A-1

Appendix A – March 31, 2017 Primary and Secondary Research Findings

A-2

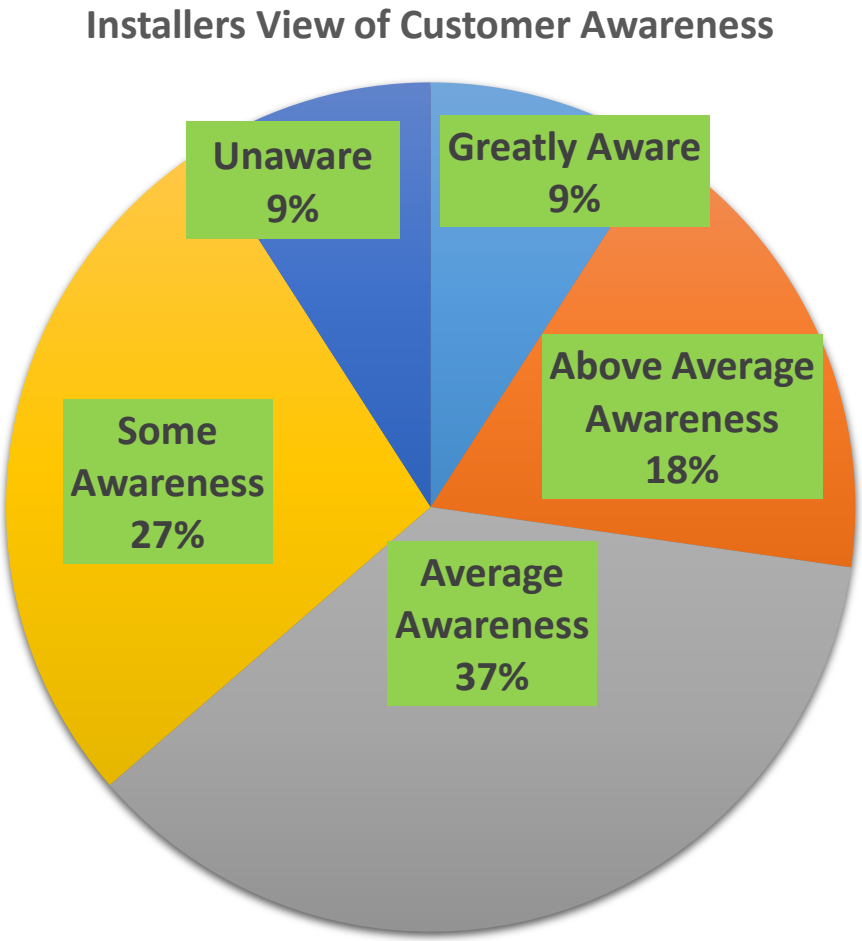
Awareness

Research Task: Assess installer overall awareness of DMSHPs, including what/how the manufacturers see the distributors' awareness, what/how the distributors see the installers' awareness, and what/how the installers see the customers' awareness (Interviewees asked to assess on a 5 point scale).

Awareness

- Secondary review did not provide significant clarification or feedback as to the Northeast levels of awareness amongst any category of market actor.

Awareness


Installers View of Customer Awareness
Unaware 9%
Greatly Aware 9%
Above Average Awareness 18%
Some Awareness 27%
Average Awareness 37%

Awareness

- Manufacturers think distributors and installers are "Greatly Aware" or have "Above Average Awareness" of DMSHPs.
- Distributors think installers are "Greatly Aware" of DMSHPs.

A-6

Barriers

Research Task: Identify barriers in the market that hinder adoption of DMSHPs.

Barriers

- Several secondary sources provide information about market barriers. No "one" barrier, but rather a mix of multiple barriers that would suggest incorporating a variety of approaches to addressing them.
- NEEP[1] recently surveyed 35 regional ASHP stakeholders. Key barriers involved:
  - Consumer awareness/education
  - Installer awareness/education
  - Technology/controls
  - Performance metrics

1- Northeast Energy Efficiency Partnership. "Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report 2016 Update". 2017.

Barriers - Market

- Upfront cost
- Lack of awareness/education by installers
  - Poor installations (NY does not require a specific HVAC installer license)
  - Ongoing perception that DMSHPs do not work in cold climates
- New manufacturers are "flooding the market with cheap products, limited access to parts and poor support"; risk of developing reputation that product doesn't work.
- Installer laziness: "Are we all trying to 'do right' by the customer? One chance to 'get it right' when they call for air conditioning."
- Low energy prices (especially natural gas).

Barriers - Technology

Summary of Primary Research - Continued

- Lack whole-house filtration system; need equipment that allows for ducting and zoning with air handler.
- Many of New York's existing HVAC systems designed for ducted distribution (forced air).
- Thermostatic controls do not work well.
- Cannot attach UV lighting.
- Potential grid impact; mitigation strategy could include a well-designed incentive program to direct more holistic installations (e.g. DMSHP plus solar, weatherization, and demand response).
- Equipment is from overseas: installers do not know where to get parts, can be lag time.
- Existing building code.

Barriers - Customer

- Upfront cost
- Customer education/awareness
  - General perception: product does not work in cold climates.
  - Economic understanding: "It'd be helpful if there was a simple way to show customers the break-even point, and how heat loss works, etc."
  - Usage: Customers understand turning up a thermostat; they do not understand *how* DMSHPs actually heat.
- Aesthetics
  - But can be overcome with an incentive, and once installed the customer usually stops noticing.

A-11

Customer Motivations-Hypothesized

Research Task: Determine primary consumer motivation for installing DMSHP: heating or cooling, or both, "going green", getting off fossil fuels or pairing with solar panels.

*All market actors (manufacturers, distributors, and installers) were asked related questions. However, the strongest responses were received by installers, who have the most direct contact with customers.

