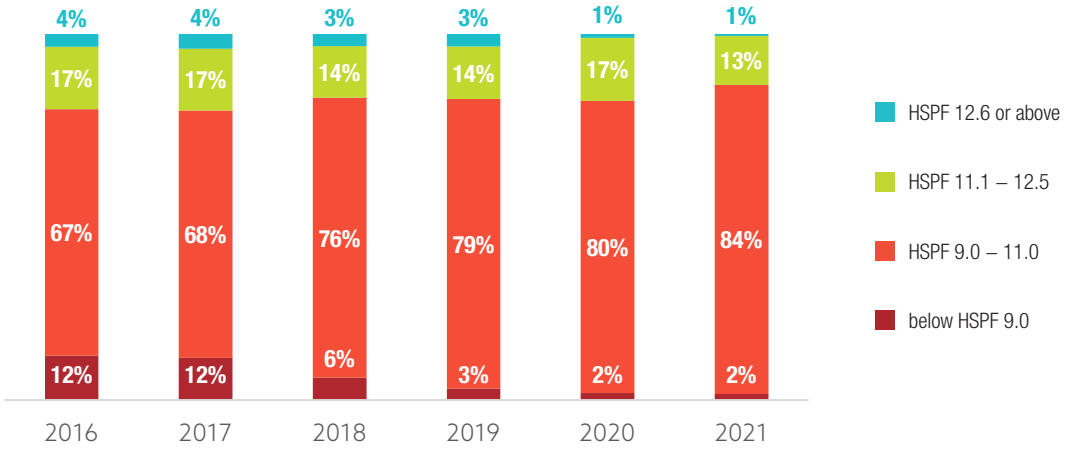
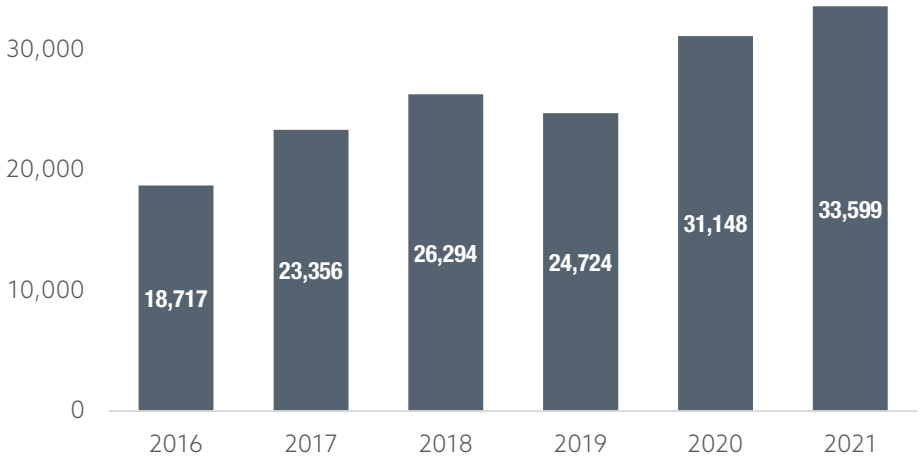


FIGURE 07

Extrapolated Sales Volumes - DHPs



Market actors interviewed in 2021 mentioned an increasing interest in mixing and matching equipment to meet specific home needs. Some homeowners pair DHPs with multiple indoor units. Contractors might also create "ducted DHPs" by pairing outdoor DHP units with indoor furnaces or use concealed heads and short lengths of duct to provide heat to several rooms. The team identified ducted DHP sales through internet searches of indoor model numbers. Using this subset of indoor model numbers and assuming that ducted DHPs are unlikely to be paired with more than one concealed head, ducted DHP sales appear to be at least 8% of DHPs in 2021.[14]

[14] The sales data include DHP outdoor and indoor units; however, outdoor and indoor unit sales are not linked to one another.

Gas Furnace

Gas furnace sales continue to hold a constant portion of just under 37% of the reported sales of key residential heating technologies (gas furnaces, ASHPs, VSHPs, and DHPs). The mid-tier gas furnace efficiency has virtually disappeared, with most sales above 95% annual fuel utilization efficiency (AFUE) and nearly one-third consistently below 90% AFUE. **Figure 8** shows the heating efficiency mix results and **Figure 9** shows the annual extrapolated sales volumes for gas furnaces.

FIGURE 08

Gas Furnace Heating Efficiency Mix

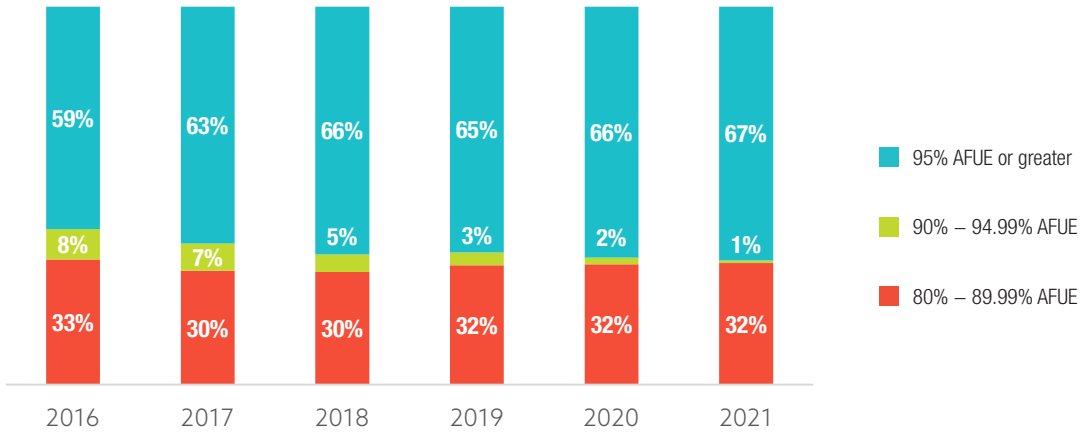
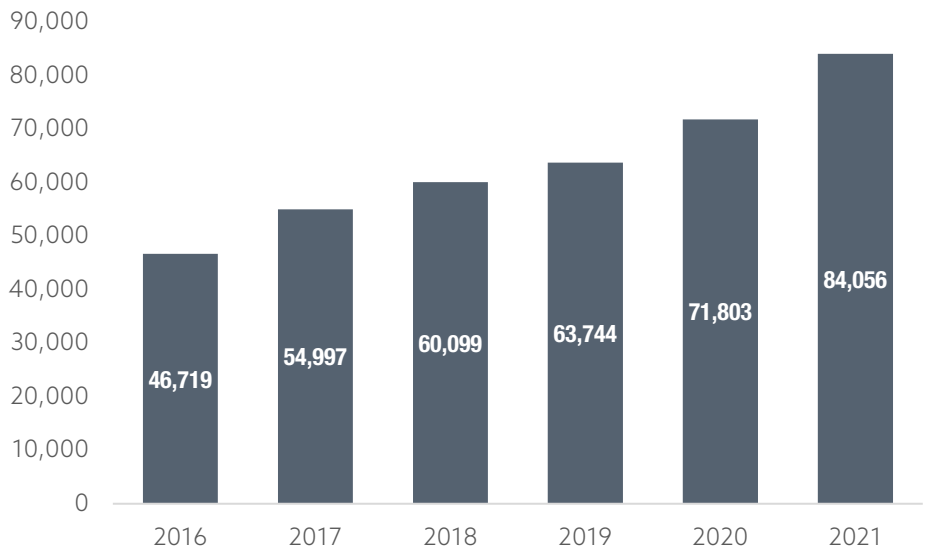


FIGURE 09

Extrapolated Sales Volumes – Gas Furnaces



CAC Systems

CAC systems provide cooled air to an entire building or home using the vapor compression refrigeration cycle to transfer heat energy from indoor spaces. CAC sales continue to increase at an approximate average of 20% year over year. **Figure 11** shows the annual extrapolated sales volumes for CACs. The most efficient unit sales are supplanting sales of the lowest efficiency units, as shown in **Figure 10.**

The team identified variable speed CAC units through model number searches and keywords. While sales have increased over the past few years, as of 2021, only a very small portion (under 2%) fit into the variable speed category.

