Memorandum

To: Bonnie Watson, Bonneville Power Administration

From: Jordan Folks and Todd Malinick (Research Into Action), Kate Bushman (Cadeo)

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Subject: HVAC Market Actor Interviews

Introduction

This memo summarizes the Research Into Action and Cadeo team's (the research team's) findings from in-depth interviews conducted with heating, ventilation, and air conditioning (HVAC) market actors located in Oregon, Washington, Montana, and Idaho. The research team conducted 30 in-depth interviews with a mix of HVAC distributors and manufacturer representatives, installation contractors, single-family home builders, and manufactured home builders. The purpose of these interviews was to inform the Bonneville Power Administration's (BPA) HVAC market modeling, follow up to investigate specific findings from BPA's previous HVAC market studies,[1] and to generally help BPA better understand emerging trends in the Northwest HVAC market.

This memo has eight sections:

(1) An overview of the study's key findings

(2) A description of the study methodology

(3) Findings related to market structure and operations

(4) Findings related to technology changes

(5) Findings related to decision-making

(6) Findings related to installation and maintenance trends

(7) Suggested topics that may warrant further research

(8) Appendices providing respondent characteristics and the interview guide

[1] Visit BPA's HVAC Market Research webpage for past research reports: https://www.bpa.gov/EE/Utility/research-archive/Pages/hvac-market-research.aspx

Key Findings

Market Structure and Operations

- **The structure of the HVAC market supply chains remain intact and largely unchanged.** Overall, market actors agreed that the market structure and flow of equipment documented in BPA's existing descriptions of the supply chains for both residential and commercial are still accurate.[2]
- **Distributors said their stocking practices are mostly driven by market demand.** Both contractors and distributors agreed that distributor stocking practices in and of themselves are not a barrier to end-users purchase decisions, because they are a reaction to market demand. However, this applies mainly to residential equipment, which tends to flow through distributors (i.e., <25 ton unitary equipment).
- **Manufactured home builders are unique; therefore, modeling these market actors may require distinct data sources.** There are many factors that set manufactured home builders apart from other market actors including: they work with a more limited HVAC supply chain, the U.S. Department of Housing and Urban Development (HUD) regulates their HVAC technologies, they employ onsite HVAC installers in their factories, air conditioning is rarely installed in the factory setting, they mostly install ducted electric forced air furnaces, and they do not interact with end-users. Since some manufactured home builders purchase their HVAC equipment directly from HVAC manufacturers, distributor sales data may not be sufficient for modeling these unique market actors.
- **Distributors have minimal involvement in decisions surrounding national account sales, although they do track sales of equipment sold to national accounts.**[3] Though some fixed-price sales may flow through distributors, manufacturers more commonly provide much of the equipment directly to national account businesses. This means that regional distributor sales data that will inform market modeling will contain some but not all HVAC equipment sales to national account businesses in the Northwest.

Technology Changes

- **Ductless heat pump (DHP) technologies will continue to be an increasingly popular residential HVAC choice in the Northwest.** Except for only minor gains in the manufactured home setting, the remaining market actors almost unanimously indicated that the use of DHPs has grown significantly, and they expect it to continue to do so. As revealed by contractor and distributor interviews, this growth represents a larger trend toward more efficient residential HVAC technology in the residential market. Market actors said they thought this shift stems in

[2] BPA's description of HVAC market supply chains can be found in BPA's HVAC Market Intelligence Report from April 2016: https://www.bpa.gov/EE/Utility/research-archive/Documents/Momentum-Savings-Resources/2016_HVAC_Market_Intelligence_Booklet.pdf

[3] For its research purposes, BPA defines national accounts as businesses with more than five stores under some type of centralized corporate control.

part from efficiency programs, technological advances, contractor efforts, and increased customer awareness.

- **Efficiency and technological advances in variable refrigerant flow (VRF), motors, inverters, smart thermostats, and building automation/controls have occurred over the past few years are expected to continue increasing in the coming years.** Perceptions of these growing HVAC trends were consistently reported across market actors, and market actors thought these advances would continue in the near future.
- **Cooling is set to become the norm in Northwest single-family homes.** Single-family home builders said they almost always include cooling in their new homes, and HVAC installation contractors report they are now often adding cooling to homes that did not previously have cooling capabilities. Conversely, manufactured home builders rarely install air conditioning at the factory site.
- **Manufactured home builders have not significantly changed their HVAC practices the past few years, nor do they expect to change in the near future.** Barring unforeseen market intervention, market actors indicated that inefficient electric-fueled HVAC in new manufactured homes will likely continue to dominate the market.
- **Market actors believe the manufacturer-provided estimated lifespans for HVAC equipment are relatively accurate.** Though certain factors affect a HVAC system's lifespan–namely location and installation/maintenance conditions–distributors and contractors feel that *on average* lifespan estimates are accurate. This suggests that no adjustment will be needed to market models to account for equipment life.

Installation and Maintenance Trends

- **Contractors report that replacement-on-burnout represents approximately two-thirds of the residential HVAC market**. Of the remaining one-third, contractors said about half are early retirement and half are new construction.
- **Installation and maintenance problems persist in the residential setting.** Contractors reported they routinely encounter improperly installed or poorly maintained systems in the field, which negatively impacts efficiency and equipment life. Contractors did not elaborate on the average age of improperly installed or maintained systems. However, the research team reasons that contractor reports of poorly installed systems are likely mostly referencing older systems, since contractors said that customers tend to wait until there is a problem before ever servicing their HVAC. However, this means that poorly maintained systems span the entire residential market, including new and old systems.

Methodology

The research team conducted in-depth interviews with 30 HVAC market actors who serve customers in the four states in BPA's service territory in October and November 2017 (Table 1). The research team ensured the market actor sample was reasonably distributed across all four states and that the distributor and manufacturer representative sample had adequate representation across both commercial and residential equipment suppliers. The distributor, manufacturer representative, and manufactured home builder samples represent a substantial proportion of the Northwest market, including some of the larger players in those spaces,[4] while the contractor and single-family home builder samples represent a smaller proportion of these market actors, due to the large number of market actors in those spaces. However, the research team included a mix of both smaller and larger contractor and single-family firms to ensure diverse information was captured. Nevertheless, because of the small sample sizes, the findings presented is study only provide broad insights into the Northwest HVAC market, and they are not necessarily statistically representative of the general population. For more firmographic information on the interview samples, see Appendix A.

Table 1: Market Actor Sample Characteristics

Market Actor	Sample Size
Distributors and manufacturer representatives*	11
Contractors	10
Single-family home builders	5
Manufactured home builders	4
Total	**30**

* Sample includes five distributors and six manufacturer representatives.

Note that the research team did not interview HVAC Original Equipment Manufacturers (OEMs) for this task, but has plans to interview these market actors at the 2018 AHR Expo in January 2018. BPA will have findings from the manufacturer interviews in March 2018.[5]

The main objective of this study was to inform BPA's residential HVAC modeling efforts by collecting key insights from distributors, contractors, and builders on how the Northwest HVAC market operates. To structure the inquiry, the research team developed research questions covering four main topic areas where additional insights were sought to provide information to better understand the operation of the HVAC market and/or suggest adjustments or refinements to the modelling efforts. The topic areas include:

[4] The research team estimates that the distributor and manufacturer representative sample covers about one-third of these market actors serving the Northwest. The manufactured home builder sample represents about half of these market actors operating in the Northwest.

[5] The AHR Expo—to be held in January 2018 in Chicago, IL—is the largest HVAC trade show in the United States with more than 2,000 exhibitors, largely comprising manufacturers. BPA research staff plan to attend to perform focused interviews with manufacturers and report on the findings in March 2018. https://ahrexpo.com/

- **Market structure and operations**: Determine if the structure or operation of the HVAC market and the flow of products has changed since BPA last conducted in-depth phone interviews with a sample of market actors in 2015.
- **Technology changes:** Assess key technology characteristics of the Northwest HVAC market and how these have been changing in the past few years.
- **Decision making:** Understand how the supply-side actors think and how end-use customers make decisions regarding equipment, as well as how programs and contractors affect these decisions.
- **Installation and maintenance trends:** Assess other installation and maintenance dynamics that affect the Northwest HVAC market.

Detailed Findings

The following discussion presents detailed findings by topic area (i.e., market structure and operations, technology changes, decision making, and installation and maintenance trends) and associated research questions. The tables at the beginning of each section (see Tables 2, 3, 6 and 7) show the research questions and applicable market actor for each topic area.

Market Structure and Operations

The research team set out to determine if the structure or operations of the Northwest HVAC market and/or the flow of products has changed since the last in-depth interviews were conducted in 2015. Table 2 shows the specific research questions for this topic and the market actors relevant to each question.

