MEMORANDUM

To: Gail Azulay, Cape Light Compact

From: Jared Powell, Monica Nevius, NMR Group, Inc.

Date: November 15, 2019

Re: Analysis of Residential HVAC Sales Data from HARDI Distributors (TXC65)

In 2019, NMR Group, Inc. (the NMR team) purchased residential HVAC sales data (*HARDI* data) from D+R International (D+R) on behalf of the PAs.[1] These data are derived from sales invoices from HVAC distributors that are members of Heating, Air-conditioning, & Refrigeration Distributors International (HARDI). The data span from 2013 into 2019 for central air conditioners (CAC), air source heat pumps (ASHP), gas and oil furnaces, and gas and oil boilers.

The primary objectives of this study were to purchase the HARDI data on behalf of the PAs and provide PAs with access to the data; analyze the data to assess Massachusetts market share and compare these against estimates collected from distributors via the Residential HVAC Efficient Market Share Estimates study (TXC52); assess the potential to use the HARDI data to quantify market effects; and determine if there is any reason to purchase additional, custom data reports to meet PA evaluation needs.

The HARDI data may offer better coverage of the markets for Massachusetts residential HVAC equipment than data the PAs collected directly from distributors in the past, and so may better represent the market. The purchased HARDI data are presented in an online, graphical user interface, referred to by D+R as the DRIVE portal. Customized reports are available from D+R for an additional cost.

This memo begins with caveats, a summary of key findings, and conclusions and recommendations. The rest of the memo is organized as follows:

- Section 1 provides background information about the data, and reports and summarizes trends in sales, market share of efficient equipment, and percentages of each equipment type supported by Mass Save. This section also compares the HARDI data sales estimates with estimates generated from distributor interviews conducted in 2018 for the Residential HVAC Efficient Market Share Estimates study (TXC52).
- Section 2 summarizes HARDI data coverage by equipment type for each state and assesses the potential to use the HARDI data to quantify market effects.

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[1] All HARDI data referenced and included in this report were obtained from the HARDI Unitary Report via the DRIVE portal, prepared by D+R International under data license by HARDI members. Reuse is prohibited without permission. All rights reserved.

- Appendix A explains how the NMR team estimated heating capacity and efficiency for ASHPs.
- Appendix B shows the different geographical regions into which HARDI data can be automatically grouped for analysis.

CAVEATS

- D+R estimates that, as of 2018, the HARDI data cover the following percentages of the Massachusetts residential markets for each equipment type: approximately 73% of the CAC market, 47% of the ASHP market (ducted and ductless)[2], 18% of the furnace market, and 7% of the boiler market. These shares are not likely to have varied much from 2013 to 2018 as new distributors were required to provide sales data back to 2013.
  - D+R does not provide coverage estimates by fuel type. These estimates are across fuels for each system type.
  - D+R does not provide coverage estimates separately for central ducted and mini-split ASHPs.
  - Higher percentages indicate better coverage of a particular market, but are not guarantees that the data truly represent the market. Distributors who do not participate in these data collection efforts may sell systems with substantially different efficiencies than those included in the HARDI data. To the extent D+R can recruit more distributors as data participants, the data coverage, and thus representativeness, may improve over time.
- D+R does not identify the distributors providing data.
- D+R presents natural gas and propane-fired units together, as gas systems.
- D+R acknowledges that due to the low coverage of sales data for the boiler market, the boiler sales estimates may not reliably represent the market, especially at the state level. For this reason, they present the boiler sales data at the regional level.[3] Because of the low market coverage of the boiler data, the observations about boilers presented in this memo should be interpreted with caution.
- The HARDI estimates of the size of the furnace and boiler markets may be somewhat conservative because these data exclude large-capacity residential furnaces and boilers (i.e., larger than 160 kBTUh). While these larger capacities are technically residential, equipment of these sizes is most commonly installed in commercial settings, and D+R believes that residential furnaces and boilers larger than 160 kBTUh only represent a small percentage of overall residential sales. The 2017 Massachusetts Saturation and

[2] D+R does not split coverage for ducted and ductless systems, considering them as one market.
[3] The Northeastern HARDI region includes Connecticut, Maine, Massachusetts New Hampshire, New York, Rhode Island, and Vermont.

Characterization study supports this conclusion. For example, less than 10% of gas furnaces installed in Massachusetts homes as of 2017 fell into this category.[4]

KEY FINDINGS

Sales Trends – 2013 to 2018

- Sales of most equipment types increased modestly from 2013 to 2018, with only the central ASHP market staying essentially flat.
- There was little fluctuation in the Massachusetts market share of efficient CAC equipment over this period. More than 50% of sales in each year was of moderate-efficiency, 13 SEER units. The market share of high-efficiency (16+ SEER) units remained flat, representing about a quarter of sales.
- Central ASHP sales were dominated by low-efficiency units (13 and 14 SEER / 8.2 HSPF), but these units started to lose market share to higher-efficiency systems (16+ SEER) after federal minimum standards went into effect in 2015, stopping the manufacture of 13 SEER systems. As of 2016, sales of 13 SEER units were displaced by 14 SEER / 8.2 HSPF units that met the 2015 federal minimum standards.
- The mini-split ASHP market grew over this period, as did the share of high-efficiency units sold. Relatively high-efficiency systems (≥ 18 to < 20 SEER / ≥ 10 to < 12 HSPF) rose from less than 40% of market share to over 60%, displacing mid-level systems (≥ 15 to <18 SEER / ≥8.2 to < 10 HSPF), which dropped from nearly 60% market share down to about 40%. Extremely high performance systems (≥ 20 SEER / ≥ 12 HSPF) maintained a relatively flat market share in the single-digits. Market share of the least efficient models (below 15 SEER) started out in the low single digits in 2013 and all but disappeared in 2015, when federal standards changed.
- While the gas boiler data from HARDI cover a small part of the Massachusetts market, the data suggest there was substantial growth in the high-efficiency market (95+ AFUE) at the expense of equipment at all other efficiencies.
- Nearly half of gas furnace sales were efficient units (≥ 95 AFUE to < 97 AFUE), while super-efficient units (97+ AFUE) represented nearly another 10% of sales. The lowest-efficiency units retained a substantial presence in the market, at nearly 20% of annual sales. The market shares of these different efficiency categories remained relatively stable from 2013 to 2018.
- For the years that comprehensive Mass Save rebate and incentive data were available (2014 through the first half of 2017), the data suggest that Mass Save supported about 10% of the total estimated sales of gas furnaces, central ASHPs, and central AC systems in Massachusetts. The data also suggest that Mass Save supported over 75% of all mini-split ASHP sales across that time frame. (These systems have also historically been

[4] http://ma-eeac.org/wordpress/wp-content/uploads/MA-RES-1-Baseline-Study-Final-Saturation-Results-Plots-2018-04-12.pdf

eligible for incentives from the Massachusetts Clean Energy Center [MassCEC].) Additionally, the data suggest that Mass Save supported just over 25% of all gas boilers. However, as noted earlier, the gas boiler estimates should be interpreted with caution due to the poor coverage of gas boiler sales data reported to D+R.

Comparison with 2018 Residential HVAC Efficient Market Share Estimates Study

- In the 2018 Residential HVAC Efficient Market Share Estimates (TXC52), the NMR team collected self-reported sales figures from distributors. Comparing these data with the HARDI data offers insights into the coverage of the data collected via the TXC52 study and the relative value of these different approaches to obtaining sales estimates.
- Based on the market sizes reported in the HARDI data, the NMR team estimates that the TXC52 respondents' sales covered approximately 63% of the CAC market in Massachusetts, 59% of the central ASHP market, 26% of the mini-split ASHP market, 10% of the gas furnace market, and 9% of the gas boiler market. These figures are relatively comparable to HARDI data coverage, indicating that there is merit in both approaches to obtaining information about relatively large sections of the market. Of course, the reasonably similar coverage for many equipment types in TXC52 and the HARDI data may also reflect similar sources of bias (e.g., the distributors who participate in these sorts of research efforts may sell different system types from those who choose not to participate).
- The TXC52 study may somewhat overstate sales of residential-sized furnaces and boilers that were installed in residential settings.

Suitability of Data for Market Effects Analysis

- While HARDI has sales data for 38 states, the total share of market sales represented by reporting distributors varies considerably by state and by equipment type.
- The number of states for which D+R estimates reporting distributors represent at least 30% of market sales (a threshold based on a review of D+R's state-level estimates of market coverage) is 10 for CAC, 18 for ASHP, and 20 for gas furnaces, making these states and equipment types the best candidates for inclusion in a market effects study based on these data.
- The HARDI data could be used to inform market effects studies, either through making direct comparisons between market data for Massachusetts and one or more comparison states, or through a modeling approach. Making direct comparisons would be the most straightforward approach, while modeling could more easily account for demographic, socioeconomic, and climate differences among states, and potentially even account for issues with data coverage or representativeness.
- Any future market effect analyses should try to address the impact of other market interventions, such as incentives from the MassCEC for heat pumps, which may also drive adoption of efficient systems.

Purchasing Custom Reports

- The HARDI data (via the DRIVE portal) summarize cooling capacity and efficiency for ASHP systems, but do not describe heating capacity or heating efficiency. D+R could provide a custom report that includes heating statistics, for a cost between $2,750 for one year's data to $8,750 for five years' data, for Massachusetts alone.[5] However, with linear modeling, the NMR team produced equations based on the AHRI directory of HVAC equipment[6] that can be applied to the HARDI data to produce reasonable estimates of the heating performance of the ASHP systems included in the HARDI data, without purchasing a custom report. Additionally, if the PAs find sufficient value in monitoring the ASHP market purely based on cooling performance, sales systems can be tracked in HARDI based on SEER without any additional calculation to estimate heating performance.

CONCLUSIONS AND CONSIDERATIONS

Based on the findings from this study, we offer the following conclusions and considerations.