FIGURE 10

CAC Efficiency Mix

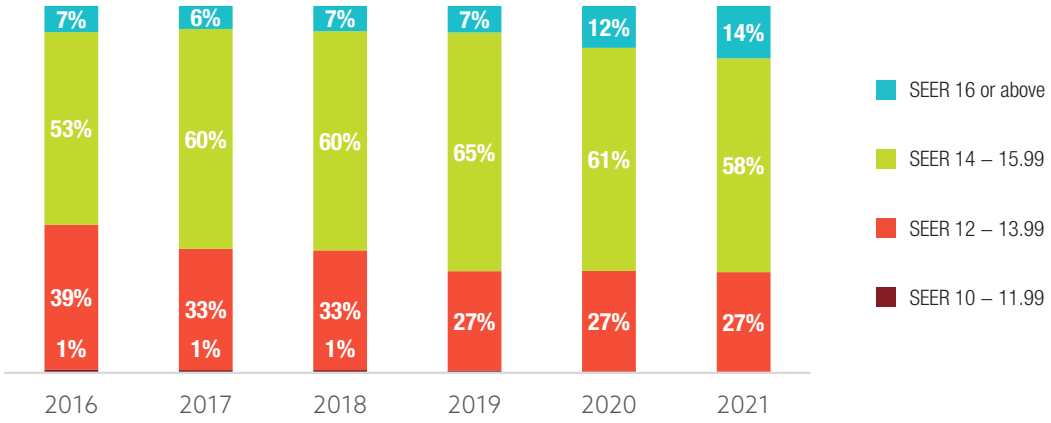
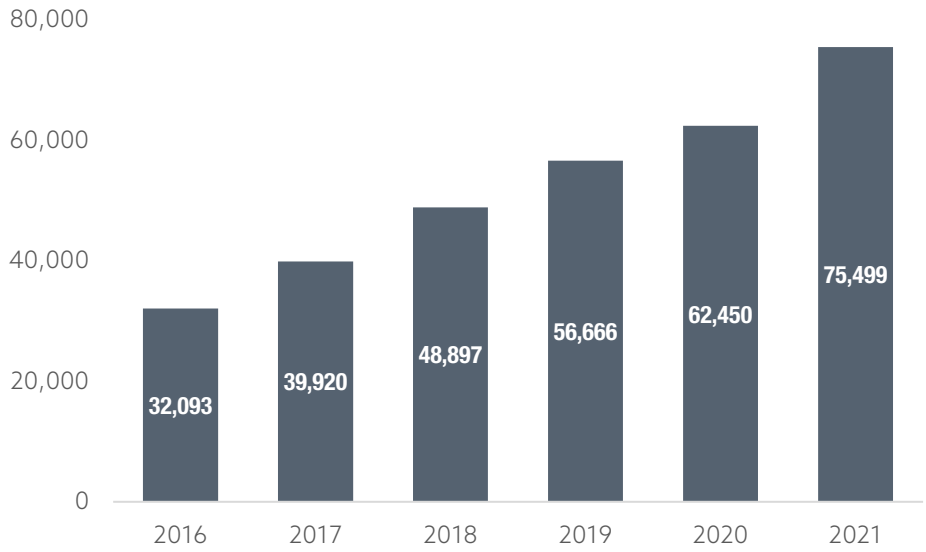


FIGURE 11

Extrapolated Sales Volumes – CAC

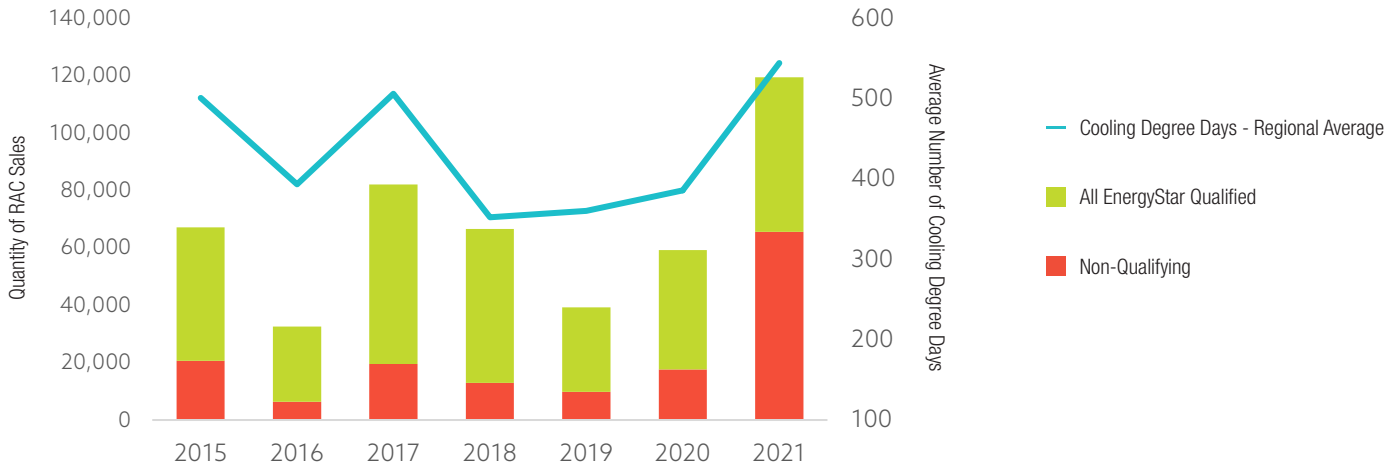


Room ACs

NEEA's retail product portfolio (RPP) works directly with corporate-level national retailers to provide mid-stream incentives on qualified energy-efficient products. In exchange for the incentives, retailers provide sales data for all products in the portfolio. One of the key products is room AC units that consumers place in windows and typically remove during winter months. NEEA estimates that the room AC units in the RPP sales data represent roughly half of the total Northwest room AC market.

Room AC sales can vary significantly but have increased year over year since 2018. **Figure 12** indicates that room AC sales typically correspond with the number of cooling degree days, a metric that shows how "hot" a particular year was. In 2021, the number of nonqualifying (lower efficient) units surpassed the ENERGY STAR®-qualified units for the first time in the previous six years. The research team theorizes that supply chain issues may have impacted the availability of higher efficient units.

FIGURE 12 Room Air Conditioner Sales - EnergyStar vs. Non-EnergyStar



Updated Standards in 2023

Starting January 1, 2023, suppliers of residential CACs and ASHPs will have to meet new standards, using the metrics of seasonal energy efficiency ratio 2 (SEER2) for cooling and heat seasonal performance factor 2 (HSPF2) for heating as shown in **Table 3**. The new rating procedure requires that manufacturers test units using a higher external static pressure than the previous test. The more difficult testing procedures result in values of SEER2 and HSPF2 that are lower than the previous SEER and HSPF values, so users should be careful not to compare the two.