Customer Motivations-Hypothesized

- Secondary review suggested customers are installing DMSHP systems for both heating and cooling.
- Two evaluation studies provided insight

Study/Paper	Heating Only	Cooling Only	Heating and Cooling
Cadmus: Ductless Mini-Split Heat Pump Customer Survey Results, 2014	1%	25%	74%
Cadmus: Interaction of Cold Weather Ductless Heat Pumps and Primary Fossil Systems, 2016	4%	31%	65%

- Reports are focused on “cooling programs”, so perhaps the program messaging is playing a role in customer responses.

Customer Motivations-Hypothesized

Responses as a Percentage					
	Cooling	Going Green	Saving $ and Energy	"Application Driven"	All
Manufacturers	Inconclusive				
Distributors	20%	20%	20%	20%	20%
Installers	30%	0%	20%	0%	50%

A-14

Customer Satisfaction

Research Task: Determine satisfaction level of the customer.

Customer Satisfaction

- Connecticut Report[1] - Customers overwhelmingly satisfied even though they are not using the DHPs as efficiently as possible. Customer experience in CT is likely to be approximately the same as in NY.
- There were some variations regarding customer satisfaction from management companies of multi-family structures, depending on the business model of these management companies. For example, some companies found a slight increase in maintenance cost due to having to clear snow off the outdoor unit, while others found a decrease in maintenance cost as there was no longer a need to remove and insert room air conditioning units.[2]

1-DNVGL: Ductless Heat Pump Evaluation - Connecticut Energy Efficiency Board, June, 2016
2-DOE EERE NREL: Mini-Split Heat Pumps MF Retrofit Feasibility Study

Customer Satisfaction

- 9/11 installers stated customers were in satisfaction range of 7-10 (10 being high). One stated a 6 and another did non answer.
- Installer explanations for customer dissatisfaction:
  - Installer installed the DMSHP in an application that was poorly suited for DMSHPs (i.e. single-head DMSHP installed for whole-house heating in a home with many separate rooms)
  - Customers expected more from technology (e.g. a heat pump located in a home where the movement of the air in the areas wasn't conducive to heat the entire space).

A-17

Displaced Fuel

Research Task: Estimate displaced fuel/fuel costs per install by fuel type (fossil or electric).

Displaced Fuel

- NEEP's 2014 Market Strategies Report[1] projected annual displaced fuel oil savings to be 164 gallons.
  - Oil savings were converted from the report's estimated 3000 kWh in electric resistance savings to the64 gallons.

1- Northeast Energy Efficiency Partnership. "Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report". 2014.

Displaced Fuel

A-19 Summary of Secondary Research - Continued

- 2016 MA/RI Ductless Mini-Split Heat Pump Impact Evaluation[1]

Table ES-7. Energy Savings, Each Baseline Applied to All Sites, Top 25%

Season	Baseline System	Sample Size	Electric Usage of DMSHP [kWh]	Baseline Energy Reduction	Average Energy Savings	Precision at 90% Confidence [%]
Winter 2016	90% AFUE Furnace	15	1,566	18.68 MMBtu	13.34 MMBtu	30
	85% AFUE Furnace		1,566	19.78 MMBtu	14.44 MMBtu	30
	82% AFUE Boiler		1,566	17.43 MMBtu	12.09 MMBtu	31
	HSPF 7.7 DMSHP		1,862	2,433 kWh	571 kWh	13
	HSPF 8.2 DMSHP		1,761	2,184 kWh	423 kWh	15
	Electric Resistance		1,566	4,188	2,622 kWh	33

= 186 therms

= 197 therms

= 125 gallons (Gallon/MMBtu conversion factor= 7.09)

DMSHP Market Characterization Study

1- The Electric and Gas Program Administrators of Massachusetts and Rhode Island. "Ductless Mini-Split Heat Pump Impact Evaluation". 2016.

Displaced Fuel

- Seven installers provided estimates for how DMSHP primarily function.

	% of Projects that displace heating	% of Projects providing Whole-House Heating	% of Heating Load typically Served by HP	% of Project that provide cooling
Installer 1	50%	50%	80%	100% of projects provide some cooling
Installer 2	20%		10-20%	80% of projects are cooling focused
Installer 3	25%	75%	For Displacement function: 30% For Whole-house function: 100%	
Installer 4	10%	90%	100%	
Installer 5	80%		60%	20% of projects are cooling focused
Installer 6	50% (customers "surprised" with the great heating)	50%	For Whole-house function: 80-100%. For Displacement function: 50%.	100% of projects provide some cooling
Installer 7	50%		20%	50% of projects provide whole house cooling

(4/11 interviewed installers did not answer at all or did not provide estimated percentages)

Displaced Fuel

- Percentage of customers that keep existing fossil fuel system in place:
  - 9/11 installers said 90% -100% of customers keep fossil fuel system in place. In fact, installers "encourage customers to keep them for back up, in case of needing a repair part from Asia, or it's snowing or dark – but only 20% of customers will ever use the back up."
  - 1/11 installers stated 75% of customers keep fossil fuel system in place.
  - 1/11 installers stated 25% of customers keep fossil fuel system in place.
- Installers reported that all types of fuel were being displaced:
  - Oil, propane, wood, pellets, electric resistance.
  - One installer said "no fuel was being displaced, but all AC window units were."
  - Many installers said natural gas was being displaced, but not as much as other fuels.

A-22

Distribution & Sales Channels

Research Task: Confirm product distribution channels and sales channels.

Distribution & Sales Channels

- Northwest report[1] described hub-and-spoke model, with the supply chain consolidated at the manufacturing and distribution levels.
  - However, the report found the installers and builders within the residential market to be very fragmented (e.g. not a lot of coordination between installers and builders).
- The secondary review did not provide information directly relevant to New York State for this area of inquiry although we could assume distribution channels do not greatly differ from other regions.