Conclusion: There is a role for both primary data collection from HVAC distributors and HARDI data. HARDI time series data provide estimates of market share by efficiency from a large and stable group of distributors and can serve the backbone of market effects studies, while TXC52-style data collection efforts are useful for triangulating estimates of market size and obtaining market insights to inform market effects and other studies. The TXC52 study included interviews with distributors who represented a sizeable amount of the Massachusetts market. With sufficient outreach, it is possible to obtain feedback from key market actors on sensitive topics, even including sales volumes. However, follow-up studies cannot guarantee participation from the same respondents, limiting the ability to make year-over-year comparisons. Residential Energy Consumption Survey (RECS)[7] and Commercial Buildings Energy Consumption Survey (CBECS)[8] data from the EIA can be useful for estimating market sizes, but they are rarely updated and do not include efficiency information. HARDI data include five years of comparable sales data and straightforward estimates of market size (at least for select equipment types), valuable characteristics for market effects analyses. The NMR team does, of course, acknowledge the uncertainty associated with scaling up sales from HARDI distributors to represent the entire market. While distributors who provide data to D+R could end their participation and make comparisons over time problematic, the coverage of the D+R dataset has increased over time, ensuring the value of the time series.

Conclusion: The HARDI data appear to be useful for market effects quantification. An objective of this study was to assess the potential to use the HARDI data to quantify market effects. The NMR team found that the data should support market effects quantification via cross-sectional analysis using direct comparison or modeling approaches, as it represents a broad and

[5] This pricing is based on conversations with D+R from late 2018, and reflect additional costs on top of the purchase of DRIVE portal access.
[6] https://www.ahridirectory.org/Search/SearchHome?ReturnUrl=%2f
[7] https://www.eia.gov/consumption/residential/
[8] https://www.eia.gov/consumption/commercial/

detailed, readily-available market data set that can speak to many different states (with some limitations, as described in this memo).

Consideration: If the PAs choose to use the HARDI data to quantify market effects, it would be best to first explore the viability of modeling, and, if modeling proves to be a viable approach, undertake *both* direct comparison and modeling to triangulate the market effects. A direct comparison approach between Massachusetts and other comparison states would be simple and relatively low-cost, while a modeling approach could better account for potential sources of cross-state variation, such as demographic, socioeconomic, or climate differences and differences in coverage of the HARDI data across states. Undertaking *both* direct comparison and modeling would offer a means of triangulating the market effects. However, additional statistical review would be needed to determine if modeling with these data will provide reliable estimates of program effects on the market. Either approach would need to consider attribution for other market interventions, such as MassCEC incentives for heat pumps.

Conclusion: There is no reason to purchase additional, custom data reports to meet PA evaluation needs. An objective of this study was to determine if there is any reason to purchase additional, custom data reports to meet PA evaluation needs – in particular, Massachusetts-specific boiler sales and more detailed ASHP data to assess heating performance. For boilers, the NMR team scaled down the regional HARDI data to develop estimates of Massachusetts sales. This approach is imprecise, given the low share of Massachusetts boiler sales reflected in the HARDI data. Purchasing Massachusetts-specific boiler data from D+R would be similarly imprecise, and therefore seems of limited additional value for the time being. Until more Massachusetts boiler distributors report data to D+R, increasing the coverage (and hopefully representativeness) of the Massachusetts boiler data, it is the NMR team's opinion that the scaled-down regional boiler data is sufficient as a proxy for Massachusetts boiler sales. For ASHP systems, DRIVE only includes cooling performance, not heating performance. Using free information from AHRI's HVAC equipment specification directory, the NMR team developed equations to use the cooling performance data reported in the DRIVE interface to develop estimates of the heating performance of those systems. This rendered the purchase of a custom ASHP report unnecessary. This memo includes an appendix with the equations so that they can be used in future studies. However, rather than doing any such calculations, the PAs may find value in simply using HARDI to assess the ASHP market based on cooling performance alone, without conducting additional analysis to estimate heating performance.

Conclusion: Additional market size research may be helpful to corroborate the market size estimates presented by D+R. The HARDI data include valuable information, such as longitudinal estimates of system sales and granular estimates of system efficiencies. However, given the limitations of the HARDI data, there is room to conduct additional, independent market size analyses to ensure that the HARDI estimates appear reasonable when compared to other approaches.

Consideration: Conducting a limited market size assessment using techniques such as a stock-turnover analysis may provide an additional check on the relative accuracy of the D+R market size estimates. While the HARDI data have numerous strengths, conducting a limited scope stock-turnover analysis could serve to ensure that the PAs feel confident relying on the HARDI data to inform program efforts.

Section 1 Sales Trends and Comparisons

1.1 Overview

The D+R data are derived from sales invoices from HVAC distribution companies that are members of the Heating, Air-conditioning, & Refrigeration Distributors International (HARDI) trade association. Not all HARDI members have agreed to provide these data, and not all distributors are HARDI members, so the distributors reporting to D+R represent a subset of the HVAC equipment markets. D+R scales the invoice data they receive to state and regional levels based on Residential Energy Consumption Survey (RECS) and Commercial Buildings Energy Consumption Survey (CBECS) data. D+R then makes these data available for purchase through their custom web portal, DRIVE, and through custom reports. The NMR team purchased one year of access to DRIVE on behalf of the PAs. DRIVE includes D+R's estimated HVAC sales data from 2013 to 2019 for central air conditioners (CAC), air source heat pumps (ASHP), gas (natural gas and propane-fired) and oil furnaces, and gas (natural gas and propane-fired) and oil boilers. The system sales summarized in DRIVE are grouped at a granular level of efficiency (i.e., in one-unit increments of SEER[9] or HSPF), and include cooling and ASHP systems up to 72 kBTUh and fossil fuel-fired heating systems for equipment capacities up to 160 kBTUh.

To prepare the information presented in this memo, the NMR team downloaded the data from the DRIVE portal and conducted additional analysis. This included assigning the data into the various levels of efficiency supported by Mass Save programs at the time the study was conducted, to help identify trends in efficiency across time. That said, program requirements have changed across the 2013 to 2019 years for which we have HARDI data. The NMR team also estimated the heating capacity and efficiency of ASHPs as those data are not included in the DRIVE portal. We were able to estimate heating capacity and heating efficiency based on cooling capacity, efficiency, and year of manufacture. A detailed review of these efforts can be found in Appendix A, including the challenges of categorizing systems into program incentive thresholds based on their performance relative to two different metrics (cooling efficiency and heating efficiency).

1.1.1 Representativeness of the Data for Massachusetts

D+R estimates the portion of sales that they believe their data represents, i.e., the data's market coverage. The coverage varies by equipment type, state, and region. The variation is associated with the number, size, and geographical distribution of distributors supplying invoices to D+R. Presumably, as the market coverage increases, the data better reflects the types of systems being sold in the market. Notably, I portion of the market represented by the HARDI data does not vary over time; when D&R recruits a new distributor to provide data for the portal, the new contact is required to provide both historic and current data.

[9] EER ratings are not included in DRIVE.

D+R estimates that the unscaled HARDI data represent the following percentages of the Massachusetts residential markets for each equipment type: approximately 73% of the CAC market, 47% of the ASHP market, 18% of the furnace market, and 7% of the boiler market. Because D+R estimates that their sales data cover just 7% of boiler sales, the DRIVE portal only includes data for boilers at the regional level,[10] and D+R acknowledges that their boiler sales estimates are at a greater risk of not being representative of the market. For this analysis, the NMR team scaled down the New England boiler data to Massachusetts based on census data. Because of the low coverage of the data on which these values are based, the boiler data should be interpreted with caution. For information about the coverage of the HARDI data for other states, see Section 2.

The HARDI data do not include heating efficiency values for ASHP systems. The NMR team approximated these missing values by creating a correlation factor between cooling capacity and efficiency and heating capacity and efficiency. See Appendix A for a description of the modeling approach we used to develop the correlation factor.

Table 1 lists the characteristics of the data as they appear in DRIVE.

Table 1: Characteristics of HARDI Data in DRIVE

Category	Description
Cooling	
Types	AC, ASHP (with heating), ASHP (cooling only)[11]
Capacity	0.5-6 tons, half-ton / 6 kBTUh increments
Efficiency	1.0 SEER increments (EER data not provided)
Configuration	Split *and/or* packaged
Distribution	Ducted *and/or* ductless (mini- and multi-split)
Res vs. C&I	Based on capacity/specs (not actual install location)
Heating	
Types	Furnace, boiler, ASHP
Capacity	Furnace and boiler: <160 kBTUh, 20 kBTUh increments; ASHP: <72 kBTUh, half-ton increments
Efficiency	Furnace and boiler: 1.0 AFUE increments; ASHP: 1.0 SEER increments
Fuel	Furnace and boiler: oil, gas (natural gas and propane combined); ASHP: electricity
Distribution	Ducted *and/or* ductless (mini- and multi-split)
Res vs. C&I	Based on capacity/specs (not actual install location)
Location coverage	Regional for boilers, MA otherwise

The NMR team analyzed the data on heating and cooling systems included in this memo based on the efficiency categories of interest described in Table 3 identifies the federal minimum

[10] The Northeastern HARDI region includes Connecticut, Maine, Massachusetts New Hampshire, New York, Rhode Island, and Vermont.
[11] Technically, cooling-only ductless mini-splits are included in DRIVE as ductless AC systems. The NMR team excluded them from this analysis as the focus here is on ASHPs with heating functionality.

efficiency values governing the manufacture of each of the system types of interest across the 2013 to 2019 period. For these equipment types, federal minimum efficiency values only changed for ASHP systems and gas furnaces, both of which saw modest increases in 2015. There is no federal EER requirement for the Massachusetts climate zone for the applicable cooling system types included in this study.

Table 3Table 2, which were set at the start of the Residential Market Share Estimates study (TXC52), and included program thresholds (as they existed at that time in 2018). The efficiency categories essentially represent low, medium, and high-efficiency equipment. The values shaded in green correspond to efficiency levels incentivized by Mass Save programs. Oil systems were not part of the data collection effort.