TABLE 03

Current and Future CAC & ASHP Standards[15]

	Current Standards		Standards as of Jan.1, 2023 (using old metrics)		Standards as of Jan. 1, 2023 (using new metrics)	
Product Class	**SEER**	**HSPF**	**SEER**	**HSPF**	**SEER2**	**HSPF2**
Split-System Air Conditioners	13		14		13.4	
Split-System Heat Pumps	14	8.2	15	8.8	14.3	7.5

[15] Standards as of Jan. 1, 2023 (using old metrics) are from Table I-1 of 82 FR 1786 https://www.federalregister.gov/documents/2017/01/06/2016-29992/energy-conservation-program-energy-conservation-standards-for-residential-central-air-conditioners

Commercial Insights

The research team does not consider the supplier data representative of commercial sales. Commercial-sized equipment accounts for roughly 3% of the reported sales in this data set and is likely a small portion of the overall commercial HVAC market.

The suppliers who currently provide data through this project focus more on residential equipment, but some sell into the commercial market. Most commercial equipment flows through a different type of supplier, often called manufacturer representatives, who have strong ties with their equipment manufacturers. Manufacturer representatives typically have engineers on staff who provide detailed design and technical support. Recruitment of manufacturer representatives to provide sales data has been and will continue to be a priority for the data collection effort.

The only type of commercial equipment that is continuously represented in the sales data is designated as "unitary large equipment." Please see **Table 2** for annual sales volumes. Unitary large equipment refers to single packaged units that are often found on the roof of commercial buildings. Typically, they provide direct-expansion refrigerant cooling and heating through either gas or electric resistance. After model matching, the research team identifies units over 60,000 British thermal units per hour as commercial equipment.

BPA is working on a commercial HVAC market model that will help the region more fully understand the commercial market. BPA plans to publish results for this model in 2024.

Memorandum

To: Bonnie Watson and Joan Wang, Bonneville Power Administration

From: Elizabeth Daykin and Isaac Schultz, Cadeo

Date: January 6, 2022

Subject: 2016–2021 HVAC Supplier Data Analysis

Introduction and Context

This memorandum describes analysis conducted by the Bonneville Power Administration (BPA) and Cadeo (the research team) on full-category Northwest heating, ventilation, and air conditioning (HVAC) supplier sales data for 2016–2021. These supplier sales data are the result of an annual data collection project conducted by the Northwest Energy Efficiency Alliance (NEEA) and a contractor. This year, NEEA partnered with D+R International.[1] This memo includes the research team's assessment of gaps in the collected sales data and approach to developing estimates of annual efficiency mix and technology mix for four key residential heating and cooling technologies sold in the Northwest: central air conditioners, air-source heat pumps, gas furnaces, and ductless heat pumps.

BPA and NEEA initiated this sales data collection effort with the goal of obtaining regional full-category sales data for HVAC equipment by leveraging NEEA's existing relationships with regional HVAC suppliers. This effort has been ongoing for five years. In 2021, BPA used analysis results of data covering sales for 2016–2020 in BPA's Residential HVAC Market Model to estimate total market energy consumption and Momentum Savings from the adoption of efficient HVAC equipment for 2016–2021. This document presents analysis results of the fifth round of data collection, covering sales occurring during the years 2016–2021. There were several significant improvements to the data collection effort in this year's round of analysis; these improvements are highlighted in bold throughout the memo.

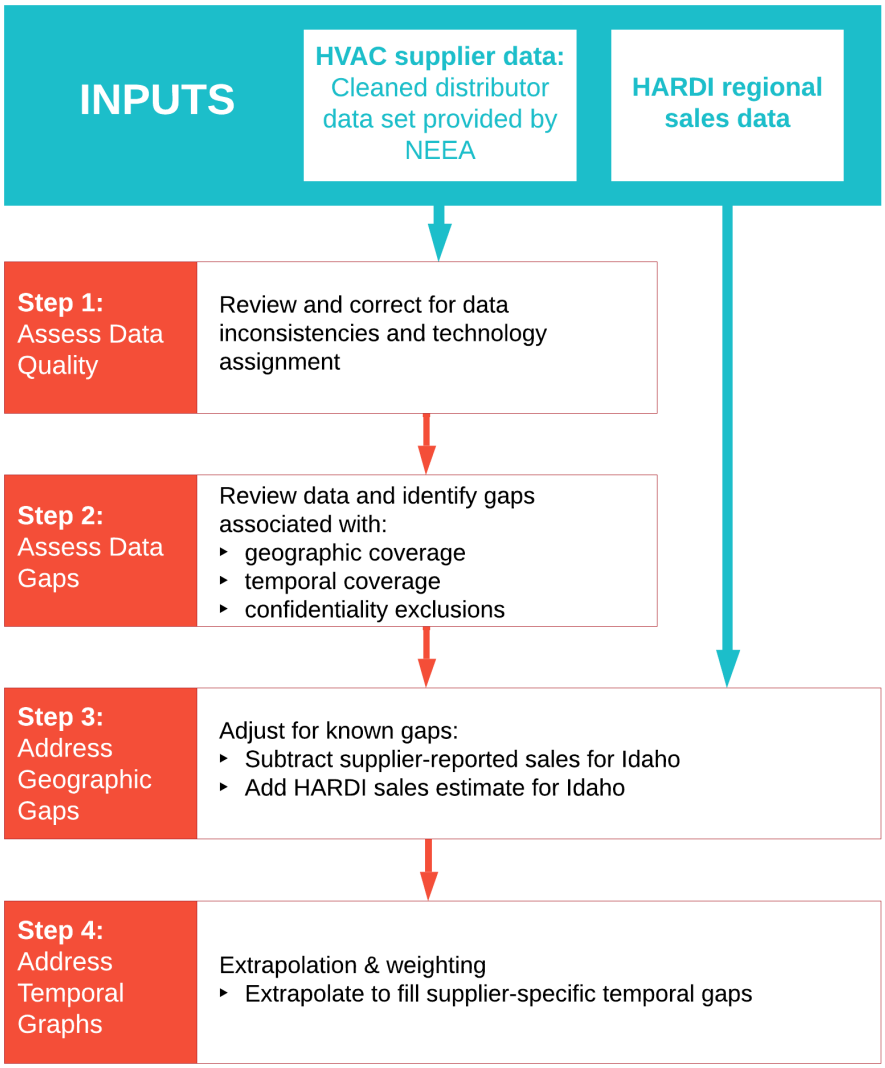
This memo begins with an overview of the analysis methodology followed by assessments of data quality and data gaps and the approaches used to address temporal and geographic gaps, and final results. Finally, the memo describes additional gaps and sources of uncertainty and recommendations for future rounds of analysis. A spreadsheet that contains the aggregated and anonymized results of the sales data analysis accompanies this memo.

[1] Details of NEEA's data collection or model matching are not part of this analysis and memo.

Overall Methodology

This section describes the methodological steps that the research team used to analyze NEEA's sales data. The analytical approach and methodology for this round largely follows the prior rounds of analysis completed for BPA. Figure 1 presents an overall map of the analytical steps undertaken in this round of analysis, each of which are detailed in this memo.

Figure 1: Analysis Process



As shown in Figure 1, the research team uses regional HVAC sales data from Heating, Air Conditioning and Refrigeration Suppliers International (HARDI), accessed through NEEA's subscription[2] to address known data gaps in the supplier data. HARDI data have sales by year, state, technology, and efficiency

[2] In this document the term HARDI refers to a data product that D+R International developed in partnership with HARDI. These data contain HVAC sales data for the Northwest region.

bin for key residential technologies, but at a much lower level of detail than that provided by the NEEA supplier data.

The resulting data set provides total reported volumes of sales by technology and year from participating suppliers which is then extrapolated. These data are useful for assessing year-over-year changes in sales volumes within a given technology. On their own, however, these data are not a complete view of the overall residential HVAC market, subregions, or the commercial HVAC market. Data gaps and uncertainties are discussed further in the remainder of this memo.