1- Bonneville Power Administration. "HVAC Market Intelligence Report". 2016.

Distribution & Sales Channels

A-24 Summary of Primary Research

Interviewee	Product Distribution (wholesale) Channels	Product Sales Approach
Manufacturer	Sell to distributors	Education and training
Distributor	Buy from manufacturers	Sell to installers. Provide education and training (equipment, sales training, provide energy models)
Installer	Buy from distributor	Obtain customers via: utility website lists, lead generation service, on-line advertising, direct mail, existing customer base, RFPs, word-of-mouth Customer Approach: • 9/11: Identify customer interests, assess/audit building, model energy use, propose work scope, close deal • 2/11: Called in by another business to complete install based on provided design specifications

Manufacturer quote: "There is more mark up in the US than Europe and Asia because manufacturers sell through middle man, as opposed to direct to customer."

A-25

Impact Analysis

Research Task: Develop per-unit impact analysis estimating changes in: Electricity use, summer/winter peak, greenhouse gas, Fossil fuel use (savings).

Impact Analysis

A-26 Summary of Secondary Research

- 2016 MA/RI Ductless Mini-Split Heat Pump Impact Evaluation[1]
- Electricity and fossil fuel savings for a variety of baseline systems

Season	Baseline System	Sample Size	Electric Usage of DMSHP [kWh]	Baseline Energy Reduction	Net Energy Savings	Precision at 90% Confidence [%]
Summer 2015	EER 9.8 Window AC	114	159	213 kWh	54 kWh	15
	SEER 13.0 Central AC		159	288 kWh	129 kWh	14
	SEER 13.0 DMSHP		159	245 kWh	86 kWh	14
	SEER 14.5 DMSHP		159	220 kWh	61 kWh	15
Winter 2016	90% AFUE Furnace	60	763	6.9 MMBtu	4.3 MMBtu	37
	85% AFUE Furnace		763	7.31 MMBtu	4.7 MMBtu	36
	82% AFUE Boiler		763	6.44 MMBtu	3.83 MMBtu	37
	HSPF 7.7 DMSHP		763	989 kWh	226 kWh	22
	HSPF 8.2 DMSHP		763	929 kWh	166 kWh	23
	Electric Resistance		763	1,547 kWh	784 kWh	42

1- The Electric and Gas Program Administrators of Massachusetts and Rhode Island. "Ductless Mini-Split Heat Pump Impact Evaluation". 2016.

Impact Analysis

A-27 Summary of Secondary Research - Continued

- 2016 MA/RI Ductless Mini-Split Heat Pump Impact Evaluation[1]
- Summer/Winter Peak impacts for a variety of baseline systems

Season	Baseline System	Sample Size	Electric Usage of DMSHP [kW]	Baseline Power Reduction [kW]	Average Peak Period Demand Savings [kW]	Precision at 90% Confidence [%]
Summer 2015	EER 9.8 Window AC	114	0.11	0.15	0.04	16
	SEER 13.0 Central AC		0.11	0.20	0.09	15
	SEER 13.0 DMSHP		0.11	0.05	0.06	15
	SEER 14.5 DMSHP		0.11	0.07	0.04	15
Winter 2016	90% AFUE Furnace	60	0.25	0	-0.25	34
	85% AFUE Furnace		0.25	0	-0.25	34
	82% AFUE Boiler		0.25	0	-0.25	34
	HSPF 7.7 DMSHP		0.25	0.33	0.08	24
	HSPF 8.2 DMSHP		0.25	0.31	0.06	25
	Electric Resistance		0.25	0.58	0.33	38

1- The Electric and Gas Program Administrators of Massachusetts and Rhode Island. "Ductless Mini-Split Heat Pump Impact Evaluation". 2016.

Impact Analysis

A-28 Summary of Secondary Research - Continued

- Electricity and fossil fuel savings (Top 25%)

Season	Baseline System	Sample Size	Electric Usage of DMSHP [kWh]	Baseline Energy Reduction	Average Energy Savings	Precision at 90% Confidence [%]
Summer 2015	EER 9.8 Window AC	29	358	484 kWh	126 kWh	12
	SEER 13.0 Central AC		371	663 kWh	292 kWh	11
	SEER 13.0 DMSHP		363	556 kWh	193 kWh	12
	SEER 14.5 DMSHP		332	468 kWh	136 kWh	14
Winter 2016	90% AFUE Furnace	15	1,566	18.68 MMBtu	13.34 MMBtu	30
	85% AFUE Furnace		1,566	19.78 MMBtu	14.44 MMBtu	30
	82% AFUE Boiler		1,566	17.43 MMBtu	12.09 MMBtu	31
	HSPF 7.7 DMSHP		1,862	2,433 kWh	571 kWh	13
	HSPF 8.2 DMSHP		1,761	2,184 kWh	423 kWh	15
	Electric Resistance		1,566	4,188	2,622 kWh	33

Impact Analysis

A-29 Summary of Secondary Research - Continued

- Summer/Winter Peak impacts (top 25%)

Season	Baseline System	Sample Size	Electric Usage of DMSHP [kW]	Baseline Power Reduction [kW]	Average Peak Period Demand Savings [kW]	Precision at 90% Confidence [%]
Summer 2015	EER 9.8 Window AC	29	0.24	0.33	0.09	13
	SEER 13.0 Central AC		0.25	0.45	0.20	11
	SEER 13.0 DMSHP		0.23	0.36	0.13	12
	SEER 14.5 DMSHP		0.22	0.31	0.09	13
Winter 2016	90% AFUE Furnace	15	0.54	0	-0.54	25
	85% AFUE Furnace		0.54	0	-0.54	25
	82% AFUE Boiler		0.54	0	-0.54	25
	HSPF 7.7 DMSHP		0.61	0.80	0.19	12
	HSPF 8.2 DMSHP		0.61	0.76	0.15	15
	Electric Resistance		0.54	1.64	1.1	26

