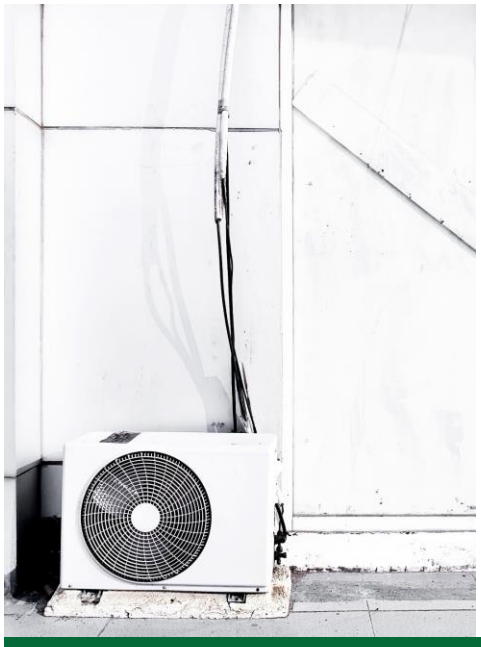

R1965 HP/HPWH Baseline and Market Characterization & R2027 HP/HPWH Reliability: *Results and Recommendations*

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Research Objectives for R1965 + R2027

- Describe the size of the heat pump market
- Describe market actor roles and perspectives
- Describe likely system configurations and applications
- Review customer cost-effectiveness by system configuration
- Assess end user satisfaction and product reliability (R2027)

Main Takeaways

The CT market is poised to take off with continued program intervention.

Market actors are generally interested in and comfortable with heat pump technologies, with some gaps that can be overcome.

Heat pump end users reported high levels of reliability and satisfaction with the technology.

CT has underperformed in terms of sales volume compared to neighboring states.

There are opportunities in CT to boost heat pump usage and installation rates.

Program Recommendations

CHANGE PROGRAM DESIGN TO FOCUS ON BOTH SALES AND USAGE OF HEAT PUMPS

- Installers and end-users reported heat pumps usually installed as supplemental system. Current program design incentivizes installations in general but could also encourage heat pumps as a primary heating system. This may require increasing customer and contractor confidence in the system's ability to heat throughout winter months.

Recommended Approaches:

- Encourage integrated controls with backup systems
- Encourage removal of fossil fuel systems (post-weatherization)
- Increase incentives for the highest efficiency systems and emerging technologies, such as GSHPs, and air-to-water heat pump systems
- Incentivize heat pumps meeting NEEP cold climate standards
- Consider solar as a complement to increased electric costs post heat pump adoption

Program Recommendations

Include delivered fuels in baseline scenarios

- The heat pump baseline for HVAC heat pumps in the PSD may not be appropriate, as roughly one-half of heat pump end users previously heated with delivered fuels and only 9% would have purchased a less efficient or less expensive HP without incentives.

Recommended Approach:

- Section 2.5.9 of DEEP approval of the 2021 C&LM plan update on 3/4/2021 makes clear that given increased focus on delivered fuel savings, utilities can calculate savings with a baseline that "reflects a fuel type that would have been chosen, absent incentives." This approval condition presents an opportunity to revise the current MSHP Program Savings Document entry to better reflect the true impacts of heat pumps by incorporating fuel switching and supplemental configurations, as those are common. This study confirms results from R1617 (Connecticut Residential DHP Market Characterization Study, 2019), which provided three approaches this new entry might take.

Program Recommendations

Increase technical and sales expertise of installers and distributors

- Customers reported high satisfaction with heat pumps. Thus, increasing installer comfort and familiarity with heat pumps will lead to more sales (and more satisfied customers).
- More than one-half of customers agreed to install a heat pump when it was recommended by an installer, but there is a gap in installer knowledge and comfort with heat pump technology: 70% of heat pump installers recommended MSHPs to customers looking for a *supplemental* system, but only 42% recommended them to *replace* a system.