Step 1: Assess Supplier Data Quality and Data Enrichment Efforts

In this round of data collection, 14 total suppliers submitted data sets to NEEA, including three new participants.[3] The three new participating suppliers represent approximately 2.5% of reported sales for the four key residential technologies included in this analysis.[4]

In their raw form, these data include model numbers, quantity sold, and the calendar month in which the equipment was sold for each supplier. NEEA's contractor D+R International supplemented this raw data with efficiency and capacity attributes by matching the reported model numbers through publicly available sources (including the Air-Conditioning, Heating, and Refrigeration Institute Directory of Certified Product Performance).[5]

The NEEA HVAC sales data are housed in a relational database consisting of confidential cleaned data (i.e., efficiency and capacity information for each model number in the raw data). NEEA and D+R International created detailed tables and views for each HVAC technology including model information and sales.

The database contains over 1,000 attributes across all the tables, though most are ancillary to this analysis. For example, attributes such as model number, input ratings, high-heat ratings are not essential to understanding the technology mix and efficiency mix of the overall HVAC market (nor are they used as inputs to the BPA Residential HVAC Market Model). For this analysis, the research team focused on the attributes listed in Table 1.

[3] NEEA received data for a 15th supplier that did not include adequate model or efficiency information sufficient to include in this analysis. NEEA hopes to build the relationship with this supplier in the future and get more comprehensive data.
[4] Central air conditioners, air source heat pumps, gas furnaces, and ductless heat pumps.
[5] AHRI maintains a directory of equipment performance data. It is available at https://www.ahridirectory.org.

Table 1: Relevant HVAC Database Description Fields

Field Name	Description
Technology	The HVAC technology type such as gas furnaces, variable refrigerant flow systems and packaged terminal heat pumps (PTHP).
Fuel Type	The type of fuel used for heating, water heating, or some packaged units (electric, natural gas, propane, oil).*
Heating Capacity, MBH	A measure of the size of a heating system, representing the maximum amount of energy the system can provide. One MBH is equivalent to 1,000 British thermal units per hour (kBtu/hr).
Cooling Capacity, MBH	A measure of size of the cooling system, representing the energy the system can provide. One ton equals 12 MBH.
SEER	The seasonal energy efficiency ratio (SEER), an energy efficiency rating for air conditioners and other cooling equipment.
Median SEER	Median SEER for the listed configurations of an outdoor central air condenser or heat pump.**
AFUE %	The annual fuel utilization efficiency (AFUE) is a measure of a furnace's heating efficiency.
Median HSPF	Median heating seasonal performance factor (HSPF), the heating efficiency rating for heat pumps for an outdoor heat pump unit.**

* The data request included water heating equipment at the request of stakeholders to support market transformation activities.

**Some HVAC technologies are composed of a combination of indoor and outdoor units. In these instances, the AHRI product directory lists the efficiency and capacity of each possible indoor/outdoor unit combination. The sales data do not enable analysis of specific indoor/outdoor equipment combinations; rather, the research team defined the HSPF and SEER value for each outdoor unit as the median of the HSPF and SEER values for all the indoor units with which it can be paired.

All data are anonymized for reporting to ensure that supplier-specific data is protected. The research team reviewed the NEEA-provided supplier data set to identify the need for any additional data cleaning. This step includes checking for incorrect value types, consistency of technology assignments, relational inconsistencies, and formatting issues. Consistent with prior years, the research team found the data to be well organized and complete.

After obtaining the final completed data set from NEEA, the research team made minor adjustments to the data to reflect the specific categorization necessary to align with BPA's Residential HVAC Market Model, including a sector categorization for residential and commercial equipment for four technology types:

- Air-Source Heat Pumps, Ductless Heat Pumps, and Central Air Conditioners:
    - Residential: capacity of less than or equal to 5 tons (60 kBtu/hr).
    - Commercial: capacity of greater than 5 tons (60 kBtu/hr).

- Furnaces:
    - Residential: capacity less than 225 kBtu/hr.
    - Commercial: capacity greater than or equal to 225 kBtu/hr.

Step 2: Assess Data Gaps

After receiving the sales data and assessing data quality, the research team identified notable temporal, technology, and geographic gaps in the data set. The specific findings for each of these gaps are discussed in this section.

Temporal Gaps

Temporal gaps refer to suppliers with gaps in their submittals associated with a specific period. Filling in supplier-specific temporal gaps is important given the limited number of suppliers in the data and the unique product mix represented by each. Moving forward without filling in the missing data could affect the accuracy of our estimate of regional HVAC efficiency. (*Step 3: Address Data Gaps* discusses the specific approach to filling temporal gaps).

NEEA asked suppliers to submit six years of sales (2016, 2017, 2018, 2019, 2020, and 2021); however, some of the 14 participating suppliers did not provide complete data for the full period. Table 2 displays the number of supplier submissions by year. **In this round of data collection, NEEA was able to collect some prior year data (in addition to the 2021 data), which filled previously existing temporal gaps from 2016 to 2020**.

Table 2: Supplier Data Submissions

Submission Types	2016	2017	2018	2019	2020	2021
Complete sales data	7	9	11	10	9	13
Partial sales data	2	1	0	1	1	0

Geographic Gaps in Residential Equipment

Geographic gaps refer to any states underrepresented in the existing data set for the four key residential HVAC technologies. The objective is to derive regional inferences from these data; therefore, the research team must build a data set that is as representative as possible of the entire region. The research team defines "region" consistent with the definition used by the Northwest Power and Conservation Council: Washington, Oregon, Idaho, and western Montana. However, the research team assumes that the sales mix in western Montana is the same as the sales mix for the entire state, and includes sales occurring in eastern Montana in the calculations that establish the residential HVAC efficiency mix for Montana (shown in *Step 4: Final Results* below). This efficiency mix is only applied to the in-region portion of the state's building stock in the Residential HVAC Market Model.

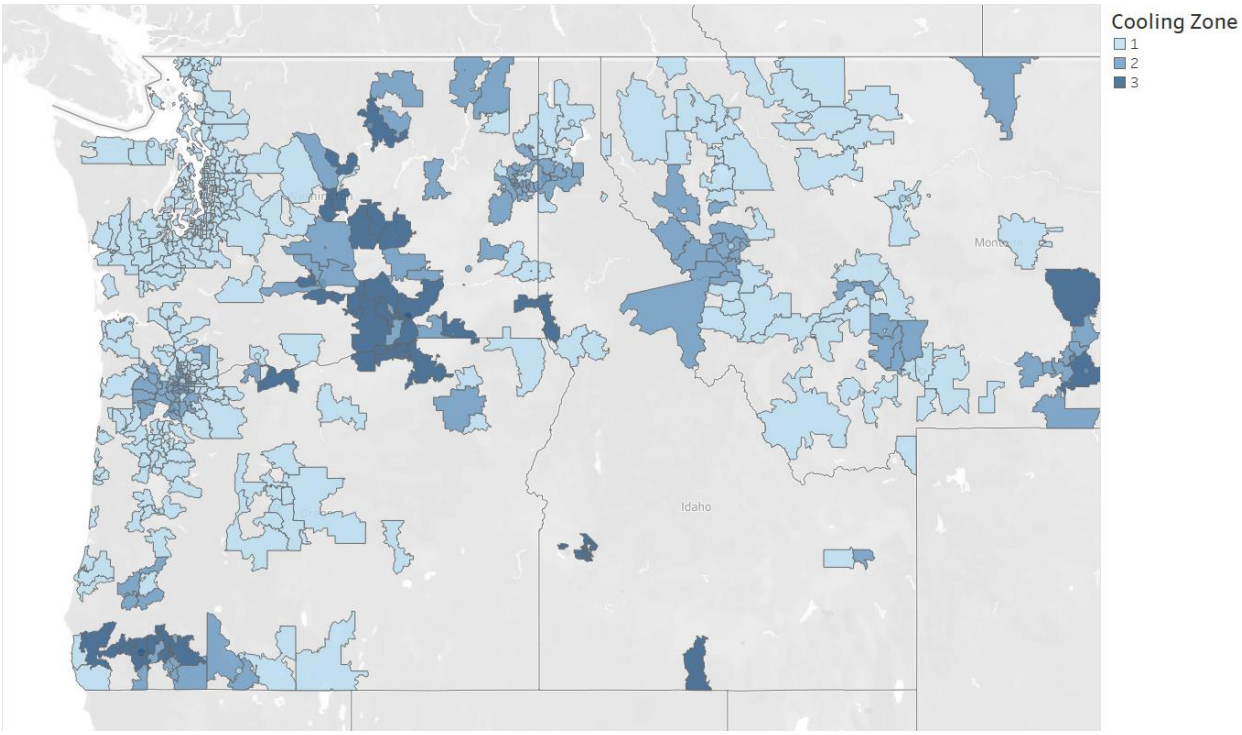
To identify geographic gaps in the 2021 data, the research team mapped the spatial distribution of the 2021 reported cooling equipment in the data set (Figure 2) by ZIP code. The research team used a two-