Impact Analysis

A-30 Summary of Secondary Research - Continued

- 2016 MA/RI Ductless Mini-Split Heat Pump Impact Evaluation

Baseline System	Annual Electricity savings (kWh)	Annual Electricity savings- Top 25% (kWh)	Annual Fossil fuel use (MMBtu)	Annual Fossil fuel use- Top 25% (MMBtu)	Summer peak reduction (kW)	Summer peak reduction - Top 25% (kW)	Winter peak reduction (kW)	Winter peak reduction- Top 25% (kW)	Annual GHG Emissions reduction (tons CO2)	Annual GHG Emissions reduction- Top 25% (tons CO2)
Electric resistance	784	2622					0.33	1.1	0.188	0.629
Standard DMSHP (8.2 HSPF)	166	423					0.06	0.15	0.040	0.102
Standard DMSHP (14.5 SEER)	61	136			0.04	0.09			0.015	0.033
Gas Furnace (85% AFUE)	-763	-1566	7.31	19.78			-0.25	-0.54	0.204	0.673
Oil Boiler (82% AFUE)	-763	-1566	6.44	17.43			-0.25	-0.54	0.293	0.913
Window AC (9.8 EER)	54	126			0.04	0.09			0.013	0.030
Central AC (SEER 13)	129	292			0.09	0.2			0.031	0.070

*Factors used to calculate GHG reduction impacts- .24 Metric tons/MWh (NY ISO: Power Trends 2016 Report) and EPA's Emission Factors for Greenhouse Gas Inventories (for fossil fuel)

Impact Analysis

- 5/11 installers had no idea or no comment on energy savings as they relate to DMSHPs.
- Anecdotal estimates include:
  - "15-30% savings" (without follow-up monitoring)
  - "2-5% of a customer's annual fuel bill"
  - "Maybe a couple of hundred dollars a year"
- One installer was adamant that there are no savings - his customers install as a solution to a problem area, not to realize energy savings, and that there isn't a heating or cooling system displaced in these scenarios.
- Some installers stated that energy savings mattered more to customers when fossil fuel costs were higher.
- Some installers stated that savings vary depend on application and usage: "You really have to say to the customer 'I can't give you a specific number, but I can give you an equivalency and how it works in your house, and how you prefer to run it will ultimately determine your savings.'"

A-32

In-Field Performance

Research Task: Characterize in-field performance of ductless mini-split systems.

In-Field Performance

- 2014 NEEP Meta-study summarized a variety of in-field performance studies. Generally concluded that DMSHP systems were performing to technical expectations.
- 2016 MA/RI Mini-split Heat Pump Impact Evaluation[1]:
  - On average, field-measured seasonal efficiencies for most units were somewhat below their rated values, although some units met or exceeded their ratings.
  - Correlation found between a systems observed in-field capacity and the systems rated capacity.
  - "Non-cold-climate" models operated at outdoor ambient temperatures below 0°F, but at lower efficiency levels than "cold-climate" models.

1- The Electric and Gas Program Administrators of Massachusetts and Rhode Island. "Ductless Mini-Split Heat Pump Impact Evaluation". 2016.

In-Field Performance

- Little to no information collected regarding in-field performance of DMSHP systems.
- Manufacturers stated their products are AHRI tested, although that doesn't give information for real world scenarios.
- No installers indicated conducting any in-field monitoring of the systems they have installed. They are concerned with installing the system to the customer's satisfaction, and not with the details of its technical performance.

A-35

Installer Value Proposition

Research Task: Confirm value proposition for installers --- i.e., understand the installers' business models -- what the drivers are for installers, and how installers view the value propositions of the customers.

Installer Value Proposition

- Secondary review did not provide insight into this question for New York State or other Northeast jurisdictions.

Installer Value Proposition

- Variety of Lead-Generating Approaches
  - Utility website lists, lead generation service, on-line advertising, direct mail, existing customer base, RFPs, word-of-mouth, "town dinners" where installer advertises free dinner in combination with energy presentation.
- Variety of Business Models
  - Installer specializes as "building science" expert only (calls installation crew to undertake construction).
  - Installer is versed in building science and completes construction.
  - Installer specializes in HVAC (mechanical).
  - Installer is installation crew only (called in by engineer/developer/architect).
- General Customer approach
  - Identify customer interests, assess/audit building, model energy use, propose work scope, close deal.
  - 10/11 installers do some energy modeling, but depth varies widely: "One-line calculation estimating future energy costs based off current fuel bills" to RESNET model. 1/11 installer does no modeling at all.

Installer Value Proposition

Installer View of Customer Value Proposition

- Many customers are *initially* interested because they want additional/new cooling.
- Most customers ultimately choose and use DMSHPs for a mix of reasons – not just one. Motivations include:
  - Cooling
  - Heating
  - Going green
  - Saving money

Installer Value Proposition

- What percentage of your total sales do DMSHP represent?
  - 75-80% of interviewees: 5 – 10 % of business
  - 20-25% of interviewees: 20 – 40% of business
- Perspective on Market Trend
  - 9/11 say upward trend
  - 2/11say “no real trend”, or do not answer
- Have they seen effective marketing?
  - Most answer: “No”.
  - Some answer:
    - Best marketing is from manufacturers.
    - Some marketing by local installers but they don’t know if effective.
  - Marketing has focused on DMSHPs providing multiple benefits.

A-40

Market Actors

Research Task: Identify and confirm key market actors by type, including assessing their roles in promoting technology and levels of activity.