Table 2: Equipment-level Efficiency Categories Used for Analysis

Equipment	Efficiency
Central AC	13 SEER
	> 13 to > 16 SEER
	≥ 16 SEER
Central ASHP	≤ 14 SEER & ≤ 8.2 HSPF+
	> 14 to < 16 SEER & ≥ 8.2 to < 8.5 HSPF
	≥ 16 to < 18 SEER & ≥ 8.5 to < 9.6 HSPF
	≥ 18 SEER & ≥ 9.6 HSPF
Mini-split ASHP	< 15 SEER & < 8.2 HSPF
	≥ 15 to <18 SEER & ≥8.2 to < 10 HSPF
	≥ 18 to < 20 SEER & ≥ 10 to < 12 HSPF
	≥ 20 SEER & ≥ 12 HSPF
Gas boilers	82 AFUE
	> 82 to < 90 AFUE
	≥ 90 to < 95 AFUE
	≥ 95 AFUE
Gas furnaces	80 AFUE
	> 80 to < 90 AFUE
	≥ 90 to < 95 AFUE
	≥ 95 to < 97 AFUE
	≥ 97 AFUE

Table 3 identifies the federal minimum efficiency values governing the manufacture of each of the system types of interest across the 2013 to 2019 period. For these equipment types, federal minimum efficiency values only changed for ASHP systems and gas furnaces, both of which saw modest increases in 2015. There is no federal EER requirement for the Massachusetts climate zone for the applicable cooling system types included in this study.

Table 3: Federal Minimum Efficiency Values

Equipment	2013	2014	2015	2016	2017	2018	2019
Central AC	13 SEER						
Central & mini-split ASHP	13 SEER & 7.7 HSPF		14 SEER & 8.2 HSPF				
Gas boilers, steam	80 AFUE						
Gas boilers, water	82 AFUE						
Gas furnaces	78 AFUE		80 AFUE				

Table 4 describes the minimum efficiency requirements for receiving rebates or incentives from the Massachusetts programs for 2014 through the first half of 2017 (the years for which we were provided complete program tracking data).[12] Minimum program thresholds remained constant during this period, except for mini-split ASHPs.

Table 4: Minimum Program Incentive Thresholds

Equipment	2014	2015	2016	2017	2018	2019
Central AC	16 SEER					
Central ASHP	16 SEER & 8.5 HSPF					15 SEER & 9 HSPF
Mini-split ASHP, ductless	16 SEER & 8.2 HSPF		18 SEER & 8.5 HSPF	18 SEER & 10 HSPF		15 SEER & 10 HSPF
Mini-split ASHP, ducted						15 SEER & 9 HSPF
Gas boilers, water	90 AFUE					
Gas furnaces	95 AFUE					

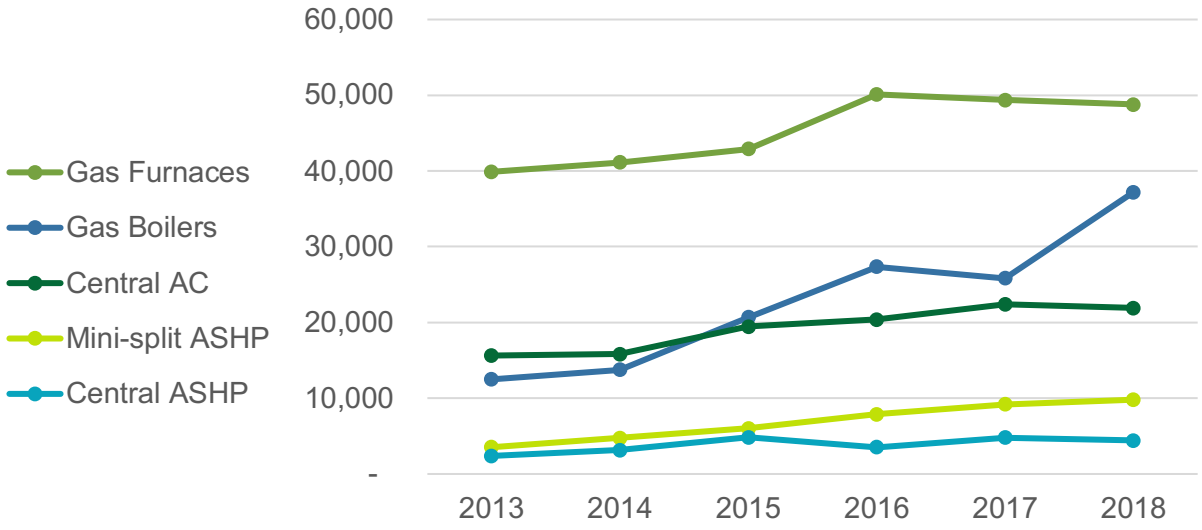
1.2 Massachusetts Sales Trends

1.2.1 Market-level Sales

Figure 1 displays the total unit sales of the equipment types of interest from 2013 through 2018, as reported in the HARDI data. This information is available with additional granularity in the DRIVE portal itself, and it is updated fairly regularly. As discussed in Section 1, the boiler sales figures below should be interpreted with caution, as they represent regional-level sales that have been proportionally scaled down for Massachusetts based on population data. As Figure 1 shows, furnaces, boilers, and central ACs dominate sales, while mini-split ASHP systems show low but climbing sales. Central ASHP sales are low and relatively flat across this period.

[12] The NMR team requested rebate and incentive data for 2013 through 2018 for this study, but data from mid-2017 through 2019 were not yet available when this report was prepared.

Figure 1: Estimated Massachusetts Annual Equipment Unit Sales (2013-2018)

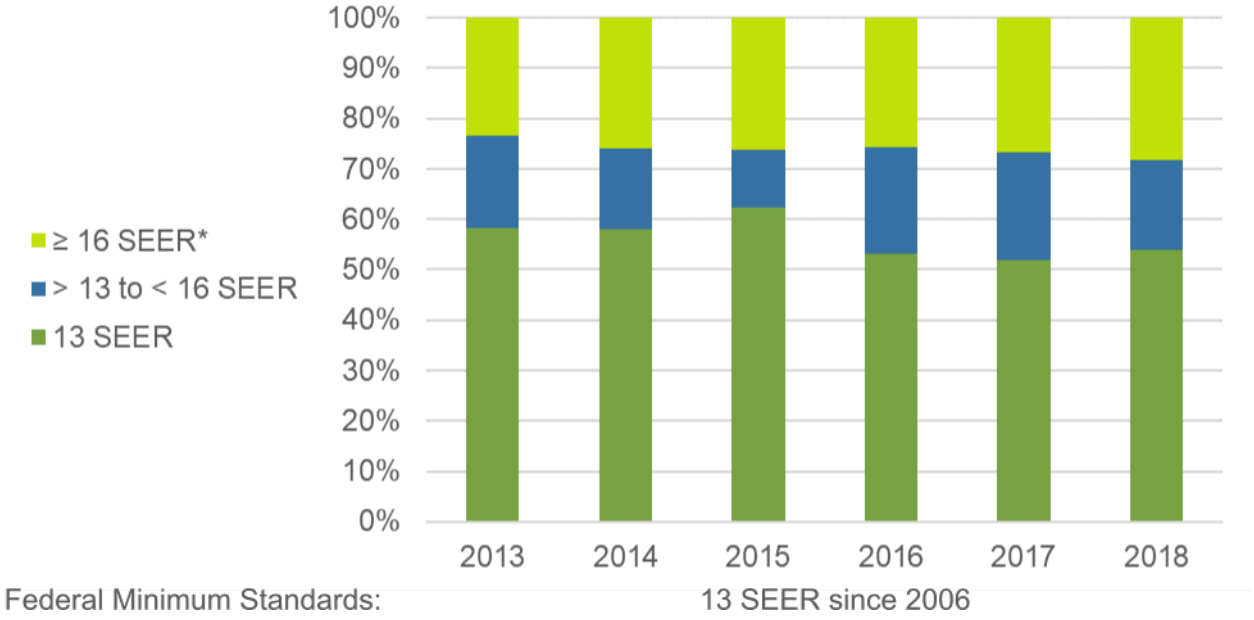


Figures 2-6 show the proportion of annual unit sales in Massachusetts of each equipment type by the efficiency thresholds described in Table 2.[13]

Central AC Systems. As Figure 2 shows, the HARDI data indicate that the proportion of sales of CAC systems at each efficiency level was fairly steady from 2013 to 2018. The least efficient equipment – 13 SEER systems – dominated sales despite the availability of far more efficient systems.

[13] Sales for the first quarter of 2019 are available on DRIVE, and the remainder of the year will be made available under the PAs' current subscription.

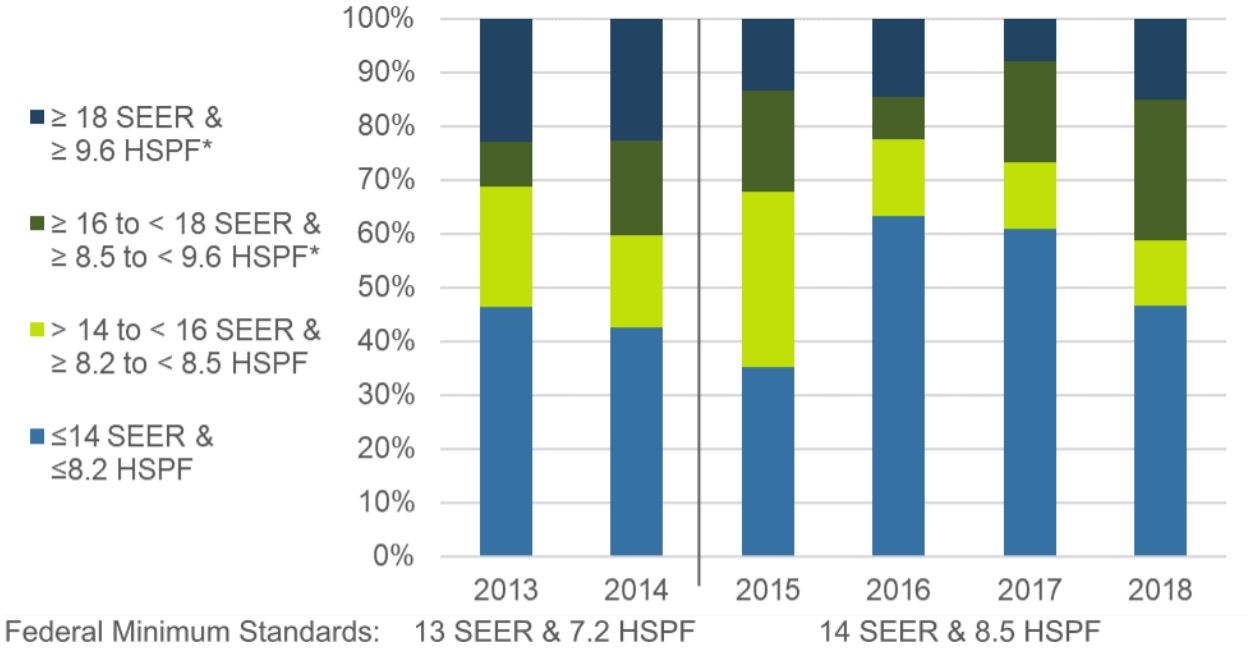
Figure 2: Proportion of Central AC Units Sold Annually by Efficiency