step approach to determine the sales location for the HVAC units sold and reported in this data collection effort:

- Use ship-to ZIP code if available (26% of sales)
- If ship-to ZIP code is not available, use ship-from ZIP code (adding this step increased the known geographic assignment to 100% of reported sales)

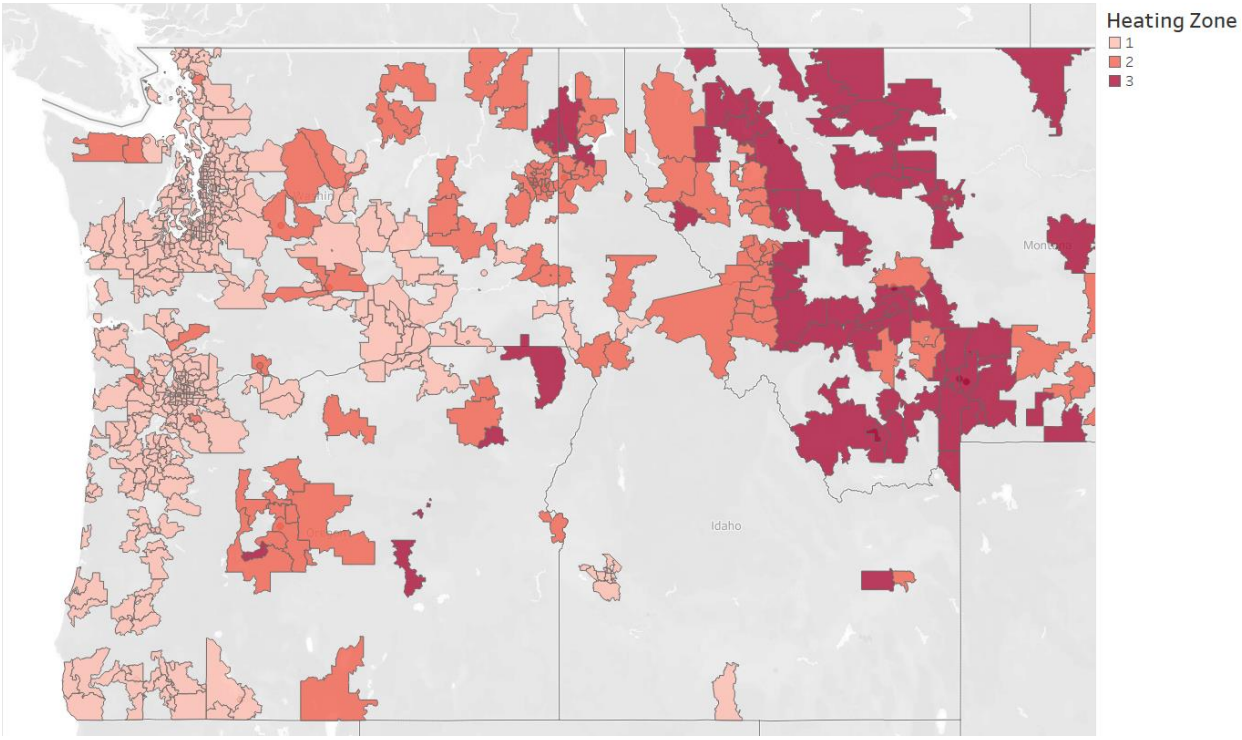
ZIP codes are shaded where one or more suppliers sold cooling equipment, with lighter blue shading indicating cooling zone 1 and the darkest shading indicating cooling zone 3. ZIP codes not represented in the sales data are not shaded. Unsurprisingly, the shading largely aligns with population centers. This map shows that southern Idaho, where Boise is located, is very sparsely shaded, indicating a geographic gap for cooling equipment.

Figure 2: Reported Residential 2021 Sales of Cooling Equipment, by Climate Zone



Similarly, Figure 3 displays the distribution of 2021 reported heating equipment by ZIP code. Each ZIP code with heating equipment sold by one or more suppliers is shaded, with lighter red shading indicating heating zone 1 and the darkest shading indicating heating zone 3. ZIP codes that are not represented in the sales data are not shaded. This map also suggests a similar geographic gap for heating equipment in southern Idaho.

Figure 3: Reported Residential 2021 Sales of Heating Equipment, by Climate Zone



These maps illustrate the limited coverage of reported sales in the southern Idaho region, consistent with geographic gaps the research team identified in the prior rounds of analysis. *Step 3: Address Data Gaps* discusses subsequent adjustments to improve geographic coverage.

Technology Gaps by Sector

Identifying technology gaps requires assessing the comprehensiveness of the technologies in the data relative to the residential and commercial HVAC equipment stock in the region. During this step, the research team screened the data for supplier confidentiality issues by identifying and removing any technologies with fewer than three suppliers and any technologies with fewer than 100 units in annual sales across all suppliers. Although this process preserves anonymity of participating suppliers, it can create gaps in coverage for some technologies.

Table 3 and Table 4 present all the technologies represented in the data. Technologies that do not meet the three supplier and 100 units sold criteria are noted. These are removed from further analysis to preserve supplier confidentiality.

Note that air-source heat pumps, which are one of the four key residential technologies, are represented by two subcategories in Table 3: (1) "Heat Pump – Air Source, Single- and Two-Stage," which encompasses single-stage and two-stage air-source heat pumps, and (2) "Heat Pump - Air Source, Variable-speed" which encompasses variable-speed (or variable capacity) heat pumps.

Table 3: Residential HVAC Technologies in Supplier Data Set[6]

Technology	Included in Analysis	Excluded: Too Few Units	Excluded: Not Enough Supplier Submissions
Central Air Conditioning – Condenser	Yes		
Gas Furnace	Yes		
Heat Pump – Air Source, Single- and Two-Stage	Yes		
Heat Pump – Air Source, Variable-speed	Yes		
Heat Pump – Single Packaged	Yes		
Heat Pump – Ductless	Yes		
Gas Packaged Unit	Yes		
Variable-Speed Mini-Split and Multi-Split Air Conditioning	Yes		
Central Air Conditioning – Single Packaged	Yes	For 2016 and 2017	
Boilers	No		Yes
Oil Furnace	No	Yes	
Direct Heating Equipment	No	Yes	Yes
Water heaters	No	Yes	Yes

Table 4: Commercial HVAC Technologies in Supplier Data Set

Technology	Included in Analysis	Excluded: Too Few Units	Excluded: Not Enough Supplier Submissions
Central Air Conditioning - Packaged Terminal (PTAC)	Yes		For 2016, 2019, 2020, and 2021
Heat Pump – Air Source, Variable-speed	Yes	For 2020 and 2021	For 2020 and 2021
Heat Pump – Packaged Terminal (PTHP)	Yes		For 2016 and 2020
Variable Refrigerant Flow	Yes	For 2016, 2017, and 2020	
Unitary Large Equipment	Yes		
Heat Pump – Air Source, Single- and Two-Stage	No	Yes	Yes

[6] Electric furnaces cannot be identified through model number matching to publicly available sources. In previous rounds of analysis, the research team used different methods that are inherently less reliable to identify those sales in the raw data. The updated Residential HVAC Market Model is a more reliable source for understanding electric furnace sales, so the research team removed this technology from this round of analysis.