Table 2: Market Structure and Operations Research Questions by Market Actor

Research Question	Distributors and Manufacturer Reps	Contractors	Single Family Home Builders	Manufactured Home Builders
Are there any notable changes in market structure? New actors? Changing loci of influence?	X			
Are there any notable changes in flow of products in the market?	X			
Other than the small versus large equipment distinction, is there any other technology-specific variability in the supply and distribution chains?	X			
To what extent are national account HVAC equipment sales flowing through local regional distributors? How do the distributors track those sales?	X			

Research Question	Distributors and Manufacturer Reps	Contractors	Single Family Home Builders	Manufactured Home Builders
How do distributor stocking practices impact the efficiency or type of equipment sold to customers by contractors?	X	X		
How do new home builders and manufactured home builders fit in to the known supply chain? What is different about them and the decisions they make?			X	X
Are there supply-side barriers to adopting more efficient technologies in certain applications?		X	X	X

The structure of the HVAC market supply chains remain intact and largely unchanged.

The research team provided distributors and contractors with descriptions of how the HVAC market supply chains are believed to work based on prior research.[6] They then asked respondents if they felt these descriptions were accurate and if there are any new actors, any changing loci of influence, changes in the flow of products, or technology-specific variability. From the distributors perspective, the research team probed for both the residential and commercial supply chains, and differentiated between small (<25 tons) and large (>25 tons) equipment within the commercial chain.

All the distributors and contractors agreed that the existing descriptions of the HVAC market supply chains are still quite accurate. The only revisions to the existing model centered on providing additional clarification of distinctions across distributors in the residential market and adding insights into how contractors obtain equipment.

The research team learned there are two specific types of distributors operating in the Northwest market: (1) *supply distributors,* which provide equipment and any other materials that go into a project, and (2) *equipment distributors,* which tend to only sell major pieces of equipment, and try to sell this equipment to contractors in volume. The equipment distributors said they often offer buy-up programs that focus on putting as much inventory into their customers warehouses as possible.

The existing supply chain model describes the contractors' role as picking up equipment on an as-needed basis from distributors. However, several distributors noted that some contractors warehouse common equipment, sometimes inventorying a week or two of supply. Interviews suggest this is more common among larger contractors and those serving rural areas, with the latter due to logistical challenges associated with making frequent, long trips to a distributor facility. Several of the distributors also noted that they provide delivery services to contractor facilities or job sites. Some have their own trucks and

[6] The research team used the supply chain descriptions presented in the 2016 BPA *HVAC Market Intelligence Report*. See questions 4 and 5 in the distributor interview guide included in Appendix B for exact question wording.

others use common freight carriers. One distributor estimated they deliver about half of their sales and contractors pick up the other half.

There are two primary types of single-family home builders, and they differ in their relationships with the larger HVAC market.

In general, two types of single-family home builders arose from the interviews: (1) smaller, custom builders, and (2) larger, "spec" builders (i.e., builders who focus on pre-specified building plans). While both types of builders said they generally subcontract the installation work to HVAC contractors, the manner in which they obtain their equipment in some ways mirror the small and large commercial supply chains. The smaller, custom builders said they tend to work with contractors who obtain the equipment they need directly from distributors; thus, these sales will be included in distributor sales data. In contrast, the larger, spec builder we spoke with said they tend to deal with large volumes of equipment and obtain equipment directly from manufacturers via a manufacturer's rep; thus, sales to larger spec builders may not appear in distributor sales data.

Manufactured home builders add a unique twist to the HVAC supply chain model.

Manufactured home builders are arguably the most unique market actors in the supply chain. While single-family home builders sub-contract the installation work to standard residential HVAC contractor firms, manufactured home builders deviate significantly from the standard manufacturer-distributor-contractor model: manufactured home builders purchase their HVAC equipment—almost exclusively electric forced air furnaces—from distributors or directly from niche manufacturers, and they install the equipment on the factory line using their in-house HVAC technicians. Although these technicians are trained HVAC professionals, they are not traditional HVAC contracting firms. Instead, they are dedicated factory-line HVAC installers, directly employed by the manufactured home companies.

HUD tightly regulates new manufactured homes requiring manufactured home builders to install space heating for each inhabitable room and regulating which gas furnaces can be installed in manufactured homes. These regulations, as well as this market's disproportionately low-income customer base,[7] heavily influence manufactured home builder's HVAC decisions.

Further differentiating their role in the supply chain, manufactured home builders do not interact with end-users. Instead, they sell the homes to independent dealers, who then sell the homes to end-users. End-users may buy a standard "spec" manufactured home, or they may customize their future home with the dealer. The dealer then works with the manufacturer to accommodate the end-user's customization requests. However, end-user customization requests rarely affect HVAC choices; one dealer said they occasionally install DHPs as an upgrade option and some customers with natural gas access will choose a gas forced air furnace for their new home. Buyers of manufactured homes instead primarily customize floor designs and shell or interior components (such as cabinetry).

Manufactured home builders indicated that two companies manufacture the bulk of the furnaces commonly installed at manufactured home plants, one of which is the predominant HVAC manufacturer

[7] Compared to other housing types, more than twice as many manufactured home residents have gross annual household incomes of less than $20,000 (40% vs. 16%). (U.S. Energy Information Administration. 2015 *Residential Energy Consumption Survey*.)

for the new manufactured home industry. As a result, manufactured home builders in the Northwest said they mostly get their HVAC products from the same manufacturer. Manufactured home builders said they typically get weekly shipments of furnaces, which provides them with enough product to meet their production schedule for the week.

Distributors have minimal involvement in decisions surrounding national account sales, although they do track sales of equipment sold to national accounts.

According to several of the interviewed distributors, they have little to no role in negotiating sales of equipment to national accounts; this typically occurs at the national level, directly between the customer and the manufacturer. Prices are usually fixed based on these negotiations. This is consistent with what BPA learned through its 2017 study of national accounts, which included interviews with HVAC manufacturers.[8]

Distributors explained that the equipment is usually all pre-specified for the construction of new facilities, because each customer will typically have one or just a few building plans. For example, one distributor explained how most big-box retailers and national fast-food restaurants tend to use a single floorplan that calls for specific equipment. For other, unique facilities (e.g., customers taking over existing spaces), the equipment is not necessarily predetermined, but the customer (or contractor) will still work directly with the manufacturer to determine the project needs and equipment pricing; distributors indicated they play no role in these negotiations.

Some equipment associated with these sales to national accounts do flow through local distributors in the normal ways. That is, the installing contractor contacts the distributor and obtains the equipment. However, in these instances, distributors explained they are held to the fixed, discounted prices. Conversely, some equipment associated with national accounts is obtained by contractors directly from the manufacturers, and the local distributors said they play no role in providing the equipment. The only caveat to this latter scenario is that one distributor said that some manufacturers pay distributors a territory credit, which helps compensate distributors for lost sales, while ensuring the distributor can serve as a resource if questions or issues arise about equipment after installation.

None of the distributors said they track national account sales any differently than other product sales. Thus, any national account sales that flow through distributors (as opposed to direct-from-manufacturer shipments) should be present in distributor sales data.

Distributors said their stocking practices are mostly driven by market demand.

In keeping with the earlier *BPA Market Intelligence Report* findings, distributors reported that they only stock what they can sell, meaning demand drives their stocking practices. In addition, distributors did not feel their stocking practices negatively affect the efficiency of equipment in the market. Contractors

[8] A presentation documenting the key findings from this study is available on BPA's website at: https://www.bpa.gov/EE/Utility/research-archive/Documents/Momentum-Savings-Resources/National_Accounts.pdf

agreed that there are no significant supply-side barriers for efficient products because they can readily get the equipment they need from the extensive distribution networks available to them.[9]

While it is virtually impossible to stock everything a contractor might want, given the number of manufacturers, equipment types, and parts that might be needed, most distributors said they stock equipment of varying efficiency levels that meet the common needs of the market. Interviews revealed that some contractors tend to work with higher-end equipment, while others tend to work with lower-end equipment. However, most distributors agreed that even lower-end equipment is becoming more efficient. Distributors and contractors indicated that it was not long ago that basic equipment was a standard 80% efficient furnace or a 13 Seasonal Energy Efficiency Ratio (SEER) heat pump, but now the basics seem to be a 95% efficient furnace and a 14 SEER minimum on the heat pump. One distributor mentioned how he used to sell only one or two 20 SEER units a year, but now stocks half a dozen at all times to keep pace with demand.

When there are instances where a certain piece of high-efficiency equipment is not stocked, it is typically available from a regional distribution center from which it can typically be obtained by contractors in a day or two. Other, rarer or more specialized equipment might need to be ordered elsewhere, which might take 7-10 days to obtain.

Similarly, single-family home builders did not report any major barriers to obtaining more efficient technologies, likely because they operate within the same general supply chain. One builder mentioned they sometimes face challenges finding appropriate DHPs, because these are sometimes super-high-efficiency options selected by customers as a custom option; however, that was the only stocking issue the interviews identified.

Government regulations and associated equipment limitations pose barriers to increasing efficiency in manufactured homes.

Manufactured home builders said they face some supply-side barriers to obtaining HVAC equipment, which may impact the efficiency of installed HVAC systems. Since interviewees reported that HUD must approve gas equipment for the manufactured home setting, they said that there are fewer gas furnace options to choose from. However, one respondent noted that they have access to HUD-approved 95% efficient gas forced air furnaces. Further, respondents said that there are few companies that specialize in electric or gas furnaces geared toward manufactured homes, which limits manufactured home builders' HVAC choices. Given their production schedule, which can be about one month out, respondents said wait times do not hinder installation of specialized HVAC equipment. The research team heard that a single, inefficient technology—electric forced air furnaces—dominates manufactured homes, and this is not expected to change.