Central ASHP Systems. As we described earlier, the DRIVE portal includes the cooling performance, but not the heating performance, of heat pumps. To develop a meaningful comparison with program-supported sales, we estimated HSPF values for the systems by applying the modeling results described in Appendix A. Figure 3 shows sales by the SEER values in the HARDI data and the modeled HSPF. From 2013 to 2015, the lower-efficiency category (13 to 14 SEER, with HSPF values no better than 8.2) represented a declining portion of the central ASHP units sold. The market changed in 2015, when federal efficiency standards mandated a performance floor of 14 SEER and 8.2 HSPF for heat pumps.[14] Among the equipment types included in Figure 1, only central ASHP sales decreased in 2016. By that point, the majority of remaining sales fell into the lower-efficiency – and presumably less expensive – 14 SEER category. Investigating the reason for this change could be a topic of future research, but may have to do with outside factors, such as the availability of favorable incentives for competing technologies from other sources, such as the Massachusetts Clean Energy Center (MassCEC).

[14] HARDI data show that 13 SEER sales dropped to negligible volumes in that year.

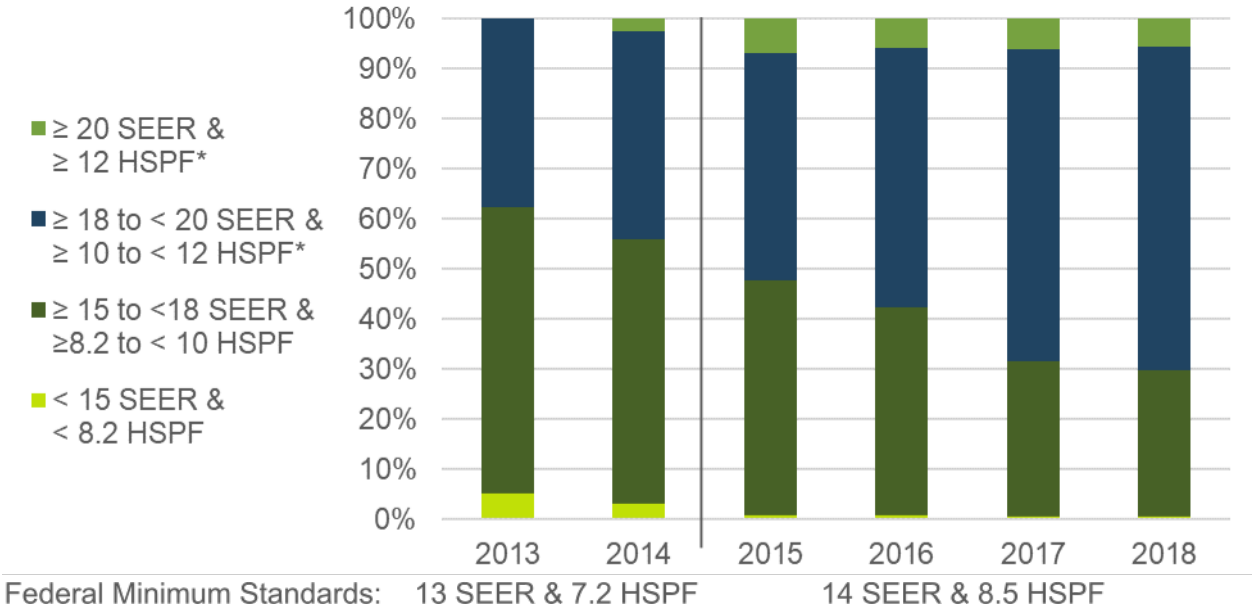
Figure 3: Proportion of Central ASHP Units Sold Annually by Efficiency



Mini-split ASHP Systems. As Figure 4 shows, the ductless ASHP market has seen substantial growth in the share of relatively high-efficiency systems (18 to just below 20 SEER and 10 to just below 12 HSPF), at the expense of the mid-level systems falling into the 15 to 18 SEER category. Market share of the least efficient (worse than 15 SEER / 8.2 HSPF) and the most efficient (20 SEER / 12 HSPF or better) systems has stayed relatively low as a percentage of the ductless ASHP market. The least efficient models (below 15 SEER) all but disappeared in 2015, coinciding with 2015 federal standards setting a minimum efficiency of 14 SEER and 8.2 HSPF for heat pumps.[15] As with the central ASHP systems discussed above, to incorporate heating efficiency into the figure below, we applied the modeling results described in Appendix A to the HARDI sales data.

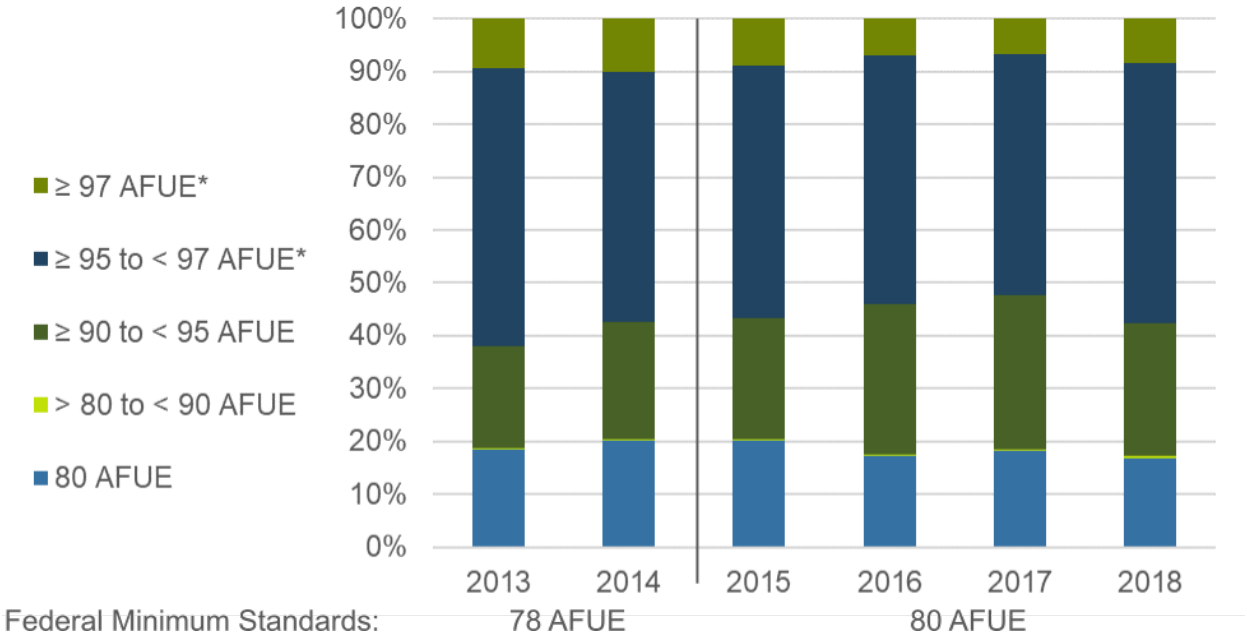
[15] This ASHP analysis only includes systems with a heating function. Cooling-only mini-splits represent a small number of systems in DRIVE, and are not a focus of this study.

Figure 4: Proportion of Mini-split ASHP Units Sold Annually by Efficiency



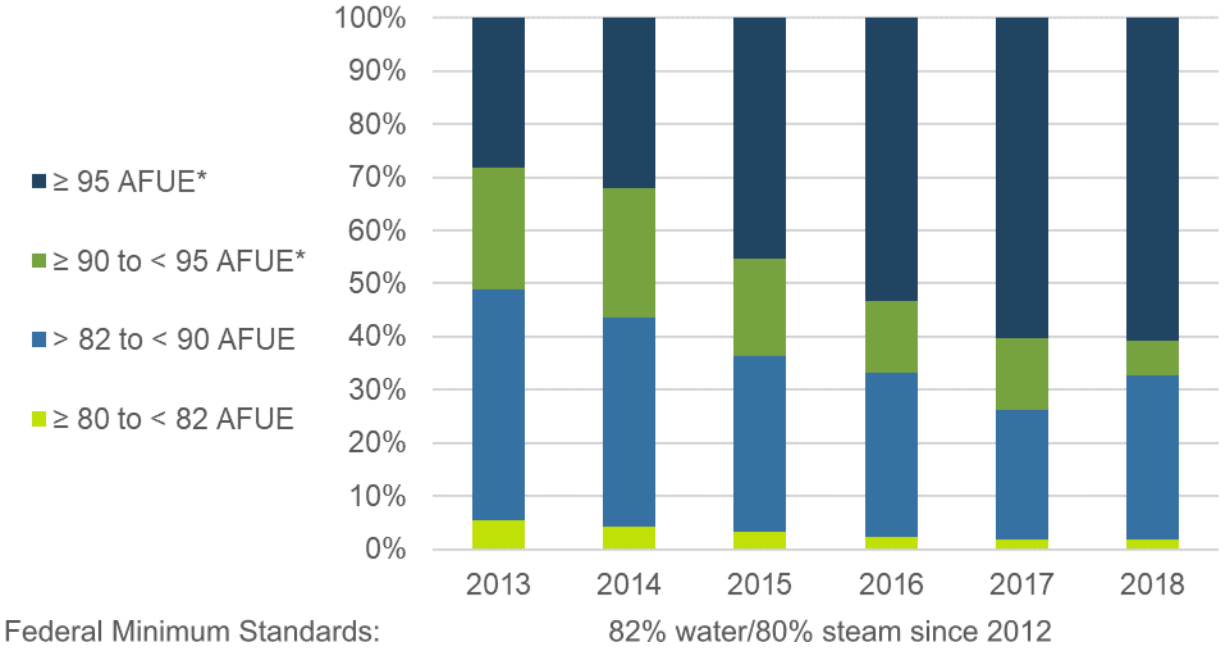
Gas Furnaces. The data show that the share of gas furnaces sold at each efficiency level has been relatively stable over this period. Sales of units of at least 95, but less than 97, AFUE represent about half of all sales, by far the largest share of the market. This is followed by sales of units of at least 90, but less than 95, AFUE, which represent about a quarter of the market (Figure 5). Units at the lowest allowable efficiency level (80 AFUE) have also maintained a substantial presence in the market, at about 20% of sales most years. This is essentially double the size of the market of the highest-efficiency furnaces (97 AFUE or higher) over this time. HARDI data report negligible sales of gas furnaces with an AFUE range higher than 80 but lower than 90.