Technology	Included in Analysis	Excluded: Too Few Units	Excluded: Not Enough Supplier Submissions
Central Air Conditioning - Single Packaged	No	Yes	Yes
Heat Pump – Single Packaged	No	Yes	Yes
Single Packaged Vertical Air Conditioners & Heat Pumps	No	Yes	Yes
Heat Pump – Ductless	No	Yes	Yes
Boilers	No	Yes	Yes
Gas Furnace	No	Yes	Yes
Water Heaters	No		Yes
Heat Pump – Water Source	No		Yes
Water heaters	No		Yes

Table 5 and Table 6 present the annual reported sales volume for the technologies that pass the reporting criteria. Based on product flow estimates from BPA's Residential HVAC Market Model, **the research team estimates that the sales data from the 14 suppliers encompasses approximately 31% to 50% of the residential sales** for each of the four main residential technologies: gas furnaces, air-source heat pumps (including variable-speed heat pumps), ductless heat pumps, and central air conditioners. **This estimated coverage is a slight improvement compared to coverage in last round's data collection (25% to 45%).**

In the commercial sector, where there is more variation in HVAC equipment types and a greater presence of manufacturer-direct sales, the research team estimates that the database represents a small portion of the market. NEEA targeted manufacturer representatives in this round of data collection, but **despite the incremental improvements in commercial data, many of the commercial technologies present in the database do not pass anonymity requirements, and therefore the research team cannot include them in the results.** Improving commercial sales data coverage will continue to be a priority for NEEA in future rounds of data collection.

Table 5: Reported Residential Supplier Sales Volume by Technology (Not Extrapolated)

Sector	Technology	2016 Reported Quantity	2017 Reported Quantity	2018 Reported Quantity	2019 Reported Quantity	2020 Reported Quantity	2021 Reported Quantity
Residential	Central Air Conditioning – Condenser	16,562	28,315	43,531	51,823	27,547	68,604
Residential	Gas Furnace	36,285	47,179	59,085	62,655	39,402	84,056
Residential	Heat Pump – Air Source, Single- and Two-Stage	11,640	16,770	21,453	23,666	16,238	27,239
Residential	Heat Pump – Air Source, Variable-speed	1,578	2,287	3,158	3,324	3,173	8,576

Sector	Technology	2016 Reported Quantity	2017 Reported Quantity	2018 Reported Quantity	2019 Reported Quantity	2020 Reported Quantity	2021 Reported Quantity
Residential	Heat Pump – Ductless	13,641	21,413	25,805	24,198	25,155	33,599
Residential	Heat Pump – Single Packaged	461	650	794	728	224	565
Residential	Variable-Speed Mini-Split and Multi-Split Air Conditioning	863	1,261	970	1,131	343	1,170
Residential	Central Air Conditioning – Single Packaged	NA	NA	170	147	155	201

Table 6: Reported Commercial Supplier Sales Volume by Technology (Not Extrapolated)

Sector	Technology	2016 Reported Quantity	2017 Reported Quantity	2018 Reported Quantity	2019 Reported Quantity	2020 Reported Quantity	2021 Reported Quantity
Commercial	Gas Packaged Unit	1,808	2,380	2,919	2,763	442	2,410
Commercial	Heat Pump – Air Source, Variable-speed	100	157	199	213	NA	NA
Commercial	Heat Pump – Packaged Terminal (PTHP)	NA	666	1,286	1,299	NA	393
Commercial	Central Air Conditioning – Packaged Terminal (PTAC)	NA	225	245	NA	NA	NA
Commercial	Variable Refrigerant Flow	NA	NA	170	137	NA	264
Commercial	Unitary Large Equipment	748	1,069	1,998	2,076	350	1,658

Step 3: Address Data Gaps

Address Geographic Gaps in Residential Equipment

In *Step 2: Assess Data Gaps*, the research team confirmed the need to address the underrepresentation of Idaho in the reported supplier data for residential equipment. To do so, the research team integrated data from HARDI,[7] which the research team received through a nondisclosure agreement with NEEA.

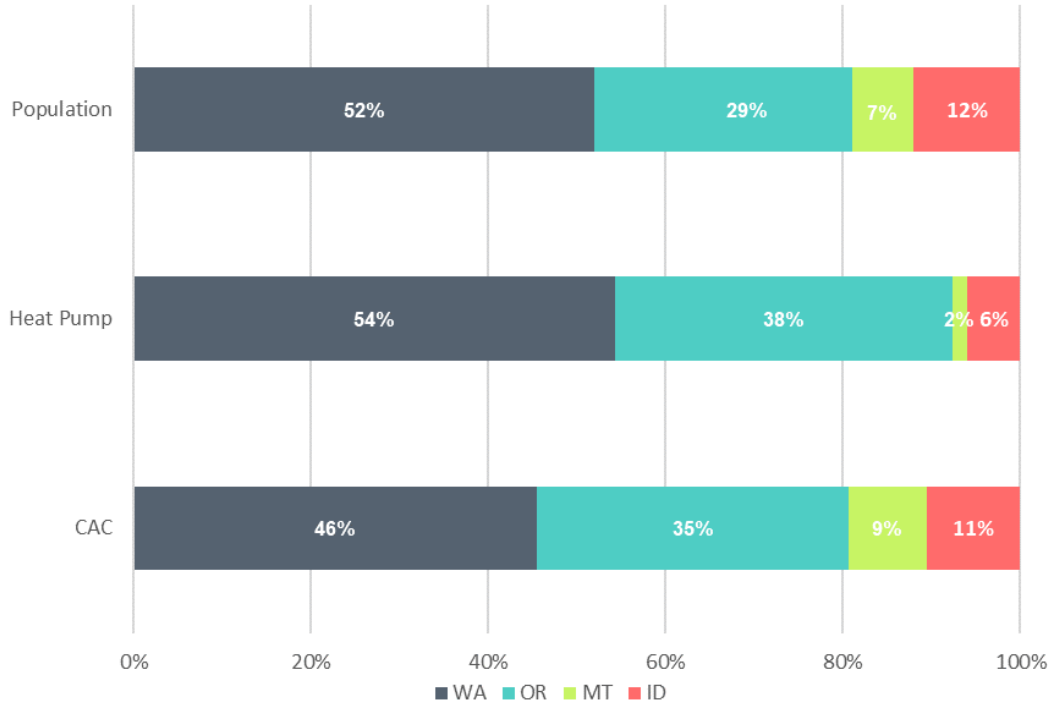
Though the HARDI report helps to fill a geographic gap, the suppliers that contribute to it are anonymized, making it difficult for the research team to determine the extent of overlap between the NEEA supplier data and the HARDI data. For this reason, the research team subtracted Idaho sales from

[7] Data prepared by D+R International.

the NEEA supplier data and replaced it with HARDI data for Idaho for two residential technologies: central air conditioners and air-source heat pumps (including variable-speed heat pumps).[8] In prior years of analysis, the research team also used HARDI data to fill a geographic gap in gas furnace sales in Idaho. **This year the research team found that there were more gas furnace sales in the collected data compared to HARDI, and therefore gas furnace HARDI data is no longer needed.** This approach leverages both data sets for a more complete view of the region while relying more heavily on the NEEA supplier data that has greater transparency and detailed equipment information.