[9] While these findings may seem to conflict with the existing understanding of the market—namely that distributor stocking practices are a barrier to increasing efficiency—it is important to note that the findings presented here are based on distributor and contractor perspectives. That is, the distributors and contractors interviewed as part of this study did not feel the distributor stocking practices were a barrier to increasing efficiency. However, this is not the same thing as other market actors' (e.g., BPA or others associated with energy efficiency programs) perceptions of whether the market is efficient enough or whether more could be done to increase efficiency.

Technology Changes

In addition to exploring market structure and operations (described in the previous section), the research team assessed key technology characteristics of the Northwest HVAC market and how these have been changing in recent years.[10] Table 3 exhibits the specific research questions and the relevant market actors for each question for this topic area.

Table 3: Technology Change Research Questions by Market Actor

Research Question	Distributors and Manufacturer Reps	Contractors	Single-Family Home Builders	Manufactured Home Builders
What changes in the sales mixes have occurred over the past three to four years?	X	X	X	X
What changes in the sales mixes are expected over the next several years? Which technologies are expected to grow the most? Are there any technologies that the market seems to be moving away from?	X	X	X	X
How accurate are turnover rates for HVAC technologies?	X	X		
What technologies are being installed in new construction and manufactured homes?			X	X
What is the role of smart thermostats in the marketplace? Who is selling them? How many homes have them? Are there device compatibility issues?	X	X	X	X

DHPs, VRF, new motors, and inverters have gained ground in the residential market and are expected to continue, though general improvements in equipment efficiencies with gas furnaces, heat pumps, and central air conditioners are also affecting the market.

Most recent residential market changes have centered on just a few technologies; respondents mainly cited ductless systems, VRF, efficient motors, and inverters. While most distributors could not confidently

[10] As a separate task, the research team completed an HVAC Technology Guide in January 2018 which explains how the different HVAC technologies work, their applications and competing technologies, market saturations, and how these technologies are regulated by building codes and standards.

estimate how much these technologies have changed over the past three to four years, two distributors provided rather consistent estimates: about a 35% increase in ductless systems and a 40% increase in VRF over this time period.

Almost all distributors, contractors, and single-family home builders who focus on efficient technologies noted increases in DHP and VRF systems over the past three to four years. While some noted that ductless equipment used to be a niche product—often added on in single-room or garage applications—it is becoming far more common for whole-house heating and cooling. Multiple market actors presented their belief that "ductless is taking over."

Several distributors and contractors also mentioned that there has been a general increase in constant torque motors and electronically commutated motors (ECMs) in residential and commercial applications. Both constant torque motors and ECMs are far more efficient than older, permanent split capacitor (PSC) motors, which have been the standard in lower-tier HVAC equipment for quite some time.[11] One distributor noted that as federal regulations become more stringent and the industry moves towards higher efficiency, PSC motors will likely get entirely phased out and constant torque motors will become the minimum standard due to limitations inherent with the PSC technology. In fact, the U.S. Department of Energy (DOE) issued new standards for furnace fans that go into effect July 3, 2019, which dictate new minimums for fan energy ratings that are not likely attainable with PSC technology. The one distributor who was able to quantify changes estimated that efficient motors are currently about 20-30% of motor sales at his company, but he expects this may increase to 50-60% by the end of 2018.

Higher efficiency inverter technologies are also appearing in both ductless and ducted equipment.[12] In the past, inverter technology was generally limited to super high-efficiency equipment (e.g., 20+ SEER); however, manufacturers are now beginning to include it in less efficient equipment. One distributor predicted that in the next 10 years inverters will be ubiquitous.

Finally, market actors also mentioned general improvements in residential equipment efficiency levels, emphasizing gas forced air furnaces, heat pumps, and air conditioners. Distributors mentioned how most furnaces sold used to be 80% efficient, but now 90% and 95% efficient are far more common. Likewise, 13 SEER air conditioners and 14 SEER heat pumps are becoming common.

When researchers asked respondents about the technologies they expect will increase over the *next* several years, they tended to name the same technologies they cited when asked about changes over the *past* few years. However, new refrigerants also came up as a promising new advancement for the industry. For example, though not yet common, R-32 is considered much safer for the climate and conveys heat better, meaning that equipment can run more efficiently. Table 4 shows the key market changes that have taken place in the residential market over the past several years and will likely continue in the future.

[11] Comparatively, PSC motors are the least efficient of the three main motor technologies. Manufacturers typically position ECMs as the premium-tier product and constant torque motors as the mid-tier product. https://www.achrnews.com/articles/112674-comparing-motor-technologies

[12] Inverters are an advanced variable-speed compressor technology found in condensing units in air conditioners and heat pumps. By using variable-speed technology to operate at the lowest possible setting at a given time, inverter compressors ensure the HVAC unit uses the least amount of energy necessary to achieve the thermostat's temperature set-point. Further, inverters avoid the on/off cycling inherent in traditional single-speed compressors, which offer the added benefit of decreased wear and, in-turn, a longer compressor lifespan.

Table 4: Changes in Sales Mixes to the Residential Market

Increasing Market Share	Decreasing Market Share
DHPs/VRF	Ducted/split systems
ECM Motors	PSC Motors
High efficiency gas furnaces (90%+)	Lower efficiency gas furnaces (80%)
Smart thermostats	Thermostats without Wi-Fi capabilities
Non-electric heat	Electric baseboard heat
New Refrigerants	Traditional refrigerants
	Oil furnaces
	Air-cooled equipment
	Other low efficiency electric equipment

New motors, VRF, and building automation/controls are infiltrating the commercial market.

Similar to the residential side of the market, only a few technology changes have affected the commercial market over the past few years and are expected to affect the commercial market over the next few years. Increases in efficient motors, VRF, and building automation/controls were most apparent in interviews. The motor changes mentioned by market actors closely mirrored the changes discussed in the residential sector—that is, constant torque and ECM motors are becoming increasingly common and PSC motors declining.

Consistent with past research findings, VRF continues to become much more common in high-rise condominium and commercial applications. The growth in high-rise multifamily and office building construction in the region over the past several years—especially the Portland and Seattle areas—is contributing to this increase. It is worth noting that one distributor discussed how, in the past (or with other equipment), projects would involve the installation of the HVAC equipment and controls—two distinct revenue streams for distributors. However, many VRF manufacturers are approaching the market differently, providing the equipment and controls as one package, thus reducing control-related revenues for some distributors. This is consistent with what BPA observed the VRF manufacturers focusing on at past AHR Expos in 2016 and 2017.

Distributors noted that advanced building automation and controls represent one of the fastest-changing technologies in recent years. They are advancing, and the number of automation/control products available is growing each year. Cloud-based systems that do not tie to the building's computing infrastructure were highlighted by contractors, and considered safer than older systems, with one distributor mentioning the large Target data breach that occurred in 2013, in which hackers gained access to Target's computing network through the HVAC automation system. One distributor also noted that because of the range of available technology solutions and competitive costs, advanced building automation/controls are also becoming more common in light commercial applications than they have been in the past.

Like with the residential market, when researchers asked respondents what technologies they expect to increase in the commercial market over the *next* several years, they tended to name the same technologies mentioned when asked about changes over the *past* few years. However, it is worth noting that some distributors indicated that they did not expect too much change in the commercial market, unless government regulations change, because the commercial market is driven much more by cost than by desired features. Nevertheless, Table 5 shows the key market changes that have taken place in the residential market over the past several years but are also expected to continue into the future.

Table 5. Changes in Sales Mix to the Commercial Market

Increasing	Decreasing
Efficient motors (constant torque and ECM)	PSC motors
VRF	Chillers
Building automation/controls	Air conditioning in small offices (movement towards natural ventilation)
	Oil compressors
	On-site generation and combined heat and power

Single-family homes systems vary widely, but are dominated by just a few technologies, though efficiency seems to be the trend.

Single-family home builders revealed they install a wide range of equipment, which largely includes (ducted and ductless) heat pumps, gas forced air furnaces, and central air conditioners. A couple of builders also stated they install boilers and cadet-style wall heaters.

The single larger, tract-home builder, who builds hundreds of homes across the Northwest each year, reported that they install gas forced air furnaces and central air conditioners in almost all their homes, though some occasionally get DHPs. They noted that only one out of roughly 100 developments they built in the region featured ductless homes.

The smaller, custom builders said they are installing both ducted and ductless systems. Half said all they do is ductless, while half said 80% or more of their work is ducted. However, some of the custom builders also noted that a lot of their projects are in more rural areas, which means gas is not available. In those cases, DHPs predominate.

From the single-family home builders' perspective, four main things have changed over the past few years:

- **The DHP market is growing.** What used to be a somewhat niche product has now become mainstream. And it is not just contractors recommending them, customers are also asking for them, which was relatively unusual in the HVAC market in the past.