Figure 5: Estimated Proportion of Gas Furnace Units Sold Annually by Efficiency



Gas Boilers. Given the low market coverage of the boiler data, as discussed in Section 1, the values shown in Figure 6 for gas boilers should be interpreted as merely a *suggestion* of market trends for this equipment over the 2013 to 2018 period. The data suggest that there has been substantial growth in the highly-efficient gas boiler market (95 AFUE and above) over the period, with low- and middle-efficiency units losing market share. The data also suggest that the lowest efficiency systems, between 80 and less than 82 AFUE, represent a very small percentage of sales across the period.

Figure 6: Estimated Proportion of Gas Boiler Units Sold Annually by Efficiency



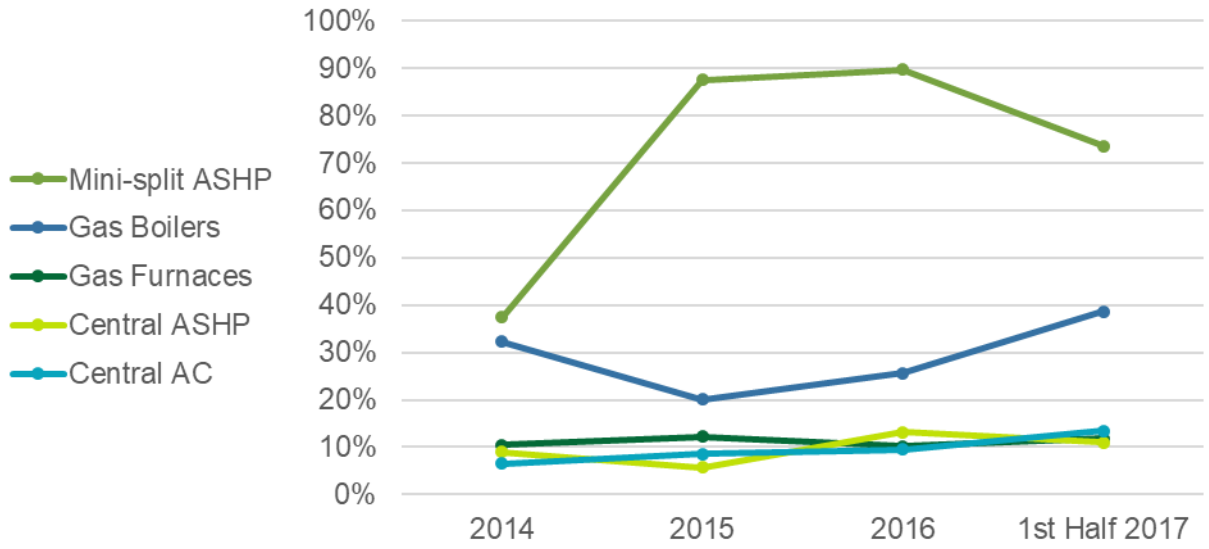
1.2.2 Program-supported Sales

Figure 7 displays *program penetration*, or the estimated percent of all Massachusetts sales of residential-sized equipment that were supported by the Mass Save residential and C&I programs in each year that program data were available.[16] For this period (2014 through the first half of 2017), the annual program penetration for gas furnaces, central ASHP systems, and central AC sales in Massachusetts hovered around 10% of equipment sales on average. Except for 2014, the program penetration of mini-split ASHP systems was quite high, capturing over 70% of all units sold. Beginning in 2015, residential customers purchasing heat pumps could take advantage of both Mass Save rebates and substantial rebates offered by the MassCEC. This could help explain the very high penetration of rebates for mini-split ASHP systems starting the same year. The annual program penetration for gas boilers varied between 20% and just under 40%, but these are *very* rough estimates due to the poor coverage of gas boiler sales data reported to D+R, as discussed in Section 1.

[16] See Appendix C for counts of program-incentivized units.

Figure 7: Estimated Program Penetration by Equipment Type, 2014 – First Half of 2017

Base: All equipment sales, regardless of efficiency

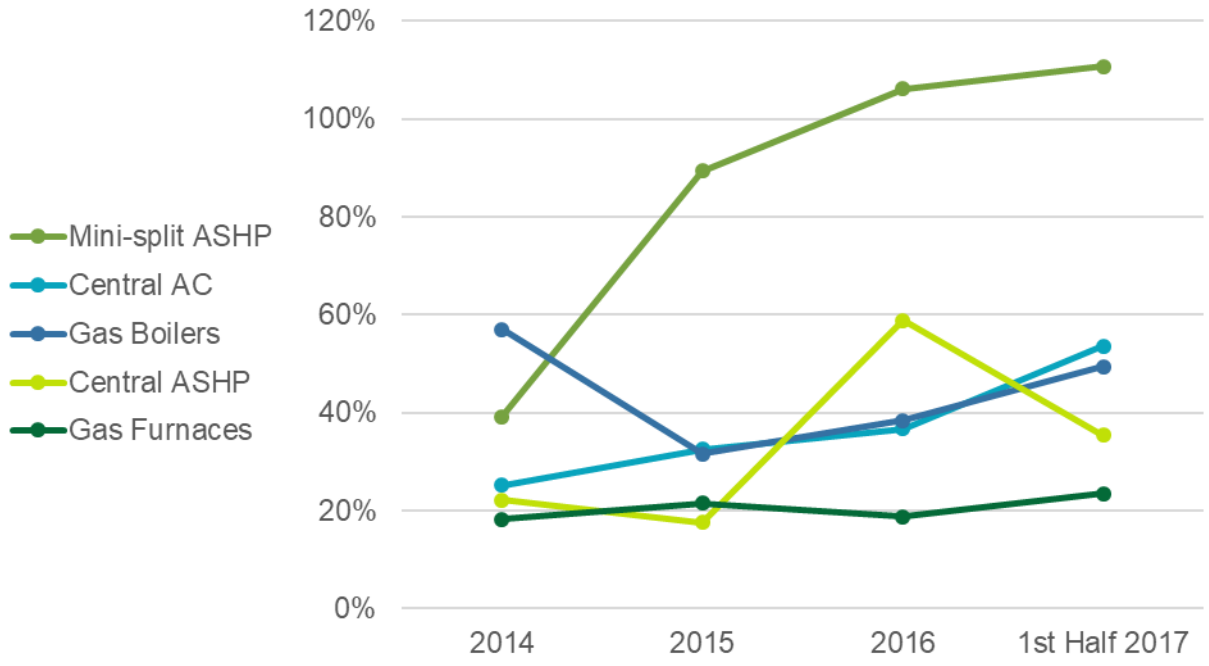


While Figure 7 showed the program's penetration relative to the entire market for each equipment type, Figure 8 estimates program penetration among equipment that was actually eligible for the program (i.e., the program's penetration in the high-efficiency market, from 2014 through the first half of 2017).[17] Over this period, Mass Save supported efficient gas furnaces at the lowest rates and mini-split ASHPs at the highest rates. The high rate of program support for mini-split ASHP is to be expected given that this equipment is comparatively new to the residential market, and also because of substantial incentives provided by the MassCEC. Program support for mini-split ASHPs exceeding 100% of sales in 2016 and the first half of 2017 could be due to a combination of factors coming together, including that D+R's estimate of the total Massachusetts market size could be somewhat low, the timing of sales versus the timing of rebate application processing, and the very high rate of program support for this equipment.

[17] We limited this figure to equipment supported by the residential program only because the base is program-qualified equipment, and Mass Save residential and commercial electric equipment requirements are quite different.

Figure 8: Percent of Eligible Equipment Supported by Program, 2014 – First Half of 2017

Base: Efficient equipment sales



1.3 Comparison of HARDI and TXC52 Sales Estimates

In 2018, the NMR team carried out the Residential HVAC Efficient Market Share Estimates (TXC52) study with the goal of updating unit sales estimates for Massachusetts gathered from HVAC distributors as part of the 2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing study.[18]

Table 5 compares the proportion of estimated 2017 sales by equipment capacity and efficiency from the HARDI data and from TXC52, highlighting the relative contributions of each data collection approach in developing a better understanding of the market.

In TXC52, the NMR team obtained useful responses from ten (34%) respondents out of a sample frame of 29 key HVAC distributors located across Massachusetts, representing 26 different distributor companies. The HARDI estimates in column B represent sales for the entire Massachusetts market in 2017.[19] Column A describes the portion of the market (i.e., the sales in column B) that fall into key efficiency categories. The green rows indicate efficiency categories that meet program thresholds. The TXC52 unit sales estimates (column D) represent the sales volumes reported by the responding distributors. These estimates are not scaled for the

[18] http://ma-eeac.org/wordpress/wp-content/uploads/2012-Residential-Heating-Water-Heating-and-Cooling-Equipment-Evaluation_Net-to-Gross-Market-Effects-and-Equipment-Replacement-Timing-Volume-I-June-2013.pdf

[19] D+R takes the sales invoice data from HARDI distributors in a given area and scales it to represent the entire market.

Massachusetts market.[20,21] By dividing the total market size estimated by D+R (column B) by the sales reported by TXC52 respondents, we can estimate how much of the Massachusetts market was represented by the nine distributors who provided sales data as part of TXC52.[22,23] The results show that the sales of distributors reporting for TXC52 represented the following:

- 63% of the CAC market in Massachusetts (compared to HARDI's 73%);
- 59% of the central ASHP market and 26% of the mini-split ASHP market in Massachusetts (compared to HARDI's combined 47%[24]);
- 10% of the gas furnace market in Massachusetts (compared to HARDI's 18% of the gas and oil furnace market – D+R does not estimate coverage at the fuel level); and
- 9% of the gas boiler market in Massachusetts (compared to HARDI's 7% of the gas and oil boiler market – HARDI does not estimate coverage at the fuel level).