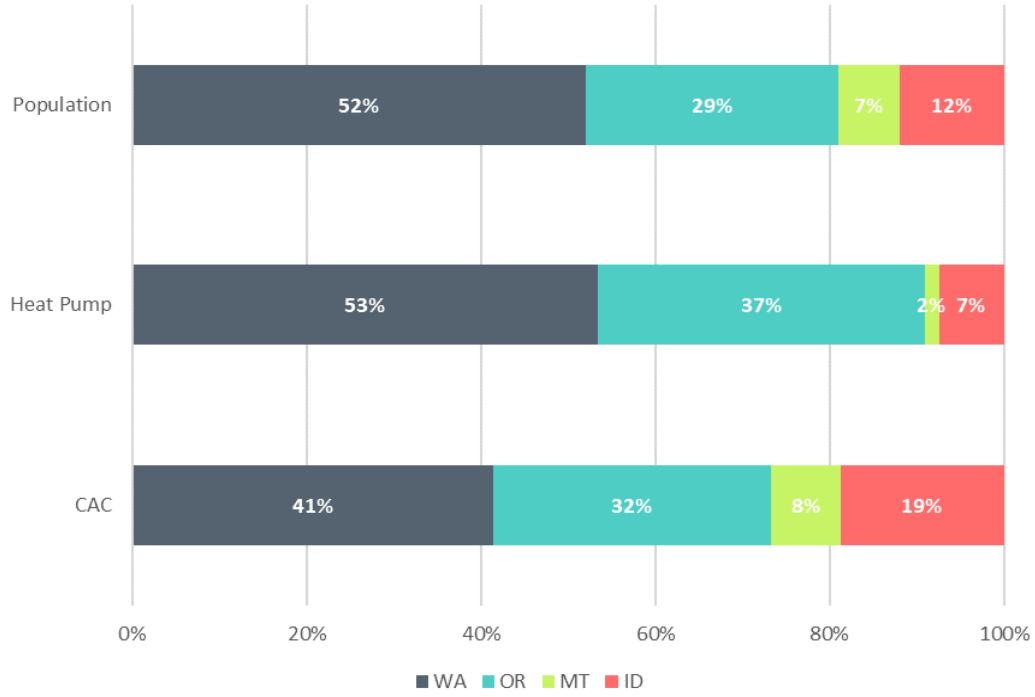
The research team summarized the effect of replacing the NEEA data with HARDI data for Idaho (limited to the two specified technologies) by comparing the distribution of each technology's reported sales by state to population distribution pre-HARDI (Figure 4) and post-HARDI (Figure 5). The research team used each state's share of population as a rough proxy for understanding the regional coverage of the reported supplier data[9] because HVAC equipment sales should be roughly correlated to population. The comparison shows that using HARDI data to fill the Idaho geographic gap resulted in increased reported sales for central air conditioning in Idaho while coverage of air-source heat pumps improved slightly. Figure 4 and Figure 5 illustrate the results of the analysis for 2021 sales.

Figure 4: Reported Residential 2021 Sales by Equipment and State, Pre-HARDI Integration



[8] Although NEEA's HARDI license includes ductless heat pumps and gas furnaces in addition to these two technologies, reported ductless heat pump and gas furnace quantities are greater in the NEEA data compared to HARDI, so they are excluded from this step.
[9] The research team also conducted a comparison of sales to housing counts (sourced from the American Community Survey) with near-identical results.

Figure 5: Reported Residential 2021 Sales by Equipment and State, Post-HARDI Integration



Address Temporal Gaps

Following the integration of HARDI data for Idaho, the research team extrapolated to fill temporal gaps in sales data from reporting suppliers. Extrapolation is important because the technology and efficiency mix for HVAC equipment varies from supplier to supplier. Creating a complete time-series data set for each supplier in the sample through extrapolation mitigates the impact of data gaps on the calculated efficiency mixes and annual sales trends.

The research team's approach rests on two key assumptions:

- **A supplier's market share remains constant over time.** For example, if a supplier's sales represented 25% of all reported HVAC sales in 2017, then the research team assumes that supplier will represent 25% of all reported HVAC sales in 2018.
- **The mix of technologies is, on average, similar for that supplier across years.** For example, if ductless heat pumps accounted for 5% of a supplier's total reported sales in 2017, then the analysis assumes ductless heat pump sales would similarly account for 5% of this supplier's total reported sales in 2018.

The research team confirmed these assumptions are reasonable by reviewing the sales patterns for suppliers who submitted at least two complete and consecutive years of data. Specifically, the research team plotted supplier-specific market share across years and supplier-specific technology mix across years. The results of these analyses are protected by confidentiality agreements, but the research team's analyses confirmed both assumptions are reasonable.

Table 7 presents the portion of sales data extrapolated for each year and shows that the overall temporal coverage of the data is good; **there were no temporal gaps to fill in 2021[10]. The temporal coverage in this round of analysis has improved since the previous round, especially for 2020** (see Table 7). The remaining temporal gaps differ between suppliers. For example, one might be missing an entire year of data, whereas another might be missing only a month. To address these differences, the research team applied different extrapolation processes in the order listed:[11]

1. For data submissions missing a month or less of sales data, the research team:
    a. Relied solely on the supplier's submitted data to ensure the most accurate prediction, rather than using other suppliers' data to extrapolate sales.
    b. Extrapolated sales for the missing weeks or month with the assumption that the relative volume and mix of those sales is the same as that month in the prior or subsequent year.
2. For the data submissions missing more than a month, the research team:
    a. Estimated an overall market share for each supplier based on the most complete, recent year of data.
    b. Applied these market share estimates to the reported data to extrapolate the total sales for the missing period.
    c. Allocated those extrapolated sales to the same technology and efficiency mix as reported in either the prior or subsequent year for that supplier (e.g., 5% of total sales are SEER 18 or higher air-source heat pumps).
3. For the one unique case where a supplier did not submit any data for 2020 but did submit complete data for all other years, the research team:
    a. Calculated extrapolated sales for that supplier for 2020 as the straight average of that supplier's sales in 2019 and 2021.

This methodology ensures the research team leverages the information gathered for each year to fill data gaps. Extrapolated sales vary based on the completeness of submitted supplier sales data, relative market share of missing supplier data, and reported sales growth for each technology. The research team cannot discuss specific suppliers or their participation status for any given year, even in an anonymized fashion, to protect study participant confidentiality.

Table 7: Proportion of Sales Data Extrapolated

Analysis Round	2016 Percent Extrapolated	2017 Percent Extrapolated	2018 Percent Extrapolated	2019 Percent Extrapolated	2020 Percent Extrapolated	2021 Percent Extrapolated
Current	26%	15%	2%	2%	29%	0%
Previous	24%	12%	0%	0%	43%	N/A

[10] Thirteen out of 14 suppliers provided complete 2021 data; however, the one participating supplier that did not provide 2021 data has sales volumes too low in previous years to warrant extrapolating for fill their 2021 gap.
[11] One of the new participating suppliers provided only 2021 sales data. Their sales volumes were too low to warrant extrapolating for previous years and low enough that including them in 2021 would not significantly impact year-over-year sales trends. This is consistent with the approach used in previous rounds of analysis for very low volume suppliers.