Market Actors

- The "usual" HVAC market actors are the same as the DMSHP market actors: manufacturers, distributors, installers, efficiency programs, and customers.
- Several interesting manufacturing partnerships between the US and Asia (York/Hitachi; Goodman/Daikin; Midea/Lennox; Carrier/Toshiba; with Trane and Mitsubishi strong enough to not partner.
- According to NYSERDA's Residential Baseline Study HVAC Market Assessment Volume 3, small installers are the largest opportunity for influencing the market due to their being responsible for nearly two-thirds of sales.

Market Actors

A-42 Summary of Primary Research

Interviewee	Who are KEY actors?	What should they do?
Manufacturers	1/5 said manufacturers, then installers	Improve distribution
	1/5 said customers and installers	Be educated how HPs work
	1/5 said utility, then manufacturer, then distributor.	Combine incentives with training to reduce install costs (e.g. reduce cost while keeping install quality high)
	1/5 said federal government, then utility, then NYSERDA and ASHRAE	Establish a tax credit (fed), provide incentive (utility), provide education (NYSERDA and ASHRAE)
	2/5 said installers	Be educated how HPs work
Distributors	4/5 said NYSERDA	Rebates, retraining design community, conduct marketing and awareness
	1/5 said "All actors"	Utilities provide incentives, manufacturers advertise and retrain installers, NYSERDA retrain customers

Market Actors

A-43 Summary of Primary Research - Continued

# of installers	Who are the KEY actors?	What should they do?
2/11	Installers, NYSERDA/utility	Actively educate customers; let customers choose incentive or very low interest financing (reduce cumbersomeness of programs)
2/11	NYSERDA	Incentives and advertising (education)
1/11	Installers	Educating customer
1/11	"All actors"	See quote on next slide
1/11	Installers – because utilities don't discriminate	Utilities should provide incentives, but only for good installs and good equipment. Since they can't "discriminate", then it's up to installers to lead.
2/11	Utilities	Incentives
1/11	Utilities, manufacturers	Incentives (utilities), advertising (manufacturers)
1/11	Customers	Spread the word!

Market Actors

Additional interviewee responses regarding what different key market actors should be doing to more effectively promote DMSHPs:

- "New York Utilities need a more educated view of the value of DMSHPs."
- "Installers convert people to HeatPumps and then the customer may get a letter saying the customer is doing a poor job with their electricity usage, because the local utility doesn't acknowledge the fossil fuel displacement. This causes unnecessary confusion and frustration."
- "Utility incentive programs have excluded ASHPs based on lower efficiency ratings by a point or two so customers weren't being able to get incentives on these even though they were a better technology compared to the existing system."

Market Actors

Additional interviewee responses regarding what different key market actors should be doing to more effectively promote DMSHPs:

- "Manufacturers have historically provided little to no guidance to customers about how to use DMSHPs. Installers have since made it a point with customers on how to use it (e.g. set it and forget it)."
- "NYSERDA could provide marketing and/or additional incentives. A distinct public education campaign initiative with specific incentives where it makes sense could be effective. Word gets around when there is an incentive from NYSERDA - as opposed to JUST marketing. After a certain period of time, they could tail it off."
- "Installers need to understand the capabilities and the challenges of the equipment and be able to change/tailor the sales to those pros and cons."

Summary quote: "Everyone has a role to play…"

Market Actors

Focused question: What can NYSERDA do, specifically?

- Promote low-temp heating.
- Support quality lower- to mid-tier priced products .
- Help relate EE to dollar savings.
- Help bridge first cost (incentives, financing).
    - Opinions on incentives vary: "tie it to a qualified install and good product"; "don't only apply it to high efficiency"; "base the install on reduced heating costs"; "provide to installer based on how well system does"; "provide direct to customer through local utility (don't require HERS – to administrative)"; "plan on phasing it out over time to address concerns about 'incentives not being sustainable'".
- Educate installers about DMSHP generally and technically (i.e. when to recommend, how to install).
- Increase awareness (public advertising): use non-bias, 3rd party role to increase public confidence.
- Educate architects and engineers.
- Reduce cumbersomeness of NYSERDA programs.

A-47

Market Indicators

Task: Identify key market indicators to effectively track DMSHP market evolution as well as identify practical data sources to inform such indicators.

Market Indicators

Summary of Secondary Research

Key market indicators worth tracking:	Recommended Data Source:
Annual sales by HSPF, SEER, capacity/size and "cold climate" (per NEEP spec)	HARDI sales data (Sales of NEEP Spec products currently not tracked)*
Sales by geographic region in NY	Currently not available
Annual DMSHP sales against fossil fuel equipment sales	HARDI sales data
Annual DMSHP sales compare to non-NY (Northeast sales w/o NY)	HARDI sales data
DMSHP Installed costs	Primary Research via market actor interviews
Penetration of DMSHP in installed base	Primary Research via customer surveys/in-field inspections

*AHRI collects sales data from their manufacturer members but does not make the data/analysis available to other parties

Market Indicators

- Market actors generally agreed with proposed market indicators and data sources.

A-50

Market Sectors

Research Task: Estimate how the size of markets differ between residential, multi-family, small commercial, and which market sectors are the most ripe for further technology adoption.

Market Sectors

Finding: None of the existing reports addressed this research task.