- **Cooling is becoming standard.** While cooling was optional for many Northwest homes in the past, some of the builders indicated they are now installing cooling in all their homes. New cooling comes in the form of both DHPs and traditional central air conditioners.
- **Homes are being built tighter, better, and more insulated, providing significant energy efficiency benefits to the market.** In many instances, builders said that this also means the HVAC system does not need to be as efficient or largely-sized as it would need to be in a less-insulated or draftier structure.
- **Gas forced air furnaces are becoming much more efficient.** While 80% efficient furnaces used to be the norm only a few years prior, now they are installing 90%+ efficient units in almost all their builds.

Heat pumps are the only technology that single-family home builders expect to grow over the next few years. It is also worth noting that the large, national home builder, who builds hundreds of homes in the region each year, mentioned how building ducted homes is becoming too expensive and will soon no longer be cost effective. He expects a large movement towards DHPs, even though they have focused very little on ductless construction to date. Nevertheless, this builder expects DHPs will increase 15-20% in the next year alone and will be in about 50-75% of their new homes in the next three to four years.

Builders said that forced air furnaces and central air conditioning systems are likely to decline in tandem with the growth of DHP technologies. Builders also expect electric resistance heat to decrease in coming years.

A single, inefficient technology—electric forced air furnaces—dominates manufactured homes, and this is not expected to change.

Manufactured home builders said they typically install ducted electric forced air furnaces in their homes, sizing the units in accordance with the square footage of the manufactured home in which it will be installed. This is consistent with findings from the 2011 Regional Building Stock Assessment, which found that 52% of manufactured homes had electric forced air furnace. Manufactured home builders said their electric furnaces typically range from 15 kW to 23 kW in size. Gas forced air furnaces are occasionally installed for end-users siting their new homes on lots with access to natural gas, but this scenario is less common. Only two respondents said they install anything other than electric or gas furnaces for heating purposes; one noted they sometimes install DHP systems with two indoor heads and the other indicated they install a "handful" of electric baseboard heaters every year.

Central air conditioning is rarely installed at the factory; only one manufactured home builder said they install central air conditioners, noting that they only install them as an occasional custom service. However, respondents said that manufactured home end-users may hire a contractor to retrofit their sited manufactured home with an air conditioning system.

Other than one respondent who said they install some DHPs now, manufactured home builders reported there have been no changes to their HVAC sales mixes in the last three to four years. Similarly, manufactured home builders predicted there will be no changes to their HVAC sales mixes in the next several years.

Estimated useful lives are generally reliable, though maintenance and installation practices impact operating life.

Most distributors and contractors feel the useful equipment life estimates manufacturers provide are generally accurate. But respondents explained that this average is a function of the maintenance and installation conditions that either shorten or lengthen the product's lifespan. The elaborated that poorly installed and maintained systems have a shorter than listed product lifespan; properly installed and maintained systems can last longer than the manufacturer's estimated lifespan. Some feel estimated lives are more accurate for high-efficiency equipment than lower-efficiency equipment, because less-efficient equipment is not using new, higher-quality components like inverters, sophisticated solid-state electronics, direct current (DC) fans, ECMs, and so forth – all technologies that in themselves tend to have more accurate and longer lives.

Nevertheless, some respondents questioned the usefulness of the estimated average life statistic because manufacturers report one estimated life for a product, regardless of where it is installed in the country. As one contact explained: an air conditioner installed in Florida or Texas would likely have a notably shorter life span than the same unit installed in Portland or Seattle.

In general, turnover rates can be higher than manufacturer estimates when a system is poorly maintained, and contractors said they routinely encounter poorly maintained systems when conducting house calls. Contractors indicated poor system maintenance is a preeminent problem in residential HVAC, because few homeowners understand the importance of routine HVAC maintenance. They noted requisite maintenance is particularly rare in low-income and rental housing. Contractors noted the following maintenance problems can shorten a product's lifespan:

- Not changing filters
- Improper system charge
- Improper air flow/static pressure

Contractors said a quality installation also affects a product's life span, elaborating that factors such as system sizing and duct sizing can affect how hard a system needs to work and how long it will last. For example, oversized air conditioners may not last as long as expected because the system tends to run for shorter periods, increasing the rate the compressor needs to start and stop, which degrades life the most. One distributor estimated that 30-40% of residential units and 5-7% of commercial units are improperly sized.

Contractors also noted that climate affects a product's expected useful life. Coastal areas have airborne salt exposure (which harms most mechanical equipment) and some areas have extreme operating temperatures (far north for heat, and far south for cooling), which can have notable impacts on equipment life.

Smart thermostats are here to stay, and everyone is starting to play.

Variability exists within market actor groups, but across all groups the trend is clear: smart thermostats are – and will continue to be – on the rise.

Most of the interviewed distributors indicated that they sell smart thermostats. Some referred to proprietary thermostats like one made by York, which is not a learning, connected thermostat; however, this section focuses on smart thermostats like the Nest, ecobee, or Honeywell Lyric. Nevertheless, all noted significant growth in the sales of smart thermostats, and one estimated 20% growth in the last year alone. Most of the distributors bundle smart thermostats with systems, but they also sell them as stand-alone equipment. When bundled, smart thermostats tend to get packaged with higher-efficiency equipment (one mentioned 20 SEER or higher). Estimates of how many bundled units are sold ranged from 10% to 90% of all HVAC system sales.

Distributors mentioned that they came into smart thermostat sales late in the game. Initially, smart thermostats were available to end-users online, either directly from the manufacturers or through other sites like Amazon, and then they moved into some of the big-box stores like The Home Depot, Lowes, and Best Buy. It was not until relatively recently that they moved into distributor warehouses.[13]

All but one contractor said they install smart thermostats. However, contractor installation activity varied significantly, with similar proportions saying they install smart thermostats rarely, on about half of their jobs, or on most of their jobs. Contractors were similarly split on their use of smart thermostats as an upsell on maintenance jobs. Although all contractors who install smart thermostats said they sometimes try to upsell smart thermostats during maintenance calls, some said they do so rarely, and others said they try to upsell on every maintenance job where the customer does not already have a smart thermostat. Most contractors offer smart thermostats as a bundled option with their new HVAC sales; estimates ranged from 40% to "nearly all" that select this option. Contractors typically provide the unit when installing them (as opposed to the customer providing a unit they purchased online or from a store), and all contractors noted they get their units from their HVAC distributors.

Two contractors elaborated that many of their customers do not enable the Wi-Fi settings on their units, with one estimating that 97% of their customers do not enable the Wi-Fi connection that is largely responsible for the "smart" features of the thermostat. For their part, contractors said they rarely encounter technical problems when installing smart thermostats. But, they did say they only install smart thermostats with ducted systems, noting that DHPs rely on unique remote control-style thermostats.

Overall, the contractor interview data suggests that smart thermostats are still a relatively rare feature in Northwest homes. About one-third of contractors estimated that 5% or fewer homes currently have smart thermostats, and the other two-thirds suggested that about 15% or more currently use them. One contractor said he estimates that smart thermostats are currently in 40% of the Spokane area homes they see.

Most single-family home builders said they are doing some builds with smart thermostats, though they are usually optional equipment. Builders elaborated that smart thermostats are most commonly installed with forced air furnace/central air conditioning combinations, or with ducted heat pumps. Estimates of current builds with smart thermostats ranged from 15-70%. Nevertheless, all builders expect explosive growth in smart thermostats over the next few years. Multiple builders estimated that over 50% of new builds will include them within the next couple years.

[13] How recently is not totally clear as one respondent reported only selling them for only the past six months, though another reported selling them since at least the beginning of 2016; other respondents did not provide a timeframe for how long they have been selling the units.

Smart thermostats are rarely installed in new manufactured homes in the Northwest. Only half of manufactured home builders ever install them, noting they install them in about 5-10% of their new homes. Both of these manufactured home builders were unsure if this figure would grow in the coming years.

Decision Making

The research team set out to understand how the supply-side actors think and end-use customers make decisions regarding equipment, as well as how programs and contractors affect these decisions. Table 6 exhibits the specific research questions and the relevant market actor interviews for this topic area.

Table 6: Decision Making Research Questions by Market Actor

Research Question	Distributors and Manufacturer Reps	Contractors	Single Family Home Builders	Manufactured Home Builders
How much do different factors influence product choices? (e.g., price, comfort, air quality, economy, existing structure, energy efficiency programs, others)?	X		X	X
How do customers decide between repairing or replacing their HVAC equipment?		X		
How often do customers make conversions (to other or like fuel)? What factors drive these decisions?		X		
How aware are contractors of energy efficiency programs? Are customers being directed to programs? Are customers asking about programs?		X		
Do contractors/builders attempt to "sell up" to more efficient technologies outside of programs? How much/how often?		X	X	X

While price, comfort, and efficiency drive equipment choices, contractor recommendations often prevail for the residential market; project needs drive choices on the commercial side.

Almost all distributors mentioned price, comfort, and efficiency as drivers of equipment choices, regardless of whether referring to residential or commercial customers. However, it is difficult to rank order these three as their importance varied from distributor to distributor.

Distributors said that the availability of incentives or rebates is also important, though more so for residential customers. On the commercial side, distributors said reliability is a concern for many business customers, where equipment downtime can equate to lost revenues, so proactive equipment replacement is common. However, some distributors and contactors also noted that some smaller commercial customers often tend to be more reactive about their HVAC equipment, running equipment until failure, then needing an immediate replacement.