The DRIVE portal does not include state-level sales for larger residential furnaces or boilers (i.e., those with capacities greater than 160 kBTUh). This means that the actual markets for boilers and furnaces installed in residences are somewhat larger than estimated in the DRIVE portal. However, while the larger equipment capacities are technically residential, they are most commonly installed in commercial settings, and D+R believes that residential furnaces and boilers larger than 160 kBTUh only represent a small percentage of overall residential sales. The TXC52 study included all residential-sized furnaces and boilers, including equipment with capacities greater than 160 kBTUh. Thus, the TXC52 study may somewhat overstate sales of residential-sized furnaces and boilers that were installed in residential settings.

[20] The distributors interviewed by the NMR team in TXC52 did not submit sales invoices and were permitted to give roughly estimated values for their total sales. We asked each distributor about the certainty of their estimates, and they variably said that the estimates they provided for each technology type were guesses, or somewhat or highly accurate. This means that the total unit sales figures from TXC52 have an unknowable degree of error.

[21] Future data collection efforts similar to TXC52 would not be able to guarantee participation by these same respondents, limiting the ability to monitor trends over time. The HARDI data include five years of sales data, avoiding this issue.

[22] The TXC52 study did ask respondents to estimate their own market share relative to the rest of the distributor market, but these estimates were imprecise. Comparing their actual sales volumes to more reliable estimates of market size based on RECS and CBECS data, like is used with the D+R market size estimates, provides better estimates of the market coverage represented by the respondents' data.

[23] We do not think it is possible to reliably confirm the extent of any overlap between the TXC52 respondents and those who provide data to D+R for the HARDI data, due to confidentiality concerns about participants in the HARDI data collection.

[24] D+R does not provide separate coverage figures for these ASHP system types. Additionally, in TXC52, distributors were asked to provide sales estimates of ASHPs based on SEER and HSPF values.

Table 5: Estimated Units Sold by Technology and Efficiency Level (2017)

Equipment	Efficiency	A	B	C	D
		HARDI		TXC52 Respondents	
		Market Share	Total MA Market Size†	Market Share	Total Units Sold‡
Central AC	13 SEER	52%	22,400	43%	14,285
	> 13 to > 16 SEER	21%		14%	
	≥ 16 SEER*	27%		43%	
Central ASHP	≤ 14 SEER & ≤ 8.2 HSPF	61%	4,797	56%	2,819
	> 14 to < 16 SEER & ≥ 8.2 to < 8.5 HSPF	13%		16%	
	≥ 16 to < 18 SEER & ≥ 8.5 to < 9.6 HSPF*	19%		19%	
	≥ 18 SEER & ≥ 9.6 HSPF*	8%		9%	
Mini-split ASHP	< 15 SEER & < 8.2 HSPF	1%	9,187	14%	2,886
	≥ 15 to <18 SEER & ≥8.2 to < 10 HSPF	31%		41%	
	≥ 18 to < 20 SEER & ≥ 10 to < 12 HSPF*	62%		25%	
	≥ 20 SEER & ≥ 12 HSPF*	6%		19%	
Gas boilers	82 AFUE	2%	25,848	21%	3,024
	> 82 to < 90 AFUE	24%		29%	
	≥ 90 to < 95 AFUE*	14%		20%	
	≥ 95 AFUE*	60%		31%	
Gas furnaces	80 AFUE	18%	49,367	8%	4,215
	> 80 to < 90 AFUE	0%		23%	
	≥ 90 to < 95 AFUE	29%		26%	
	≥ 95 to < 97 AFUE*	45%		31%	
	≥ 97 AFUE*	7%		13%	

* Program-incentive eligible tiers.
† This is the total estimated sales for the state of Massachusetts, scaled up to the state from reported data from HARDI distributors based on D+R's estimated market size.
‡ This is the total number of sales reported by HVAC distributors interviewed for TXC52; these numbers have not been scaled or adjusted to represent the state of MA.

Section 2 Potential to Quantify Market Effects

While the HARDI data contain sales for 38 states, the total share of market sales represented by reporting distributors varies considerably by state. The highest estimate of market coverage is of CAC sales in Massachusetts (73%); the lowest is CAC sales in Mississippi (4%), followed by furnace sales in Wisconsin (not reported, but presumably 0%). Table 6 shows the estimated share of market sales represented by reporting distributors by state and technology type, presented first for Massachusetts and then alphabetically by state. The table shows that the number of states for which D+R estimates reporting distributors represent at least 30% of market sales is 10 for CAC, 18 for ASHP, and 20 for furnaces. (Thirty percent was chosen because it emerged as a threshold. That is, for all technology types, the estimated share of market sales represented by reporting distributors by state drops off sharply below this value.) Figures 9-11 show the geographic distribution of this information, presented categorically.

With these levels of market coverage in mind, the NMR team sees three possible approaches to quantifying residential HVAC market effects from the Mass Save program using the HARDI time-series data. All three rely on cross-sectional analysis. Cross-sectional analysis involves identifying one or more comparison groups that will be tracked along with the program area. The comparison group serves as the *baseline* for the program area, and the evaluator subtracts savings in the baseline area from market-level savings in the program area to estimate net savings. The three cross-sectional approaches are (1) direct comparison, (2) modeling, and (3) both direct comparison and modeling.

With the **direct comparison** approach, the NMR team would, with the advice of the PAs and EEAC team, select comparison states, considering factors such as climate, program activity, population, and most importantly, sufficient equipment-level market coverage. The NMR team would compare the differences over time in Massachusetts sales by efficiency for each equipment type with the differences in sales of states that either lack programs or offer minimal program support for the equipment type. The *difference of differences* is the market effects.

With the **modeling** approach, the NMR team would develop a statistical model for each equipment type to predict efficiency level based on degree of program intervention, demographic and economic characteristics of the states, states' heating or cooling degree days, and the estimated share of market sales represented by reporting distributors for each state. The NMR team would first conduct preliminary research to determine if modeling is truly a viable approach. This preliminary analysis would include further review of the market coverage and representativeness of HARDI data, an initial review of market interventions in potential comparison areas, and a statistical review of the promise of this approach given the number of comparison states viewed as representative and suitable for modeling purposes. If early statistical review indicates that modeling will not provide reliable estimates of program effects on the market, then direct comparison would be the only analysis option.

A key limitation for both approaches is that there are other market interventions and market forces that may encourage the adoption of high-efficiency HVAC systems, outside of the PAs' efforts. For example, the MassCEC promotes the installation of high-efficiency heat pumps in

Massachusetts. Regardless of approach, the NMR team would need to exclude the impacts of any other interventions from any market effects being attributed to the PAs. For the direct comparison approach, challenges include the fact that demographic and socioeconomic differences between Massachusetts and comparison areas might result in complex weighting schemes to ensure that comparisons are valid. For modeling, the sample sizes of states where HARDI data sufficiently represents the market are limited, which may limit our ability to identify differences as statistically significant. Modeling is also inherently complex, and finding the best model is an iterative approach that requires careful analysis.

If modeling proves to be a viable approach, the PAs may want to consider undertaking **both direct comparison and modeling** as a means of triangulating the market effects, hopefully accounting for the weaknesses of both approaches.

Table 6 describes D+R's estimates of the coverage of the HARDI data, by equipment type and state. Higher coverage rates should provide better model and direct comparison results, as this indicates that the HARDI data more fully describe the full market for that state and equipment type. As a reminder, HARDI data as presented in DRIVE only provide boiler data at the regional level due to single-digit coverage at the state level. Coverage for the furnace market is across all fuel types.

Table 6: Estimated Sales Represented in HARDI Data by State

Coverage	Central AC	ASHP	Furnace
Massachusetts	72.7%	47.3%	18.3%
Other states			
Alabama	20.5%	53.4%	17.6%
Arizona	27.1%	41.8%	21.2%
California	25.6%	31.7%	40.1%
Colorado	42.3%	22.1%	48.0%
Connecticut	69.1%	34.8%	14.1%
Delaware	45.2%	33.7%	73.0%
Florida	4.5%	5.9%	1.3%
Georgia	30.2%	38.9%	46.7%
Idaho	17.2%	90.1%	26.8%
Illinois	16.2%	10.0%	26.3%
Indiana	24.5%	46.1%	37.0%
Iowa	20.1%	55.0%	39.7%
Kansas	30.6%	23.6%	39.1%
Kentucky	27.9%	26.3%	32.9%
Maryland	31.7%	33.1%	53.6%
Michigan	14.2%	5.8%	30.3%
Minnesota	30.1%	16.1%	60.9%
Mississippi	4.4%	5.4%	27.5%
Missouri	21.7%	37.1%	36.5%
Nebraska	25.6%	12.2%	25.9%
Nevada	25.2%	19.4%	13.0%
New Jersey	22.4%	18.2%	26.3%
New Mexico	18.3%	14.1%	7.9%
New York	7.1%	6.6%	13.5%
North Carolina	10.3%	15.2%	26.6%
Ohio	17.7%	34.1%	46.9%
Oklahoma	19.4%	16.0%	62.2%
Oregon	20.3%	42.9%	39.4%
Pennsylvania	42.5%	84.2%	9.2%
Rhode Island	46.2%	30.1%	11.5%
South Carolina	8.1%	25.3%	14.6%
Tennessee	17.5%	36.7%	30.7%
Texas	21.5%	26.4%	25.7%
Utah	14.5%	53.9%	32.0%
Virginia	20.1%	25.3%	61.5%
Washington	13.4%	29.7%	49.3%
West Virginia	23.7%	22.6%	50.2%
Wisconsin	23.7%	9.0%	Unknown