Market Sectors

A-52 Summary of Primary Research

Interviewee	Approx. % of sales - Residential	Approx. % of sales- Multi-Family	Approx. % of sales- Small Commercial	Sector with Most Opportunity for Growth
Summary of Manufacturer Responses	Most suggest Res represents largest % of the market	Nothing conclusive	Nothing conclusive	Tendency towards residential, but inconclusive
Select Distributor Responses	60%	2%	38%	Res. (cheap & quick) and Comm. (but currently expensive).
	50%	25%	25%	Should be MF, but not moving. Need coordination amongst market actors.
	60%	10%	30%	Single family with boilers and/or propane.
	Largest %	Still mostly conventional	Seeing growth in Boroughs	Should be in all MF. Rest of the world is 80-90% DHPs.
	Suburbs: 80% Burroughs: 20%	Suburbs: 20%	Boroughs: 80%	MF – should be a no brainer.
Summary of Installer Responses	Largest market for 7/10 respondents (3 inconclusive)	Largest market for 1 respondent (this is their niche)	"Handful of projects here and there" – growing in Burroughs/Bronx	5/10 said residential; 4/10 said MF: 1/10: "this is application driven – no specific market is most ripe"

Market Sectors

- Virtually no one in the industry tracks sales according to "residential" versus "multi-family" versus "commercial"; answers are informed estimates, at best.
- The "percentage of market share" is skewed depending on the units selected. Variable Refrigerant Flow (VRF) systems are fewer units, but greater dollars.
- Depending on the interviewees' market focus, their answers will be skewed (businesses focused on residential systems will have a better sense of the residential market).

Market Sectors

- Sector with most opportunity:
  - Most interviewees highlighted multi-family, but:
    - "Why" varies:
      - Technology works: "DMSHP units are small, and the smallest furnaces are too large", VERSUS
      - Technology doesn't work yet: "DMSHP doesn't work so well for an entire apartment. Once you close one bedroom door, you bump into having too much equipment being needed to serve the needs. Conceptually it works but not practically. If these have more "umph", then you'll see more uptake in multi-family", but the technology will improve.
    - Split incentive will need to be addressed: for retrofits, owners want to make money
  - Some interviewees said single-family because "it's cheap, quick, and fixes problems".
  - New construction also has potential, but more education and coordination is needed amongst designers, developers and installers.

A-55

Market Size

Research Task: Assess the size of the current, and potential market and characterize the New York State market.

Market Size

- See Appendix C for presentation of New York DMSHP Sales data (HARDI).

Market Size

A-57 Summary of Primary Research

Question	Manufacturers Response	Distributors Response	Installers Response
Growth in DMSHP sales over last three years (2014-2016)?	No definitive answer	Range: 3% – 25% with most responses ranging in 10%-20%	Six responses in 1%-20% range. three responses in 20%-40%, two responses in 40%-60%
Projected growth if Status Quo Maintained (2017-2019)	10%-20%	Range: 5%-25% with most responses ranging in 10% – 20%	Seven responses in 10%-20% range, two answers at 25%, two answers at 50%**
Potential growth with Program Support (2017-2019)	30% - 50%	20% – 35%	All but one response* suggested very significant growth: "Huge", "Unlimited", 50%, 100%, 200%-300%, "Could eliminate fossil fuels in twenty years"

- All ranges provided anecdotally (not based off data).
- Regardless of estimated percentages, vast majority (all but one or two) of interviewees stated that the trend would be upwards.

*One interviewee responded with 0% growth – this business closed.

**The two businesses responding with "50%" install less than 20 systems a year.

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Maximizing Energy Savings

Research Task: Assess energy savings potential of current DMSHPs installations in New York, i.e., based on location/building type & size, could a different DMPSHP system have been installed to maximize energy savings?

Note - NYSERDA is interested in exploring: 1) how to optimize performance based on how a consumer intends to use their ductless mini-split heat pump and 2) how they COULD use a DMSHP in order to maximize usage/savings.

Maximizing Energy Savings

- Finding: None of the existing reports addressed this research task.

Maximizing Energy Savings

- Interviewees thought this question out of touch with the market.
- Most DMSHPs installations are "application driven" and *not* focused on saving energy. Rather, they are used to:
  - (a) add AC in a home with no ducts
  - (b) add heat to a poorly heated or new room
  - (c) address another issue
- Installers do suggest alternatives to save additional energy, but customer may not be interested or want to spend additional money.
- Installer feedback:
  - 8/11 responded with "no" because either there were technical constraints (e.g. line-set), or the customer wasn't interested (e.g. a multi-unit would cost more)
  - 1/11 stated: sure: as technology develops and there are more product offerings – like with air handlers – we'll see opportunities emerge
  - 1/11 declined to answer
  - 1/11 did not answer

A-61

Payback

Research Task: Simple payback estimates by system type.

Payback

- 2014 DOE EERE NREL: Mini-Split Heat Pumps Multi-family Retrofit Feasibility Study[1]
  - The simple paybacks for installing a single DMSHP unit ($3,500 assumed cost) in an apartment in the New York City climate (Climate Zone 4) to fully offset a 30 MMBtu annual heat demand are estimated to be approximately 3.5, 4.2 and 8.3 years if replacing fuel oil, propane and electric resistance respectively.
    - Costs of fuel oil and propane have dropped significantly since 2014, so these estimates for oil/propane offset scenario are no longer accurate.

1- United States Department of Energy, Energy Efficiency and Renewable Energy. "Mini-Split Heat Pumps Multifamily Retrofit Feasibility Study". 2014.

Payback

- Do installers estimate payback for customers? And if so, how?
  - 7/11 installers do, using a tool/model/calculation
    - One installer estimated 5-15 years as the typical payback period.
  - 2/11 installers said they don't ("customer usage is too unpredictable")
  - 2/11 installers did not answer/don't know

Payback

Installer quotes on how low fuel prices have impacted payback:

- "There isn't a payback. We are lucky if we can show that it is neutral. We highlight the carbon impact, and the new AC options, but we don't say it'll save $ right now."
- "It's terrible, it was hit hard. We used to get savings on a gas boiler but not any more."
- "Lowered customer interest. Natural gas conversion has dropped off significantly. Try to pick a real $-for-$ operating cost. There might be a point at which using oil makes sense…but NYSERDA programs is all or nothing. These systems are not all or nothing."
- "It's made them less favorable. Though electric prices are low now as well."
- "It's killed it."
- 'It hasn't impacted things – my customers want air conditioning."

A-65

Potential Savings

Research Task: Assess potential statewide energy savings for New York.