Distributors said contractors have minimal influence on commercial customer purchase decisions, where it is mostly driven by building specifiers (i.e., engineers and architects) and project needs (e.g., the need for a specific type or size of equipment). On the residential side, contractor recommendations play a significant role, though the availability of different sources of information via the internet means customers are beginning to play a bigger part. Typically, a contractor will assess a customer's needs and propose a specific type of equipment with a bid. While a customer might obtain a couple of bids and contractors might recommend different types (or predominantly brands and maybe sizes) of equipment, the customer typically selects a bid and goes with the equipment recommended by the selected contractor. However, one contractor highlighted that this is increasingly changing, with many customers requesting a specific type and model of equipment that they learned about doing their own internet research.

For single-family homes, building codes and price are the largest drivers of equipment choices.

Single-family home builders said that building codes drive a lot of the equipment choices, elaborating that many new homes are planned out and the equipment is specified for the structure based on meeting minimum building codes for the locality. While some builders emphasize energy efficiency and often spec out the builds with higher-than-minimum equipment, others do not.

Some builders perceive price as the paramount concern for homebuyers, and they spec out their HVAC equipment accordingly. Other builders (mostly higher-end, custom builders) seem to deal with clientele who value energy efficiency, as well as comfort and equipment operating noise, so they are willing to pay more for higher-end base equipment or optional system upgrades.

For manufactured homes, price and size concerns are the largest drivers of equipment choices.

Since manufactured home builders do not directly interact with end-users, end-users have less impact on HVAC choices in new manufactured homes. In fact, interviewed manufactured home builders said they were unable to comment on end-user desires, because they sell all of their homes through independent dealers. Given that affordability is a central concern in the manufactured home market, manufactured home builders often seek low-cost HVAC options for their new homes. HVAC choices are also pragmatic; manufactured home builders choose HVAC units based on their applicability to the home's design (e.g., ductwork, cabinet space, transportability, etc.). As a result, manufactured home builders mostly use low-cost electric furnaces that are sized in accordance with the square footage of the home. If end-users have access to natural gas, they can request a gas furnace through their dealer.

Contractor's said that their recommendations dictate whether a unit is repaired or replaced.

According to contractors, residential customers are highly reliant on their contractor's recommendation when it comes to HVAC service and repair. Contractors tend to recommend system replacement to their customers when servicing a particularly old unit, or when repair costs are exceedingly high. Although most contractors are completely scenario-dependent when deciding whether to recommend replacement or repair, others focus their business model on always recommending one or the other. Contractors reported that their customers typically take their recommendation to replace their HVAC systems when the scenario justifies it. However, they noted that lower-income customers and rental property landlords commonly choose the least-cost option, which is often a repair instead of a replacement. Ultimately, homeowners tend to replace equipment when repair costs begin to approach or exceed the cost of a new system, or when servicing an old unit no longer makes financial or pragmatic sense. Interviewees revealed that homeowners typically opt to repair their existing system in all other scenarios.

Technology conversions are reportedly a minority of HVAC contracting work, but when they do occur, they are typically driven by desire to save on operating costs and enhance comfort.

Contractor interviews suggest that technology conversions are relatively infrequent in the Northwest as the technologies that commonly get decommissioned (such as electric forced air furnaces) for other technology types are not commonly found in Northwest homes. Thus, while certain technologies are more likely to be decommissioned as the result of a technology switch, the decommissioned technology types constitute only a small slice of a contractor's jobs.

Contractor interview data provides the following insights about technology conversions in Northwest homes:

- **Central air and gas furnace conversions to other technology types are rare, as customers tend to replace these systems with the same HVAC technology type;** when they do occur, contractors said their customers typically convert to ducted or ductless heat pump technology. *On average, contractors reported that 12% of their central air conditioner jobs and 7% of gas furnaces jobs result in converting to different technology types.*
- **Electric furnaces are rare in the Northwest,[14] but when contractors do encounter them they commonly replace them with a different type of heating technology;** contractors said their customers either convert to gas furnaces or (ducted or ductless) heat pumps. *On average, contractors reported that 58% of their electric furnace jobs result in converting to a different technology type.*
- **Electric baseboards are rare in the Northwest,[15] but when contractors do encounter them they commonly replace them with a different type of heating technology;** customers typically convert to DHPs, though sometimes baseboards are kept online as backup heating to

[14] As of NEEA's 2011 *Residential Building Stock Assessment* (*RBSA*), less than 10% of forced air furnaces in Northwest single-family homes used electric fuel.

[15] As of the 2011 *RBSA*, about 12% of Northwest single-family homes used baseboard heat as their primary heating system.

supplement a new DHP. *On average, contractors reported that 60% of their baseboard heater jobs result in converting to a different technology type.*

- **DHP conversions are becoming more common, which is displacing some window air conditioning;** contractors often cited DHPs as a popular technology that homeowners convert to, regardless of previous HVAC technology type. Contractors said that homeowners converting to DHPs that previously did not have central air conditioning often take out window air conditioning units after installing their new DHP.
- **Oil fuel is relatively uncommon at this point in the Northwest,[16] but there are some conversions happening there as well;** contractors said customers typically convert to either heat pumps or gas furnaces if natural gas is available on site.

Contractors explained that customers convert technologies for monetary and comfort reasons. Commonly, these switch-outs include decommissioning an old, inefficient HVAC system that produces mediocre comfort and high energy bills. Others may switch to a technology that uses a cheaper fuel type. Some customers may take proactive measures to replace their costly-to-operate system with a superior technology, but many conversions are preceded by a system failure.

Energy efficiency programs have had a big impact in the Northwest and have changed the way many contractors do business.

Contractor interviews suggest that energy efficiency programs have had a strong impact on the residential HVAC market. Interviewed contractors were very aware of energy efficiency programs, with nearly all saying they promote or use them in their daily business. Interviewed contractors commonly promote local programs "100%" of the time to their customers.[17] These findings dovetail with a larger conclusion about HVAC contractors in the Northwest: many contractors are not only selling HVAC equipment and maintenance, they are also selling energy efficiency as a service (in that they sell technological solutions to make their customer's homes more efficient).

Interviews revealed that contractors are focused on providing energy-efficient solutions for their customers, and local energy efficiency rebates or incentives constitute another sales tool contractors can use to sell their next high-efficiency system. Contractors generally indicated that their energy efficiency program activity was comparable to their competitors in their region.

Northwest residential HVAC customers appear to be well aware of energy efficiency program opportunities, as contractors reported customers frequently ask about energy efficiency rebates. Nearly all interviewed contractors said at least half of their customers ask about energy efficiency programs before they have a chance to bring them up, with about one-third indicating that 90% or more of their customers ask about them.

[16] As of the 2011 *RBSA*, less than 4% of Northwest single-family homes used oil fuel.

[17] Note that this may be a biased sample: contractors willing to speak on the phone about HVAC energy consumption market trends may be more likely to promote energy-efficient systems and programs.

Offering options for greater efficiency prevail across market actors.

Interviewed contractors indicated they almost always promote high efficiency equipment to their customers. However, contractors understand that it is ultimately the customer's decision, so they will install whatever the customer agrees to. Contractors typically offer their customers a range of efficiencies to choose from; "good, better, best" is a common sales strategy. Contractors commonly said that most customers take the middle option, but multiple contractors said half or more of their customers will choose the "best" efficiency system.

Most custom builders offer customers HVAC system options. Some customers are very involved in their HVAC system decisions, but others just trust the builder's recommendations. One builder noted that he has never once talked to a client about the HVAC system. Larger builders tend to build to specification, where they may offer customers options such as an electric heat pump or gas forced air furnace, or ducted or DHPs, but do not focus on specific brand or efficiency levels of the units. These builders determine necessary unit efficiency based on efficiency credits allowed under code, which often involves a trade-off between shell and HVAC to remain cost-effective.

Since manufactured home builders do not interact with end-users, it is up to the dealer to upsell energy-efficient options to end-users. However, energy efficiency upgrades rarely take the form of HVAC. Instead, end-users may upgrade energy-efficient shell measures (e.g., windows or insulation). Gas end-users can upgrade the efficiency of their gas furnace for an added cost; however, with the exception of one manufactured home builder who offers DHPs, manufactured home builders do not offer efficiency upgrades for electric furnaces.

Installation and Maintenance Trends

The research team explored the general dynamics at play in the Northwest HVAC market regarding installation and maintenance trends. Table 7 exhibits the specific research questions and the relevant market actors for this topic area. As shown, because these research questions were primarily focused on installation practices, these questions were directed towards contractors.

Table 7: Installation and Maintenance Trend Research Questions by Market Actor

Research Question	Distributors and Manufacturer Reps	Contractors	Single Family Home Builders	Manufactured Home Builders
Of the entire market, what proportion of units go to replace-on-burnout, new construction, and early retirement? Does this vary by technology or efficiency class?		X		
What are the trends with installation of auxiliary HVAC equipment? What proportion of buildings without existing cooling are adding cooling (mini-splits, air source heat pumps, central air		X		

Research Question	Distributors and Manufacturer Reps	Contractors	Single Family Home Builders	Manufactured Home Builders
conditioners, room air conditioners, others)?				
Are sizing practices changing (i.e., more right-sized units today than in the past)? Is this more or less prevalent with certain technologies?		X		
What proportion of units seen in the market are improperly installed/maintained such that energy consumption would increase across different technologies?		X		

Replacement-on-burnout dominates contractor installs.