Recommended Approaches:

- Offer webinars and trainings on HP technology and sales techniques, including benefits of different system types, limited incremental cost of cold climate models, performance of cold climate models, and how to address challenging HPWH installation scenarios
- Offer equipment and weatherization services to key installers and distributors for their homes to provide first-hand experience and encourage installer recommendations and sales (similar to the NEEA Pro Deal program)
- Push manufacturers to provide support to hesitant contractors and distributors

Program Recommendations

INCREASE PROGRAM SUPPORT AND RESOURCES TO PARTICIPATING DISTRIBUTORS

- Some distributors reported the midstream program in CT has put more administrative burden on them. This could dissuade distributors from pushing program heat pumps and lead to tracking data with gaps or quality issues.

Recommended Approaches:

- Ensure distributor questions are addressed by program staff in a timely manner
- Conduct outreach with participant distributors through email and phone to let them know program staff is available, new program offerings, and provide an opportunity for feedback
- Identify and conduct outreach to any non-participant HVAC and water heating distributors that operate within service territory
- Provide a list of qualifying products to avoid putting the burden on distributors to match a product to program efficiency requirements
- Develop an app or web portal to facilitate an easy-to-use rebate application system that scans and determines qualifying equipment eligibility, collects data equipment level data for program tracking, and tracks/processes incentive reimbursements

Program Recommendations

WORK WITH DISTRIBUTORS AND RETAILERS TO STOCK HPWHS FOR SAME DAY REPLACEMENT

- The water heater market is largely replace-on-failure and customers are likely to do 'like for like' replacements. HPWHs need to be a more viable option for emergency replacements.

Recommended Approaches:

- Provide an incentive to distributors to ensure HPWHs are available for same day replacement
- Provide an incentive to retailers to stock HPWHs, display them at the front of the store, and remove electric resistance water heaters from shelves
- Work with retailers to ensure that call centers facilitating water heater installations through the store recommend HPWHs over electric resistance
- Reconsider current lower incentive levels ($400) for large HPWHs (>55 gallons) relative to smaller units ($750 for 55 gallons or less), because sales rely on incentives and contractors can find non-heat pump workarounds for customers who need large tanks, despite federal minimum efficiency standards for large electric water heaters
- Monitor availability of emerging 120V "plug-in" HPWHs that can be easily installed in some applications with limited/no electrical upgrades; may be ideal for many customers with fossil-fuel water heaters

Program Recommendations

IMPROVE PROGRAM TRACKING DATA QUALITY

- The data request process for this study was long and difficult and the data was of mixed quality and challenging to piece together. Improving the way data is tracked and stored would lead to more fruitful and accurate evaluation in an area of growing importance.

Recommended Approaches:

- Assign a unique placeholder for account numbers that match across programs
- Track itemized labor vs. equipment costs for system installations, and end-user data as much as possible
- Establish program tracking data quality control measures to ensure accuracy of program counts and eliminate potential of the same installation being reported in two different programs

Program Recommendations

FURTHER INVESTIGATE OPPORTUNITIES TO REFINE THE PROGRAM(S) AND TRACK MARKET PROGRESS

- The findings of this study describe the Connecticut market and opportunities. Developing a clear market transformation approach may help drive the market toward these high-performance systems, and regular process evaluations can help ensure the program is operating as designed. Regional coordination of programs and evaluation may also ensure that programs operate reasonably consistently in the Northeast and learn from other states' successes.

Recommended Approaches:

- Conduct a process evaluation for key HP/HPWH program elements
- Consider a market transformation approach to affecting the market, tracking market progress indicators to ensure program activities lead to desired market outcomes, including building sufficient supply and demand for high-efficiency heat pump systems
- Consider a regional assessment of heat pump markets or programs to build a cohesive Northeast market
- Consider the benefits and challenges of different program delivery methods (midstream vs. downstream) as part of process evaluation(s)
- In future HVAC/DHW evaluations, consider reliability/satisfaction assessments to compare against HP findings

What's the story with Heat Pumps in CT?