Figure 9: Estimated Sales of Central AC Represented by HARDI Data by State

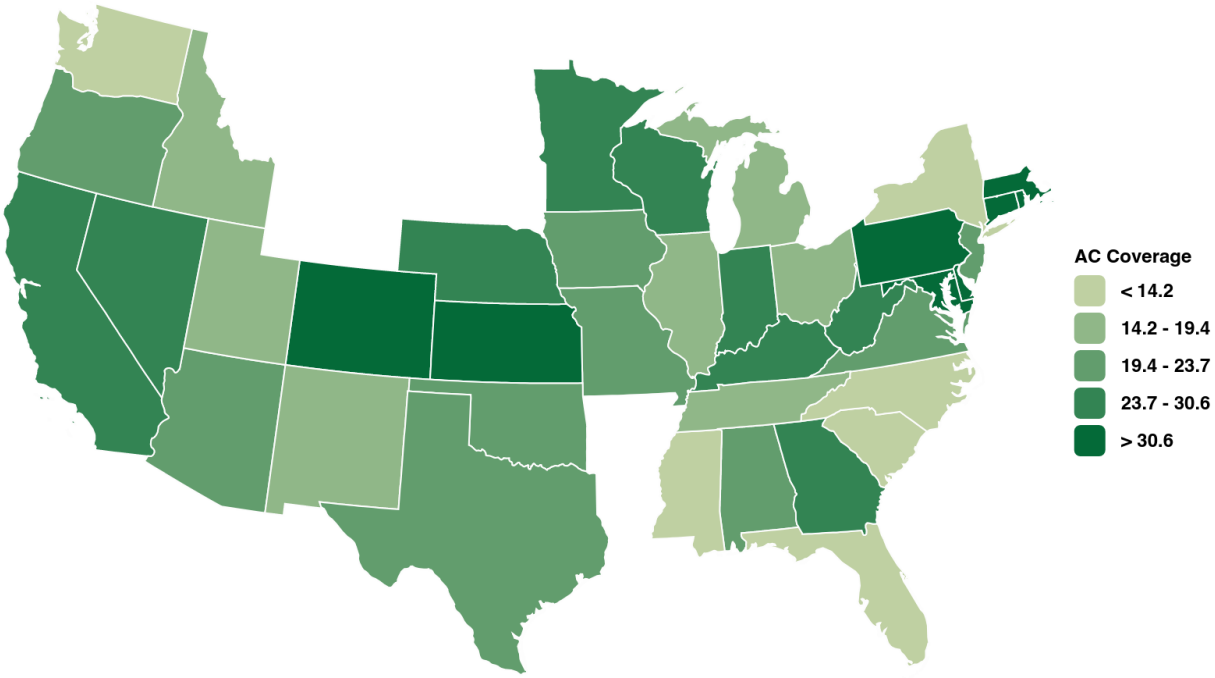


Figure 10: Estimated Sales of ASHP Represented by HARDI Data by State

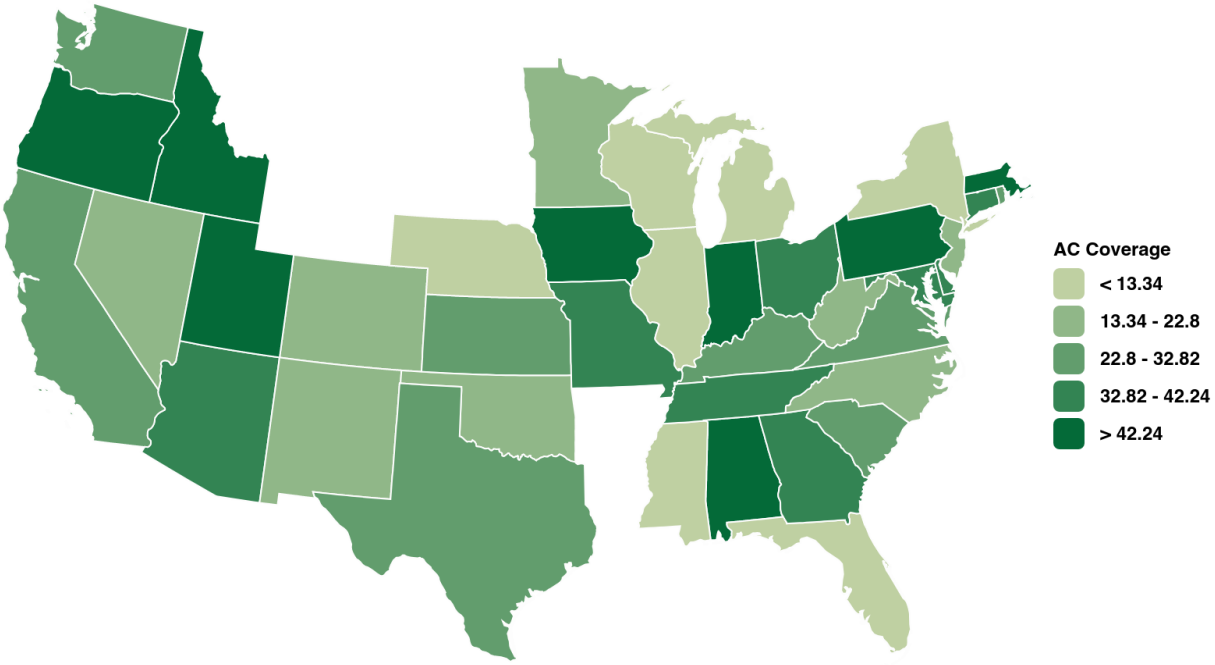
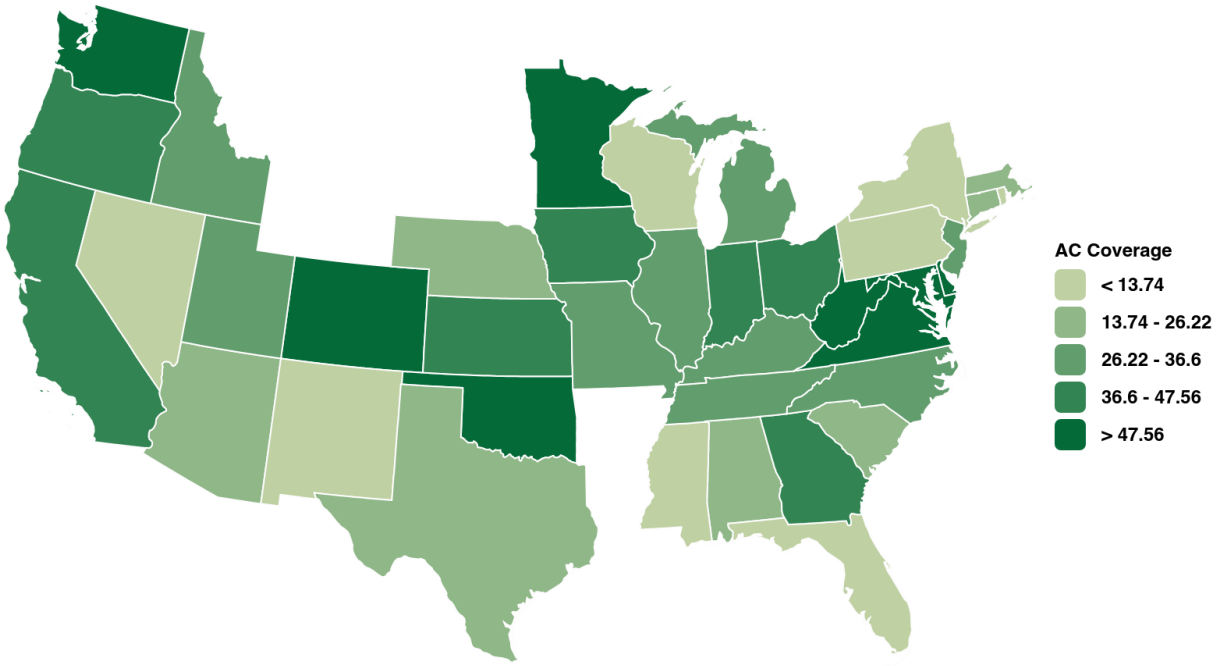


Figure 11: Estimated Sales of Gas Furnaces Represented by HARDI Data by State



Appendix A Estimating Heating Capacity and Efficiency

The HARDI data do not include heating capacity or efficiency values for ASHP in DRIVE, which are necessary to assign the data into program bins and to have a more holistic understanding of product performance. To approximate these missing values, the NMR team created correlation factors that could be used to estimate heating capacity and heating efficiency based on cooling capacity and cooling efficiency. The NMR team used AHRI product specification data to investigate the correlation between cooling performance and heating performance for ASHP systems, and applied those correlations to the cooling-only data included in the HARDI dataset in order to estimate the heating performance of those systems.

A.1 Estimating Heating Capacity Based on Known Cooling Capacity

Using a linear model based on capacity and efficiency specifications for all ASHP systems included in AHRI product specification lists,[25] the NMR team found that the heating capacity (at both 47°F and 17°F) for a given ASHP system could be calculated according to the following formulas:

$$HeatCapacity_{47°\mathrm{F}} = 1.026 \times CoolCapacity + 0.215 \times Pre2015 - 0.1 \times SEER$$

$$HeatCapacity_{17°\mathrm{F}} = -6.642 \times CoolCapacity + 0.109 \times Pre2015 + 0.289 \times SEER$$

Where:

- heating capacity and cooling capacity is measured in BTU/hr
- SEER is measured in BTU/Wh
- Pre2015 is a binary variable, where 1 is used for models produced before the 2015 increase in federal HVAC efficiency standards and 0 is for newer models

The model to estimate heating capacity at 47°F has a Pearson correlation of 0.984 with the actual heating capacities from the AHRI directory of equipment, and the model to estimate heating capacity at 17°F has a Pearson correlation of 0.968. Table 7 shows the ratio of modeled heating capacity to actual heating capacity in the AHRI directory according to our model, indicating how closely the model's heating capacity estimates compare to the actual heating capacity figures included in the AHRI database.