Contractors said that most of the new HVAC units they install go into existing homes that need new HVAC units to replace ones that have malfunctioned or "burned out." On average, interviewed contractors said that about two-thirds of new HVAC units installed in Northwest homes are replacing failed units. Early replacement (i.e., when homeowners install a new HVAC unit despite having a well-functioning one in place) is relatively rare in the Northwest (an average of about one-sixth, according to interviewed contractors). New construction constitutes a similarly small proportion (also an average of about one-sixth) of interviewed HVAC contractors' work. Contractors noted that these trends are consistent across all HVAC technologies they install.

The addition of cooling is becoming more common in residential homes.

Market actor interviews reveal that cooling is becoming increasingly common in the Northwest, with contractors indicting they frequently add cooling to homes that did not originally have cooling systems in place. New cooling activity varies significantly, with contractors estimating that between 1% and 100% of their new air conditioning installations involve adding new cooling capabilities to a home. Idaho contractors appear to be particularly less likely to add new cooling load, as both Idaho contractors said these types of projects represent 5% or less of their air conditioning-related jobs. Comparison with the 2011 RBSA suggests this finding is likely related to the already high penetration of residential cooling in Idaho.[18] Contractors said that they typically add either a heat pump or a traditional split-system central air conditioner when adding first-time cooling to a home. Contractors explained that homes without existing ductwork generally go to ductless solutions for their new cooling upgrades.

Contractor interviews suggest that auxiliary (back up) heating installation is less common than new cooling installs, with contractors indicating that 0% to 25% of their heating installations are of

[18] According to the 2011 *RBSA*, Idaho has the highest saturation of air conditioning among the four Northwest states.

supplementary systems. Contractors said this somewhat rare scenario is most frequently the installation of a DHP, which compliments the existing heating system in the home. Only one contractor mentioned installing Cadet-style wall heaters as a supplemental heating source.

Sizing issues plague the market, but there is uncertainty as to whether this is getting better or worse, or has remained unchanged.

Contractors said that improper sizing is a common installation issue that continues to hurt the efficiencies and operations of residential HVAC systems in the Northwest. Interviewed contractors said they routinely encounter improperly sized systems in the field, with contractors indicating that sizing is problematic in as few as 10% to as many as 99% of the homes they service.[19] Nearly all contractors said oversizing is the more typical problem, with some contractors noting that forced air systems are particularly vulnerable to oversizing. Contractors are divided as to whether sizing in the industry has gotten better or worse over the past few years, with one-third saying it has gotten worse, one-third saying it has gotten better, and one-third saying it has not changed. Interestingly, those who said it has gotten better typically caveated their response by clarifying that it was their firm that had improved in recent years.

Improperly installed and/or maintained HVAC systems are more the norm than the exception in the Northwest.

Contractors reported that HVAC installation and maintenance practices (or, in the case of the latter, a lack thereof) often hinder system efficiency in the Northwest. Interviewed contractors said they often encounter poorly installed or maintained systems in the field, ranging from 20% to 95% of their field visits.[20] Contractors elaborated that poor maintenance is a preeminent issue among residential customers, noting that few customers understand how to properly maintain their systems or take the initiative to do so. Contractors revealed that customers often fail to change their filters, which is detrimental to system performance, efficiency, and lifespan. Contractors said this problem is particularly pronounced in rental homes. Improper installation and maintenance is especially problematic with forced air systems, with contractors noting that shoddy ductwork (including poor design and leakage) can exacerbate the issue.

[19] Contractors did not elaborate on the average age of improperly sized systems. However, the research team reasons that contractor reports of improperly sized systems are likely mostly referencing older systems, since contractors said that customers tend to wait until there is a problem before ever servicing their HVAC.

[20] Contractors did not elaborate on the average age of improperly installed or maintained systems. However, the research team reasons that contractor reports of poorly installed systems are likely mostly referencing older systems, since contractors said that customers tend to wait until there is a problem before ever servicing their HVAC. However, this means that poorly maintained systems span the entire residential market, including new and old systems.

Future Research Opportunities

This qualitative study utilized interviews with a small number of HVAC market actors to shed light on the key market trends in Northwest HVAC market, with a particular focus on the residential sector to inform the residential market model that BPA is building prior to the commercial model. The findings address some of BPA's key questions about the HVAC market; however, the research team acknowledges some remaining questions that may require additional research.

In support of Momentum Savings analysis, the research team suggests the following questions that could benefit from additional investigation, as well as the actions that the research team will take to further investigate these areas for modeling:

- **What is the penetration rate of new cooling, especially for residential applications?** Although contractors and single-family home builders reported substantial gains in new residential cooling load, this research cannot accurately quantify it. The interviews suggest this may be a new enough trend that cooling saturations may have changed since the 2011 Residential Building Stock Assessment, a trend which may be reflected in the forthcoming results from the 2016 RBSA. If cooling in residential homes becomes ubiquitous throughout the Northwest, it will have dramatic impacts on regional energy consumption and demand during peak periods. The research team, as part of its ongoing market modeling work, will review the findings of the 2016 RBSA and compare 2011 to 2016 saturations for central air conditioning and heat pumps. The team will reflect any significant changes in saturation by allowing the saturation inputs to the model to increase over time.
- **What is the growth rate of DHPs?** Respondents unanimously agreed that DHPs are becoming increasingly popular in single family homes, but this qualitative research is unable to accurately quantify the true extent of this growth. Again, in order to better understand the current prevalence of ductless heat pumps and to gauge future growth, the team will compare DHP saturations in the 2011 RBSA to the results of the 2016 RBSA, and will reflect changing saturations over time in the development of model inputs. The research team will also review longitudinal trends in sales data collected by NEEA to assess the growth rate of DHPs.
- **What is the prevalence and growth rate of smart thermostats?** Smart thermostats are no longer a fad for "techies" or early adopters; they are mainstream and will continue to gain popularity. However, this research cannot elicit accurate estimates of the penetration of smart thermostats, due to the small sample of respondents, who provided widely varying estimates. Further, unlike most HVAC equipment, smart thermostats are available from a wide range of suppliers, many of which this study does not capture (e.g., online, manufacturers, big-box retailers). Thus, many smart thermostats are being self-installed by customers, rendering estimation of prevalence difficult. The 2011 RBSA does not explicitly track smart thermostats, but the 2016 RBSA does. To better understand the rate of change in the market for smart thermostats, the research team will explore other information sources.
- **What percent of sales go to national accounts?** While some national account sales flow directly from manufacturers to end users or their contractors, other sales flow through regional distributors. Interview findings suggest that distributors track these national sales (in cases where they do flow through regional distributors) in the same way they track other sales, meaning a portion of national account sales would be reflected in regional distributor sales data. However,

for cases where sales flow directly from manufacturers to end users (or their contractors), the interview results suggest that these sales would not be captured in regional distributor sales data. Future research efforts could be allocated to probing this issue deeper with distributors and manufacturers. It may involve bringing some manufacturers into the discussion to better understand their national account management structure and their estimates of product flow. This will be important for applying the chain logic method to commercial sales data for the commercial momentum savings model.

Appendix A - Respondent Characteristics

Prior to addressing the specific research objectives and questions, the research team collected firmographic information from each of the market actors during the interviews. This firmographic information is summarized, by market actor, in this appendix.

Distributors and Manufacturer Representatives

Table 8: Company Branch Location

State	Count
Washington	7
Oregon	4
Total	**11**

Table 9: Respondent Role at Company

Position	Count
Regional Sales	6
Branch Manager	2
Owner	2
Engineering Director	1
Total	**11**

Table 10: Sectors Served

Position	Count
Residential only	1
Commercial only	3
Both	7
Total	**11**

Table 11: Projects Served (Multiple Responses Allowed)

Position	Count
New Construction	11
Retrofit	11
Total	**11**

Contractors

Table 12: Contractor [Office] Location

State	Count
Washington	3
Oregon	3
Idaho	2
Montana	2
Total	**10**

Table 13: Respondent Role at Company

Position	Count
President/Owner	5
Manager	3
Field Estimator (Sales)	1
Non-Management Technician	1
Total	**10**

Table 14: Number of Employees at Company

Number of Employees	Count
One	2
Two or three	2
35-65	2
More than 100	4
Total	**10**

Table 15: Sectors Worked In

Sector	Count	Average Proportion of Total Jobs
Residential	10	80%
Small commercial (<25 tons)	8	19%
Large commercial (25+ tons)	2	1%
Total	**10**	**100%**

Table 16: Approximate Number of New HVAC Installs Each Year

Number of new installs	Count
Zero	1
Ten to twenty	2
500-999	3
1000-1750	4
Total	**10**

Table 17: Approximate Number of Maintenance Calls Each Year

Number of Maintenance Calls Each Year	Count
200-250	2
1000-5000	3
6000-13000	3
~100,000	1
Don't know ("$1-2 million in sales per year")	1
Total	**10**

Table 18: Firm's Technological Focus (Multiple Responses Allowed)

Technological Focus	Count
Ductless heat pumps	6
Gas furnaces	3
Central air conditioners	3
No specific focus	2
Electric furnaces	1
Maintenance	1
Total	**10**

Table 19: Firm's Specialization (Multiple Responses Allowed)

Company Specialization	Count
Maintenance	6
New installs	2
No specialties	2
Ductless	1
Indoor air quality	1
Split systems	1
High efficiency systems	1
Total	**10**

Table 20: "Using a 1-10 scale, where 1 is not at all focused, and 10 is very focused, how much of a focus is energy efficiency to your business model?"