Potential Savings

- 2014 NYSERDA Heat Pump Potential Report[1] includes estimated technical potential energy savings for New York (Fuel switching applications). This is currently the best source for estimated state-wide savings. Insufficient resources at this time to conduct new analysis with revised assumptions.

Table 1. Residential Space Heating/Cooling, Fuel Switching Measures

	2015	2025	2030	2034
Elec Cooling (GWh)	31	885	1,237	1,401
% of Res Cooling Forecast	1%	19%	25%	27%
Elec HP Space Heating (GWh)	(752)	(17,698)	(25,336)	(25,662)
% of Res Elec Forecast	-1%	-30%	-42%	-42%
Total Elec Space Htg Impact (GWh)	(722)	(16,813)	(24,099)	(24,261)
% of Res Elec Forecast	-1%	-28%	-40%	-40%
Gas Space Heating (BBtu)	5,310	142,714	215,413	236,396
% of Res Gas Space Heating Forecast	2%	53%	77%	84%
Oil Space Heating (BBtu)	2,463	58,230	86,303	88,209
% of Res Oil Space Heating Forecast	2%	52%	78%	81%

1- New York State Energy Research and Development Authority. "Heat Pump Potential for Energy Savings in New York State". 2015.

Potential Savings

- 2014 NYSERDA Heat Pump Potential Report[1] includes estimated technical potential energy savings for New York (Non-fuel switching applications).

Table 4. Residential Space Heating/Cooling, Non-Fuel Switching Measures

	2015	2025	2030	2034
Elec Cooling (GWh)	2	55	83	90
% of Res Cooling Forecast	0%	1%	2%	2%
Elec HP Space Heating (GWh)	42	898	1,263	1,233
% of Res Space Heating Forecast	1%	20%	28%	27%

1- New York State Energy Research and Development Authority. "Heat Pump Potential for Energy Savings in New York State". 2015.

Potential Savings

- Interviewees had no experience estimating statewide savings potential from this technology and thus did not provide estimates for this study.

Program Intervention Potential

Research Task: Assess potential impacts resulting from program intervention (e.g., anticipated increases in market share of high performance DMSHPs in absence of traditional per-unit measure incentives).

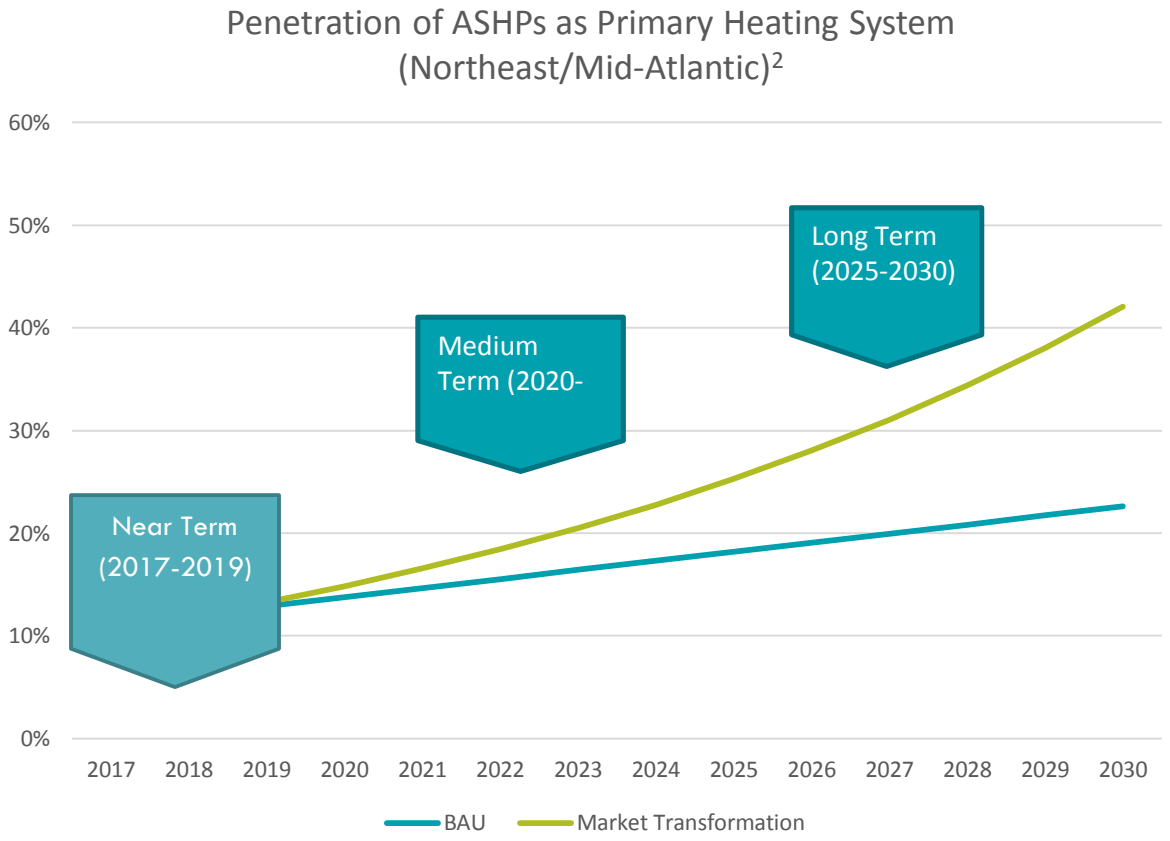
Program Intervention Potential

- Secondary research found programs can influence customers differently depending on the program goals.
- "Chicken-and-egg" situation. Due to the multiple different types of DMSHPs, the different applications and operational procedures on behalf of the customer, program designers can and do influence the market – but first program designers must determine the type of energy savings they are trying to achieve, and then target those specific applications and customer types.[1]

1- Navigant. "A Ductless Heat Pump in Every Pot…or Home?" 2015.