Step 4: Final Results

Extrapolated Suppler Data

The results, after filling in temporal and geographic data gaps, are presented in this section. Tables Table 8 and Table 9 present the estimated annual sales by sector and technology for the 14 participating suppliers.

Table 8: Reported Residential Supplier Sales Volume by Technology (Extrapolated)

Technology	2016 Extrapolated Quantity	2017 Extrapolated Quantity	2018 Extrapolated Quantity	2019 Extrapolated Quantity	2020 Extrapolated Quantity	2021 Extrapolated Quantity
Central Air Conditioning – Condenser	32,093	39,920	48,897	56,666	62,450	75,499
Gas Furnace	46,917	54,997	60,099	63,744	71,803	84,056
Heat Pump – Air Source, Single- and Two-Stage	19,091	21,614	22,107	24,261	25,668	27,686
Heat Pump – Air Source, Variable-speed	1,556	3,270	3,170	3,337	4,948	8,576
Heat Pump – Ductless	18,717	23,356	26,294	24,724	31,148	33,599
Heat Pump – Single Packaged	548	658	796	758	684	565
Variable-Speed Mini-Split and Multi-Split Air Conditioning	1,203	1,279	970	1,131	1,132	1,170
Central Air Conditioning – Single Packaged	NA	NA	170	147	211	201

Table 9: Reported Commercial Supplier Sales Volume by Technology (Extrapolated)

Technology	2016 Extrapolated Quantity	2017 Extrapolated Quantity	2018 Extrapolated Quantity	2019 Extrapolated Quantity	2020 Extrapolated Quantity	2021 Extrapolated Quantity
Gas Packaged Unit	1,957	2,386	2,920	2,764	2,558	2,410
Heat Pump – Air Source, Variable-speed	100	182	199	213	NA	NA
Heat Pump – Packaged Terminal (PTHP)	NA	669	1,290	1,303	NA	393

Technology	2016 Extrapolated Quantity	2017 Extrapolated Quantity	2018 Extrapolated Quantity	2019 Extrapolated Quantity	2020 Extrapolated Quantity	2021 Extrapolated Quantity
Central Air Conditioning – Packaged Terminal (PTAC)	NA	142	245	NA	NA	NA
Variable Refrigerant Flow	NA	NA	170	137	NA	264
Unitary Large Equipment	886	1,086	2,016	2,095	1,921	1,658

Residential Efficiency Mix

After addressing geographic and temporal gaps in the reported supplier sales data, the research team used the post-extrapolated data in Table 8 to calculate the final heating and cooling efficiency mix of four key residential technologies: central air conditioners, air-source heat pumps, gas furnaces, and ductless heat pumps. This efficiency mix, as presented in Table 10 and Table 11, is an input to the BPA Residential HVAC Market Model. With this information, the research team can better estimate how the efficiency trends in equipment sales affect regional HVAC energy consumption.

Table 10: Final Heating Efficiency Mix - Residential

Technology	Heating Efficiency		2016	2017	2018	2019	2020	2021
Gas Furnace	80% up to 89.99% AFUE		33%	30%	30%	32%	32%	32%
	90% up to 94.99% AFUE		8%	7%	5%	3%	2%	1%
	95% AFUE or greater		59%	63%	66%	65%	66%	67%
Heat Pump – Air Source	Single- or Two-Stage	HSPF 7.5-7.99	2%	1%	0%	0%	0%	0%
		HSPF 8-8.39	40%	37%	34%	30%	27%	26%
		HSPF 8.4-8.79	34%	32%	35%	39%	40%	34%
		HSPF 8.8-9.99	16%	16%	17%	18%	16%	16%
		HSPF 10 or above	1%	1%	1%	1%	0%	0%
	Variable-speed		8%	13%	13%	12%	16%	24%
Heat Pump – Ductless	Below HSPF 9.0		12%	12%	6%	3%	2%	2%
	HSPF 9.0 to 11.0		67%	68%	76%	79%	80%	84%
	HSPF 11.1 to 12.5		17%	17%	14%	14%	17%	13%
	HSPF 12.6 or above		4%	4%	3%	3%	1%	1%

Table 11: Final Cooling Efficiency Mix - Residential

Technology	Cooling Efficiency		2016	2017	2018	2019	2020	2021
Central Air Conditioning – Condenser	SEER 10-11.99		1%	1%	1%	0%	0%	0%
	SEER 12-13.99		39%	33%	33%	27%	27%	27%
	SEER 14-15.99		53%	60%	60%	65%	61%	58%
	SEER 16 or above		7%	6%	7%	7%	11%	14%
Heat Pump – Air Source	Single- or Two-Stage	SEER 12-13.99	2%	1%	0%	0%	0%	0%
		SEER 14-15.99	83%	79%	78%	77%	75%	67%
		SEER 16 or above	7%	8%	9%	11%	9%	9%
	Variable-speed		8%	13%	13%	12%	16%	24%

Remaining Data Gaps and Uncertainties

The regional HVAC supplier data set is a mix of regional and national suppliers and includes the general supply house sales that supply the residential sector. A majority of known residential suppliers provide data, and the major manufacturers of residential HVAC equipment are represented in the data set. Given those factors and the stability in efficiency trends, the research team has confidence that the residential

efficiency mix of the supplier data set (as presented in Table 10 and Table 11) are representative of the region and can serve as an input to the Residential HVAC Market Model.

There are, however, gaps beyond those discussed in Step 2 and Step 3 that the research team cannot fully assess and that create additional uncertainty with the overall data set. These gaps are discussed in the following subsections.

Commercial Equipment

The regional HVAC supplier data set is a mix of regional and national suppliers, with most known residential suppliers providing their sales data. In contrast, none of the known suppliers focused exclusively on commercial sales participate in the study and commercial-sized equipment accounts for only 3% of reported sales. NEEA and D+R International secured additional commercial sales data compared to prior years; however, the research team estimates the data set represents a small portion of the overall commercial HVAC market and therefore cannot support meaningful insights about commercial HVAC equipment.

System Configurations

Market actors interviewed in 2021[12] mentioned increasing interest in mixing and matching equipment to meet specific home needs. The supplier data set provides detailed information for each unit sold but does not provide a way to identify units sold together to serve the same home. The data set also does not have enough information to characterize how HVAC systems are configured at each site (i.e., ducted mini-splits or air-source heat pumps with gas furnace as back-up heat). The research team recommends pairing future sales data collection efforts with market-actor interviews and/or surveys that focus on in situ HVAC system trends and configurations, interpreted alongside the region's RBSA.

Retail and Online Sales

The data set does not include big-box retail and online sales; this could be a significant gap for some technologies. Market-actor interviews conducted in 2021[13] reflected consensus that online and retail sales are increasing; however, the precise volume may be unknowable without access to sales data from retail and online channels. Online sales for HVAC equipment are flowing directly to contractors and, to a lesser extent, homeowners. While estimates are difficult to make, market observers report these sales *could potentially be* as high as 20% for ductless heat pumps.

The research team believes that this gap may apply to some technologies included in this memo (such as ductless heat pumps and central air conditioners). Additionally, the NEEA sales data does not provide representative data for other technologies like room air conditioners, smart thermostats, and zonal heating equipment (baseboards and wall heaters). The team used data provided by NEEA's Retail Product Portfolio program to report on room air conditioners in the Executive Summary.

Future data collection should consider capturing sales of ductless heat pumps and other HVAC equipment through online and retail channels.

[12] Cadeo Group, "2020–2021 HVAC Market Research Interview Summary," Bonneville Power Administration, July 2021, https://www.bpa.gov/-/media/Aep/energy-efficiency/momentum-savings/bpa-hvac-market-actors-interview-findings-2020-2021.pdf.
[13] Ibid.