[25] This includes traditional, central ASHP systems and ductless mini/multi-split ASHP systems. A searchable version of this information can be found at: https://www.ahridirectory.org/Search/SearchHome

Table 7: Correlation of Modeled Heating Capacity to Heating Capacity Specifications from AHRI Directory

Models from Before 2015	Ratio of Heating Capacity at 47°F	Ratio of Heating Capacity at 17°F
Mean	0.9915	0.9938
n	431,199	431,200
Standard deviation	0.05933	0.08110
Models from After 2015		
Mean	1.0036	1.0037
n	373,565	373,565
Standard deviation	0.05431	0.09954
Total		
Mean	0.9971	0.9984
n	804,764	804,765
Standard deviation	0.05738	0.09027

A.2 Estimating Heating Efficiency Based on Cooling Efficiency

The data available from HARDI are fairly granular, but inherently less so than specifications for individual pieces of equipment included in the AHRI directory. Rather than precise model-specific details regarding efficiency and capacity, the HARDI data groups systems into SEER values at the integer-level and cooling capacities in half-ton (6,000 BTUh) increments, which complicated efforts to develop a granular model of HSPF for the systems included in the HARDI data. After testing multiple modeling approaches, the NMR team generated average HSPF values for each cooling capacity/SEER bin of AHRI data for nearly 800,000 heat pump systems from the AHRI directory and ran regressions on the resulting matrix (shown in Table 8). This approach resulted in two equations to estimate HSPF for the systems in the HARDI data: one for ASHP systems below 24 SEER and one for those at 24 SEER and above.

$$HSPF = \begin{cases} 4.176 + 0.285 \times SEER + 0.007 * CoolCapacity, SEER < 24 \\ 4.141 + 0.262 \times SEER + 0.067 * CoolCapacity, SEER \geq 24 \end{cases}$$

This equation uses one regression for all ASHP systems below 24 SEER (central ducted systems and ductless mini-split systems) and a separate regression for ductless ASHP systems 24 SEER and above because, in investigating the system-level AHRI specifications, we found that 24 SEER represented a clear break in heating performance. The resulting model has a Pearson correlation of 0.748 with the original AHRI data, and 0.958 with the model inputs in Table 8.

Table 8: Average HSPF for ASHP Systems in AHRI Directory, Grouped into Size and Efficiency Categories Used in HARDI Data

	Cooling Capacity (kBTUh)									
SEER	6	12	18	24	30	36	42	48	54	60
Central & Mini-split ASHP										
13	7.7	7.8	8.0	8.0	7.9	8.0	8.0	8.0	8.0	8.0
14	8.2	8.1	8.3	8.3	8.3	8.3	8.4	8.4	8.6	8.4
15	8.6	8.3	8.5	8.7	8.6	8.7	8.6	8.6	8.7	8.5
16	8.9	8.8	8.7	8.9	9.0	9.0	9.0	9.1	8.9	9.3
17	9.2	9.1	9.3	9.2	9.1	9.1	9.4	9.1	9.5	10.3
18	9.4	9.4	9.7	9.3	9.5	9.5	9.6	9.6	9.6	10.3
19	10.4	10.0	9.8	10.8	10.2	9.9	9.9	10.2	9.7	9.7
20	10.7	10.2	10.0	11.1	9.9	10.0	10.0	10.1	10.5	11.4
21	10.4	10.3	10.1	10.6	9.7	10.2	10.1	10.5		
22	10.3	11.0	9.9	9.9	9.6	10.3		10.3		
23	10.6	10.4	10.1	10.3	10.1	11.9		11.7		
Mini-split ASHP										
24	11.3	10.2	11.8	11.2						
25	11.2	11.2								
26	11.7	11.8								
27	10.2	12.8								
28	12.6									
29		13.7								
30	11.0	13.8								
32	13.0	14.0								
33	13.6									
37	14.1									
38	15.0									
40	14.5									
42	15.0									

Table 9 describes the number of systems in the AHRI database that were used in the modeling effort to develop the regressions that predict the HSPF based on cooling capacity and SEER.

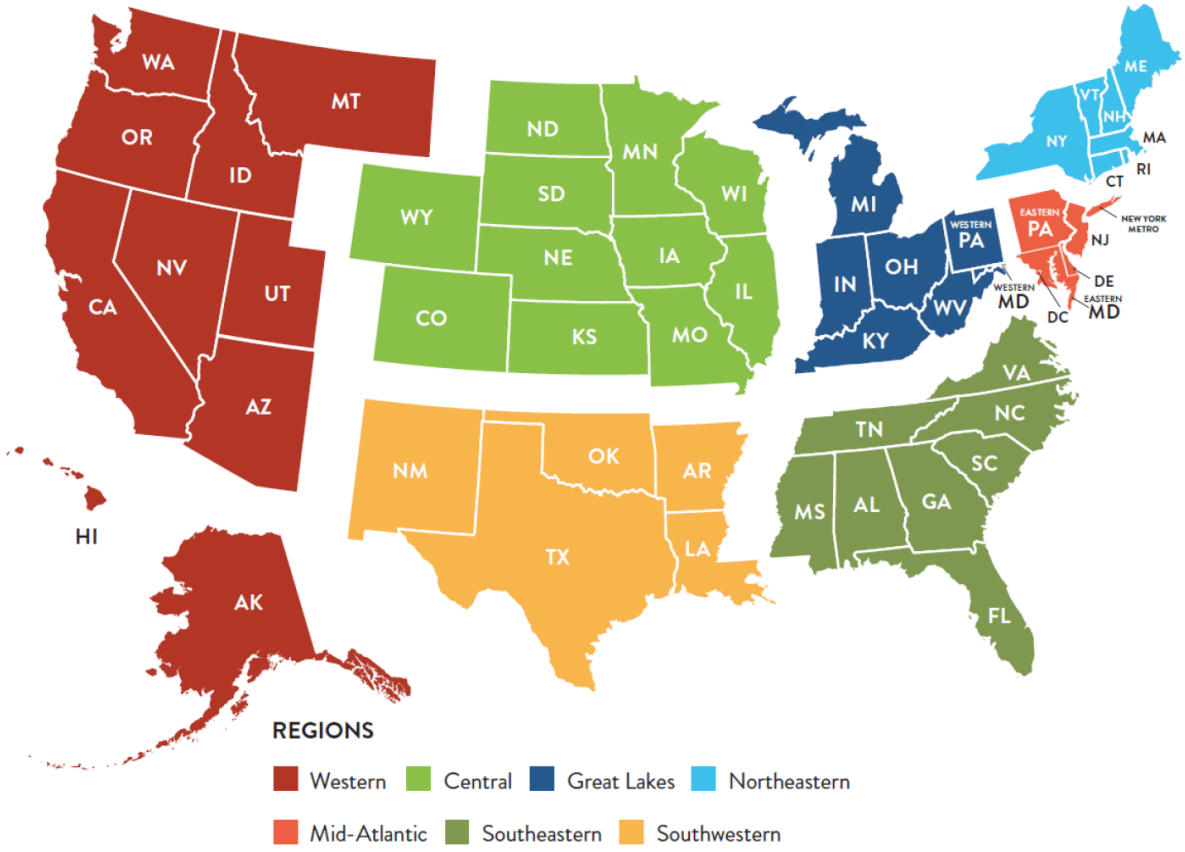
Table 9: Count of AHRI Systems Used to Develop HSPF Models, by Efficiency and Capacity

	Cooling Capacity (kBtuh)									
SEER	6	12	18	24	30	36	42	48	54	60
Central & Mini-split ASHP										
13	39	2,552	10,402	8,501	30,671	14,272	16,997	3,575	8,786	154
14	3	9,366	32,523	44,621	78,010	50,710	71,267	10,284	20,050	423
15	132	6,002	38,231	40,660	59,108	27,151	40,276	6,455	13,999	524
16	165	1,002	16,870	19,760	27,733	9,153	14,167	2,425	3,543	57
17	69	239	2,820	7,752	12,802	3,840	4,119	1,442	475	30
18	55	95	1,162	1,064	5,645	2,065	1,346	1,094	665	24
19	73	170	486	807	1,336	286	535	249	244	69
20	93	316	538	534	965	116	364	184	16	4
21	66	215	210	151	178	127	24	21		
22	121	171	140	51	13	41		22		
23	122	66	82	21	10	2		2		
Mini-split ASHP										
24	37	13	16	3						
25	36	55								
26	11	9								
27	25	3								
28	20									
29		10								
30	32	23								
32	1	6								
33	14									
37	3									
38	13									
40	11									
42	6									

Appendix B HARDI Geographic Regions

Figure 12 describes the geographic regions into which data can be grouped in the DRIVE portal. Note that HARDI only provides boiler sales estimates in New England at the regional level, not the state-level, due to lack of coverage of the data.

Figure 12: Map of HARDI Regions



Appendix C Program Data, 2014 – Half of 2017

Table 10 shows the raw counts of program-incented units from 2014 through the first half of 2017, based on program tracking data provided to the team. These values were used to estimate the program market penetration for various equipment types.

Table 10: Program Incented Units

Equipment Type	2014	2015	2016	1st Half 2017
Central ASHPs	282	276	469	246
Gas Boilers	4,427	4,150	7,003	4,010
Central AC	1,033	1,665	1,927	1,651
Mini-split ASHP	1,778	5,272	7,060	3,634
Gas Furnaces	4,288	5,221	5,094	2,738

Appendix D Revision to TXC52 Study

In finalizing this memo, the team identified a calculation error in the Residential HVAC Efficient Market Share Estimates (TXC52) Final Results Memo, Table 4: Market Size Estimates and Survey Representativeness. Below is a corrected version of Revised Table 11 from the TXC52 study memo. We provide it for informational purposes only, since the TXC52 study's scope did not include an assessment of the size of the Massachusetts HVAC market, and the assessment developed for the TXC52 study was based on data from just two distributors and is highly speculative. The results presented in Section **Error! Reference source not found.** earlier in this memo supersede both the original and revised market size estimates from study TXC52.

Revised Table 11 from TXC52: Market Size Estimates and Survey Coverage

System Type	Estimates	Estimated Market Size		Estimated Market Share Captured by Survey	
		Mean	Range	Mean	Range
Central AC	2	32,424	26,990–45,895	44%	31%–53%
Gas Water Heaters	1	31,250	25,000–41,667	16%	12%–21%
Gas Furnaces	1	9,375	7,500–12,500	45%	34%–56%
Central ASHP	2	9,006	6,250–21,250	31%	13%–45%
Mini-split ASHP	2	13,646	9,250–32,083	21%	9%–31%
Gas Boilers	1	15,000	12,000–20,000	20%	15%–25%
Electric Water Heaters	1	6,250	5,000–8,333	22%	17%–28%