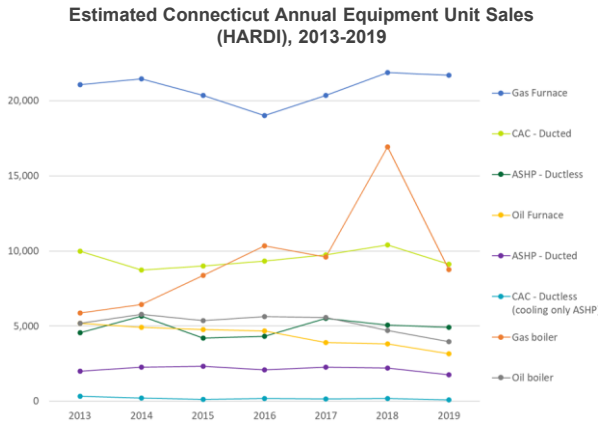
WHAT DID THE CT HEAT PUMP MARKET LOOK LIKE FROM 2013 TO 2019?

MSHPs were largest portion of CT's heat pump market, which was stable from 2013 to 2019: 4,200-5,700 units

Small ASHP market from 2013 to 2019, largely a low/mid-EE market (<16 SEER/10 HSPF) with low program penetration (5-8%)

Small, niche market for GSHPs from 2013-2019, with less than 200 installs per year

What's the story for 2020-2021? We don't know. There is no HARDI data available for 2020-2021 as coverage of distributors sales data dropped during the pandemic. It's unclear when collection will resume.



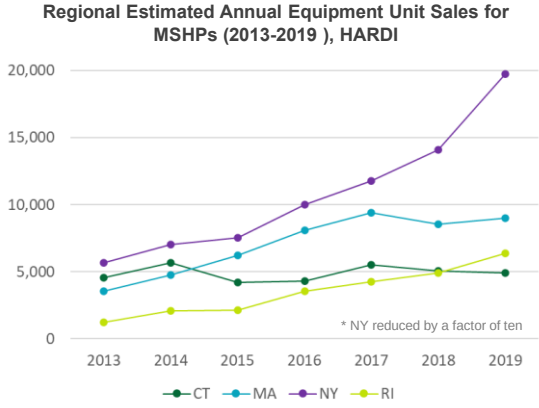
What's the story with MSHPs in CT?

WHAT DID THE CT MSHP MARKET LOOK LIKE COMPARED TO NEIGHBORING STATES FROM 2013 TO 2019?

Market flat in CT – but growing in MA, RI, NY

Average SEER and HSPF for CT MSHPs increased but was lowest in the region in 2019

CT lowest in region for proportion of higher efficiency MSHPs in market but had highest growth in the region (59% in 2013 to 84% in 2019) (catching up)



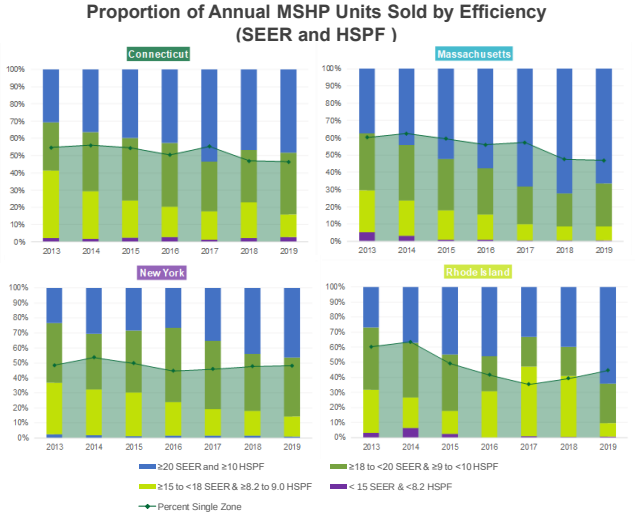
What's the story with MSHPs in CT?

WHAT DID THE CT MSHP MARKET LOOK LIKE COMPARED TO NEIGHBORING STATES FROM 2013 TO 2019?

Increased number of higher-efficiency (18+SEER/9+HSPF) MSHPs and increased market share from 59% to 84%

Both single- and multi-zone systems increased in efficiency since 2013; however, increased saturations of multi-zone systems contribute to a leveling off of overall average efficiency between 2017 and 2019.