Rating	Count
10	1
9	4
8	3
7	1
Total	**9**

* This question was added to the interview guide after the first interview had already been completed.

Single-Family Home Builders

Table 21: States Served (Multiple Responses Allowed)

State	Count
Idaho	2
Montana	1
Oregon	3
Washington	3
Total	**5**

Table 22: Respondent Role at Company

Role	Count
Construction Manager	4
Owner	1
Total	**5**

Table 23: New Homes Built Each Year by State (Multiple Responses Allowed)

State	Cumulative Count
Idaho	~20
Montana	~12
Oregon	~465
Washington	~420
Total	**~917**

Table 24: Construction Services Offered (Multiple Responses Allowed)

Role	Count
Custom	4
Spec	3
Total	**5**

Table 25: "Using a 1-10 scale, where 1 is not at all focused, and 10 is very focused, how much of a focus is energy efficiency in the homes you build?"

Rating	Count
5	1
8	2
Total	**3**

* This question was added to the interview guide after the first two interviews had already been completed.

Manufactured Home Builders

Table 26: Plant Location

State	Count
Idaho	2
Oregon	1
Washington	1
Total	**4**

Table 27: Respondent Role at Company

Position	Count
Purchasing Manager	2
Purchasing Assistant	1
Director of Engineering	1
Total	**4**

Table 28: Approximate Number of New Manufactured Homes Built Each Year

Number of Homes	Count
600	1
360	1
350	1
135	1
Total	**4**

Table 29: "Using a 1-10 scale, where 1 is not at all focused, and 10 is very focused, how much of a focus is energy efficiency in the homes you build?"

Rating	Count
5	1
7	2
8	1
Total	**4**

Appendix B – Interview Guides

Distributor Interview Guide

Firmographics

Q1. To start, what is your role in your organization?

Q2. Just to confirm, do you deal with both residential (<=5 tons) and commercial (>5 ton) equipment?

Q3. Do you deal with new constriction? Retrofit? Replacement?

Market Structure & Operations

Q4. Now I want to talk a bit about the supply and distribution chains in the industry. For the residential market (which we understand is usually all equipment <= 5 tons), our understanding is that contractors generally pick up units on an as-needed basis directly from your facilities. Also, you obtain equipment directly from manufacturers. Do you feel this is accurate? [PROBES]: Do you feel there has been any changes in the past few years? Are there any new players in the market that are not shown in the diagram? Do you think this distribution chain applies for all technologies or just some? [IF NOT ALL]: For what technologies does this differ and how?

Q5. For the commercial market (which we understand is usually equipment > 5 tons), our understanding is that the supply chain is a bit more complicated. Smaller equipment (less than about 25 tons) typically flows through you to a contractor, but other equipment, usually larger than 25 tons, typically flows through a manufacturer representative. Do you feel these are accurate? [PROBES]: Do you feel there has been any changes in the past few years? Are there any new players in the market that are not shown in the diagram? Do you think this distribution chain applies for all technologies or just some? [IF NOT ALL]: For what technologies does this differ and how?

Q6. Another thing we want to get a better understanding of is national accounts such as chains and franchises. Can you describe how such accounts work and how they are managed? For example, to what extent do national account HVAC equipment sales flow through local or regional distributors? [PROBE]: How do distributors track those sales?

Q7. Are there certain efficiency levels of equipment or types of equipment that you do not keep in inventory that a contractor would need to order? [PROBE]: What are they? [IF HIGH-EFFICIENCY EQUIP]: Why do you not stock higher efficiency units? [PROBES]: How often do contractors ask for higher efficiency equipment? Does this vary by technology? About how long would it take for you to get the higher efficiency equipment?

Technologies

Q8. First, we want to ask about your view of the HVAC market over the *past 3-4 years*. Are there specific technologies have you seen *increase* in market share over the past 3-4 years, and if so, what are they and how much did they affect your sales mix?

Q9. Are there specific technologies have you seen *decrease* in market share over the past 3-4 years, and if so, what are they and how much did they affect your sales mix?

Q10. Now we want to get your insights into how you think the market might change *in the next few years*. Are there any technologies that you think will become *more dominant* in the market over the next few years? [IF YES]: What are they and how much do you think they will change your sales mix?

Q11. Are there any technologies that you think will become *less common* in the market over the next few years? [IF YES]: What are they and how much do you think they will change your sales mix?

Q12. [IF ANY TECH CHANGES NOTED IN Q8 - Q11]: What do you think is driving the changes you mentioned (e.g., EE programs, different construction practices, changing building codes, etc.)?

Q13. Each technology has an estimated average life provided by manufacturers. How accurate do you think these averages are? For example, do you think there are certain technologies that are being replaced earlier than their expected life? Later?

Q14. We are also interested in better understanding the role of smart thermostats in the marketplace. And just to be clear, when I say, "smart thermostats," I am not referring to thermostats that are just programmable; instead, I am referring to network-connected thermostats (or "communicating" thermostats) that have learning capabilities such as the Nest, Ecobee, or Honeywell Lyric models. Do you stock and sell smart thermostats?

[IF YES]:

Q14b. About how many do you sell annually?

Q14c. What has been the trend in smart thermostat sales over the past few years?

Q15. [IF Q14=YES]: Do you bundle smart thermostats with other equipment or do you sell them as standalone equipment?

[IF BUNDLE OR BOTH]:

Q15b. What types of HVAC equipment do you bundle the smart thermostats with?

Q15c. About what percentage of your unit sales for each of these technologies include bundled thermostats?

Q16. Are there other dominant players in the smart thermostat market? [PROBE]: About what percentage of smart thermostats do you think are sold through distributors versus other vendors, such as online or from retailers?

Decision-Making

Q17. What aspects of customer wants and needs do you think are driving your product sales? For example, how much do factors such as comfort, efficiency, energy efficiency rebate offerings, price, or other factors drive what contractors obtain from you? How does this differ between residential and commercial customers?

Q18. How much do you think contractor recommendations versus customer requirements affect what is ultimately installed? That is, do you think that most people just follow contractor recommendations or do customers tend to ask for certain equipment or features? [IF CUSTOMERS, PROBE]: What do you think customers are asking for? About what percentage of

sales do you think are contractor-driven versus customer-driven? How does this differ between residential and commercial customers?

Q19. How much do you think your stocking practices affect what contractors recommend to customers? [PROBE]: Does this differ when thinking of residential versus business customers?

Q20. Have you changed any of your stocking decisions because of energy-efficiency incentives or programs? If so, how?

Market Dynamics

Q21. Finally, are there any other emerging trends that you can think of that we have not covered that might impact HVAC energy consumption or the market overall that we should consider?

Contractor Interview Guide

Firmographics

Q1. To start, what is your role at your company?

Q2. What cities/locales do you work in or provide service to?

Q3. What sectors do you work with? [PROBE]: About what percentage of your jobs each year are: [FOR RELEVANT SECTORS]: (1) residential, (2) small commercial (<25 tons), (3) large commercial (>25 tons)?

Q4. Does your firm focus on certain types of equipment? If so, which ones?

Q5. What brands of equipment do you work with on a regular basis?

Q6. What are your company's specialties? What are you best known for (e.g. maintenance, VRF, etc.)?

Q6b. Using a 1-10 scale, where 1 is not at all focused, and 10 is very focused, how much of a focus is energy efficiency to your business model?

Q6c. And how does that focus on energy efficiency compare to your competitors?

Q7. What distributors do you work with?

Q8. How many people are employed at your company?

Q9. About how many new installs does your company do each year?

Q10. About how many maintenance calls does your company do each year?

Market Dynamics

Q11. Of all your residential install jobs, what proportion of units go into new construction sites? What proportion replace failed units? And what proportion replace well-functioning units? Does this vary by technology or efficiency level, and if so, how?

Q12. What proportion of your AC installs are **adding** new cooling to a home that did not previously have AC? Which technologies are most popular (e.g., mini-splits, ASHPs, CACs, room ACs, others)?

Q13. What proportion of your heating installs are **adding** new auxiliary or backup heating? Which technologies are most popular (e.g., mini-splits, ASHPs, others)?

Q14. How often do you come across units that are not properly sized? [PROBES]: Are these units generally over-sized or under-sized? Which technologies does this tend to most be the case with? Do you feel equipment sizing has generally been getting better, worse, or about the same over the past few years?

Q15. How often do you come across units in the field do you feel are not maintained appropriately or were not installed correctly? For example, what percent of units you encounter show maintenance practices that increase energy consumption (e.g., people not changing filters, coils not being cleaned, leaky ducts, etc.)? What about units that were installed in a way that wastes energy (e.g., improper system design, improper installation practices, etc.)? How does this differ across different technologies?