Program Intervention Potential

- NEEP Regional ASHP Market Transformation Strategy Report[1] projects full implementation of the various market interventions described in the report would result in 10% annual market growth of ASHP (as primary heating system) out to 2030. Note that this includes centrally ducted ASHPs as well as DMSHP.



1- NEEP: Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report 2016 Update, January 2017

2- Northeast/Mid-Atlantic region includes ME, NH, VT, MA, RI, CT, NY, NJ, PA, MD, DE, DC

Program Intervention Potential

A-72 Summary of Primary Research

Interviewee	Growth if Status Quo (2017-2019)	Growth with Program Intervention (2017 – 2019)
Manufacturer	10%-20%	30%-50%
Distributor	5%-25%	20%-35%
Installer	10%-50%*	50%-300%

* The two contracting businesses who stated 50% are very small, and complete few projects per year.

All ranges provided anecdotally; interviewees did not analyze respective business data to determine these percentages.

Program Intervention Potential

Recommendations related to program design/activity according to market actors:

- Clarify objective of potential DMSHP market engagement: GHG reductions, customer savings, strategic electrification, or DMSHP market development? This will help give direction to any deliberations about program design and general market involvement.
- Develop a DMSHP program offering to help organize and orient the marketplace to more efficient equipment in installations that maximize savings.
- Ensure nimble and responsive market intervention in a rapidly changing and evolving DMSHP marketplace.

Program Intervention Potential

Recommendations related to program design/activity according to market actors:

- Address key market needs:
  - Build awareness and demand across public market
  - Require technical and customer education for installers
  - Make the up front investment more attractive through rebates/financing
  - Develop robust QA and evaluation to ensure quality installations and program feedback.
- Target the rebates/financing to the markets & applications NYSERDA wants to see grow.
- Coordinate regionally with other DMSHP promoters (i.e. NEEP's Regional ASHP Market Transformation Initiative, Renewable Thermal Alliance).

Program Intervention Potential

Additional market actor input related to potential program interventions:

- Promote low-temp heating
- Help relate EE to dollar savings
- Help bridge first cost (incentives, financing)
  - Opinions vary: "tie it to a qualified install and good product"; "don't only apply it to high efficiency"; "base the install on reduced heating costs"; "provide $ to installer based on how well system does"; "provide direct to customer through local utility (don't require HERS – too administrative)"
- Educate installers
- Increase awareness (public advertising): use non-bias, 3rd party role to increase confidence
- Educate architects and engineers

A-76

Unit Cost

Research Task: Estimate unit cost by efficiency/capacity/ system optimization (cooling/heating/both) (by manufacturer, distributor, and installer).

Unit Cost

- 2016 NEEP Market Transformation Strategies Report[1] pulled together unit cost data from several sources including:
  - 2013 NEEP Incremental Cost Study- Mini-splits (single-zone)

SEER				
13	18	21 (typical)	26	System size (tons)
$2,733	$3,078	$3,236	$3,460	¾
$2,803	$3,183	$3,407	$3,363	1
$3,016	$3,374	$3,640	-	1 ½
$3,273	$3,874	-	-	2

  - 2016 NEEP Incremental Cost Study
    - Multi-split- $3,728/ton
  - 2015 NEEA: Residential Inverter-Driven HP Technical & Market Assessment

Technology	Average Installed Cost ($/ton, installed)	Range
Mini-split	$4,322	$3,500 - $5,325
Cold-climate mini-split	$4,635	$3,200 - $5,850

1- Northeast Energy Efficiency Partnership. "Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report 2016 Update". 2017.

Unit Cost

Eight anonymized installers provided anecdotal estimates of how total installed costs break down between equipment costs and labor costs (each line indicates the response of a unique installer).

	Heat Pump and Other Equipment	Labor and Other Costs (e.g. Profit, G&A)
Installer A	30%	70%
Installer B	35%	65%
Installer C	50%	50%
Installer D	50%	50%
Installer E	60%	40%
Installer F	60%	40%
Installer G	65%	35%
Installer H	75%	25%
Average	**53%**	**47%**

Unit Cost

- For installers who install few of these systems, the costs vary widely based on location and other factors such as system configuration and application.
- Not surprisingly, many would not give specific cost information (8/10 installers would not share this information).

Source of estimate	Type of heat pump	Price per ton (equipment only)
Distributor	Multi-head	$1,200-$1,800
Distributor	Cold climate	$1,440 - $2,340
Manufacturer	Frederick, Carrier, York	$700 - $1,000
Manufacturer	Mitsubishi, Fujitsu	$1,500

Unit Cost

- Variables that impact labor rates:
  - Unit location, unit access points, unit placing in wall
    - "They [customers] would like these to be plug-in toasters, but they are not."
- Installers view on future DMSHP costs:
  - 2/11 installers projected costs will increase
  - 4/11 installers projected costs will decrease
  - 3/11 installers projected costs will fluctuate
  - 2/11 installers did not provide answer to this question

A-81

Upstream Decision-Making

Research Task: Analyze upstream manufacturer and distributor sales and shipment decisions (e.g., decision-making related to production and distribution of this high-efficiency product).

Upstream Decision-Making

- Secondary review provided no insight into manufacturers' and distributors' decision making.

Upstream Decision-Making

Manufacturers cite the following as having potential impacts to sales and shipment decisions:

- Demographics of various locations
- "Acts of God" "We make everything in Asia…so Acts of God, a dockworker strike, you name it – it can impact us"
- Price of fossil fuels
- Energy policies
- Sales trends
- Program Promotions/Partnerships

Upstream Decision-Making

Distributors cite that their decision making when it comes to sales and shipments is based on:

- Customer demand/sales
- Public awareness
- Installer confidence
- Energy policies
- Customers wanting to save energy dollars