Technologies

Q16. First, we want to ask about your view of the HVAC market over the ***past 3-4 years***. Are there specific technologies have you seen ***increase*** in market share over the past 3-4 years, and if so, what are they and how much did they affect the mix of technologies you deal with?

Q17. Are there specific technologies have you seen ***decrease*** in market share over the past 3-4 years, and if so, what are they and how much did they affect the mix of technologies you deal with?

Q18. Now we want to get your insights into how you think the market might change ***in the next few years***. Are there any technologies that you think will become ***more dominant*** in the market over the next few years? [IF YES]: What are they and how much do you think they will change the mix of technologies you deal with?

Q19. Are there any technologies that you think will become ***less common*** in the market over the next few years? [IF YES]: What are they and how much do you think they will change the mix of technologies you deal with?

Q20. [IF ANY TECH CHANGES NOTED IN Q16 - Q19]: What do you think is driving the changes you mentioned (e.g., EE programs, different construction practices, changing building codes, etc.)?

Q21. Each technology has an average estimated life provided by manufacturers. How accurate do you think these averages are? For example, do you think there are certain technologies that are being replaced earlier than their expected life? Later?

Q22. We are also interested in better understanding the role of smart thermostats in the marketplace. And just to be clear, when I say, "smart thermostats," I am not referring to thermostats that are just programmable; instead, I am referring to network-connected thermostats (or "communicating" thermostats) that have learning capabilities such as the Nest, Ecobee, or Honeywell Lyric models. How often do you deal with smart thermostats? For example, about what percentage of your jobs involve installing smart thermostats?

Q23. Do you provide the smart thermostats or are customers providing them?

Q24. [IF CONTRACTOR PROVIDES]: Do you get the thermostats from distributors or another source?

Q25. [IF CONTRACTOR PROVIDES]: Do you try and upsell customers into a smart thermostat when doing maintenance calls?

Q25b. [IF YES]: How often do you do this? For example, about what percentage of your maintenance calls involve trying to sell someone a smart thermostat? [PROBE]: What types of equipment does this tend to apply to?

Q26. [IF CONTRACTOR PROVIDES]: Do you bundle smart thermostats with new HVAC equipment?

Q26b. [IF YES]: How often do you do this? For example, about what percentage of your new installs involve a bundle with a smart thermostat? [PROBE]: What types of equipment does this tend to apply to?

Q27. About what percentage of homes do you think currently have smart thermostats?

Q28. What types of equipment are you seeing smart thermostats being installed with?

Q29. Are you facing any challenges installing smart thermostats with certain types of equipment? [IF YES]: What kind of challenges are you seeing?

Market Structure & Operations

Q30. How do distributor stocking practices impact the efficiency or type of equipment you recommend and sell to your customers? [PROBE]: Are there certain types of equipment that are not readily available from distributors? Are there longer wait times for super high efficiency equipment or any particular technologies?

Q31. Are there any (other) supply-related barriers to adopting more efficient HVAC technologies that we have not yet discussed? [IF YES]: What are these?

Decision-Making

Q32. What is your firm's approach to replace vs. repair? Do you typically recommend one or the other? Are there certain conditions where you always recommend repair and others where you always recommend replacement? What proportion of your customers take your recommendation?

Q33. Residential customers (<5 tons) sometimes change from one HVAC technology to another. I am going to name some technologies and for each I want you to tell me how often you experience customers changing **away from** this technology to a different technology. [Probe for fuel types of most common conversion technologies.]

- **Central air conditioners**: About what percentage of your total annual jobs represent these types of unit conversions? What technologies are they converting to?
- **Gas forced air furnaces**: About what percentage of your total annual jobs represent these types of unit conversions? What technologies are they converting to?
- **Electric forced air furnaces**: About what percentage of your total annual jobs represent these types of unit conversions? What technologies are they converting to?
- **Baseboard heating or some other form of electric resistance heating**: About what percentage of your total annual jobs represent these types of unit conversions? What technologies are they converting to?
- **Room air conditioners**: About what percentage of your total annual jobs represent these types of unit conversions? What technologies are they converting to?

Q34. What factors tend to drive the decision to convert to a new technology type?

Q35. To what proportion of your customers do you recommend energy efficiency programs? How do you think this compares to your competitors? [PROBE]: Why do you recommend energy efficiency programs to your customers?

Q36. How often do your customers ask about energy efficiency rebate opportunities without you mentioning it first?

Q37. When a unit needs to be replaced, about what percentage of the time do you focus on replacing a unit with the same or similar unit to what they already have?

Q38. Do you typically offer your customer options to choose from, such as "good, better, best" specifically in terms of efficiency? [IF YES]: How receptive are customers to the options? For example, about what percentage of the time do customers choose a higher efficiency option?

Single Family and Manufactured Home Builders Interview Guide

Firmographics

Q1. What is your role in your company?

Q2. What geographic locations does your company operate in? [ENSURE WE CAPTURE INFO ON PNW OPERATIONS]

Q3. About how many new homes does your company produce each year in [AS APPLICABLE] Oregon? Washington? Idaho? Montana?

Q4. Do you provide custom home building services or are all your homes built to spec?

Q4a. Using a 1-10 scale, where 1 is not at all focused, and 10 is very focused, how much of a focus is energy efficiency in the homes you build?

Q4b. And how does that focus on energy efficiency compare to your competitors?

Market Structure & Operations

Q5. As a builder, we want to understand how you work with other parts of the HVAC market. For example, for the existing residential market, manufacturers generally sell product to distributors and then contractors pick up product from distributors on an as-needed basis, though special orders may take more time. How would you describe your place in the market? [PROBES]: Do you have HVAC technicians as part of your work force – that is, does your company install the equipment yourselves – or do you work with separate HVAC contractors to have equipment installed in the homes you build? [IF THEY HAVE HVAC TECHS]: Who do you obtain the HVAC equipment from, distributors or directly from manufacturers? Do you keep an inventory of HVAC equipment warehoused or do you obtain it on an as-needed basis?

Q6. Does your company face any supply-side barriers to obtaining or including energy efficient HVAC technologies in the homes you build? For example, are you unable to obtain higher efficiency products because distributors don't stock them or manufacturers don't offer technologies that work with your home designs?

Technologies

Q7. What HVAC equipment is being installed in your homes? [PROBE]: What proportion are getting electric furnaces versus gas furnace versus heat pumps versus other heating technologies? What proportion of your homes get air conditioning installed? What AC technologies are being installed?

Q8. What proportion of your homes are built with ducted systems, versus ductless (including baseboard/electric resistance)?

[ASK IF MANUFACTURED HOME BUILDER]

Q9. Our understanding is that some efficient HVAC equipment does not fit into the homes you build because the equipment is too big. Is this true? [IF YES]: Can you please explain some of these limitations? Have you tried to make, or do you plan to make, any changes to your home designs to accommodate more efficient equipment?

Q10. Has the mix of technologies installed in your homes changed much over the past 3-4 years? [IF YES]: What has changed? Are there certain technologies that are now being installed less? Which ones are now being installed more?

Q11. Looking forward to the next several years, which HVAC technologies do you think will become more common in the homes you build? [PROBE]: By how much do you think your use of [INSERT TECH MENTIONED] will grow? Are there any HVAC technologies that you are moving away from?

Q12. Do you offer smart thermostats as an option with the homes you build, or would the installation of a smart thermostat be left to the home buyer? And just to be clear, when I say, "smart thermostats," I am not referring to thermostats that are just programable; instead, I am referring to network-connected thermostats (or "communicating" thermostats) that have learning capabilities such as the Nest, Ecobee, or Honeywell Lyric models.

Q12a. [IF YES]: About what percentage of the homes you built in the last year had a smart thermostat installed? [PROBE]: Do you think this will increase over the next few years, and if so, by how much? What types of equipment are smart thermostats generally installed with?

Decision-Making

Q13. Please explain how HVAC units are chosen for your homes. For example, do you start with a base model, and customers can upgrade from there? [PROBE]: In terms of efficiency, what is your base model spec for heating? What about air conditioning?

Q14. [IF CUSTOMERS CAN CHOOSE] Can you tell me about your HVAC sales practices? For example, is system efficiency a primary component of the value proposition you present to customers?

Q15. [IF CUSTOMERS CAN CHOOSE] About what percentage of the time do you try and upsell a customer to a HVAC unit that is more efficient than the code minimum? Do you typically offer your customer options to choose from, such as "good, better, best" (specifically in terms of efficiency)?

Q16. [IF CUSTOMERS CAN CHOOSE] What are the primary factors that influence which product a given customer will choose (e.g., price, comfort, efficiency, rebate offerings, what you recommend to them)? [PROBE]: How do these factors interact with each other? For example, are customers willing to pay more for improved comfort, efficiency, or air quality? Do these factors differ for customers of different income levels or budgets? If so, how?

Q17. Are you aware of any energy efficiency programs that are applicable to your business? [PROBE]: What are these? How do these programs influence what you offer your customers?

Market Dynamics

Q18. Are there any other emerging trends in your industry that might impact HVAC energy consumption in the homes that you build that we should consider?