The average cooling efficiency for MSHPs leveled out between 2017 and 2019, just below 20 SEER (21.5 for the program).



What's the story with MSHPs in CT?

WHAT DID DISTRIBUTORS AND INSTALLERS SAY ABOUT MSHP MARKET TRENDS IN CT?

Heat Pump Installations:

~29% of HVAC installations in existing homes

~38% of HVAC installations in new homes

Cold Climate MSHPs:

Installers: 74% are ccMSHPs

Distributors: 48% are ccMSHPs

Incremental cost for cold climate equipment (excluding labor):

Installers: ~19%

Distributors: ~21%

- MSHPs were well stocked and consumer demand was high
- Ductless MSHPs most common configuration being sold and installed in CT
- Ducted and partially ducted MSHPs becoming increasingly popular; ~48% of new construction MSHP installations

What's the story with MSHPs in CT?

WHAT DID THE CT MSHP PROGRAM LOOK LIKE FROM 2014 TO 2021?

MSHP Incentives

System Configuration	Efficiencies		Incentives		
	SEER	HSPF	2014	2015-2016	2017-2020
Ductless HP	14.5	8.2	$250	-	-
Ductless HP – Displacing ER heat	14.5	8.2	$1,000	-	-
Single Zone	20.0	10.0	-	$300	$300
Single Zone – Displacing ER heat	20.0	10.0	-	$1,000	$700
Multi-Zone	18.0	9.0	-	$300	$500
Multi-Zone – Displacing ER heat	18.0	9.0	-	$1,000	$700

Changes in 2021: Two tiers per category

System Configuration	Efficiencies		Incentives
	SEER	HSPF	2021
Single Zone	18.0	10.0	$250
	22.0	10.0	$500
Single Zone – Displacing ER heat	22.0	10.0	$1,000
Multi-Zone	16.0	9.5	$250
	20.0	10.0	$500
Multi-Zone – Displacing ER heat	20.0	10.0	$1,000

What's the story with MSHPs in CT?

WHAT DID CT MSHP PROGRAM ACTIVITY LOOK LIKE FROM 2017 TO 2019?

From 2017 to 2019, program incentivized MSHPs increased from ~2,600 units to ~4,500 (72% increase in volume)

A relatively flat MSHP market and increased program activity increased programs MSHP market share by 48% from 2017 to 2019

Rapid increase in market share driven by high levels of sales through the midstream HVAC program

			2017	2018	2019
Total Incentivized Units		Program MSHP counts	2,599	3,738	4,479
		Program % of MSHP market	48%	74%	93%
Programs	Midstream HVAC	Program MSHP counts	2,450	3,590	4,344
		Program % of MSHP market	45%	71%	91%
	HVAC Add-on (HES)	Program MSHP counts	109	36	30
		Program % of MSHP market	2%	1%	1%
	RNC	Program MSHP counts	36	105	95
		Program % of MSHP market	1%	2%	2%
	SBEA	Program MSHP counts	4	7	10
		Program % of MSHP market	<1%	<1%	<1%

What's the story with MSHPs in CT?

WHAT DID DISTRIBUTORS SAY ABOUT THE CT MSHP PROGRAM?

The burden of program administration is put on distributors in a midstream model, with limited support.

Lack of clarity on qualifying equipment and no way to pre-qualify; Distributors reported having to pay out rebates to contractors and hope equipment qualifies, leading to losses.

Communication has been poor. Questions about qualifying equipment and program applications go unanswered for long periods of time.

Distributors have to hire staff to process rebates but do not recoup that money.

Differences in program delivery that might account for regional differences in MSHP adoption:

- Rebate levels in CT have been historically lower than other states in the region
- MA offers a substantial incentive for integrated controls
- CT requires contractors to have a full HVAC license, whereas other nearby states only require a short certification course
- Not adopting NEEP standards has slowed adoption of cold climate models and full displacement of fossil fuel systems in CT

What's the story with MSHPs in CT?

WHAT ARE THE COMMON MSHP INSTALLATION SCENARIOS?

Installers

MSHPs most commonly installed as supplemental system rather than whole-home heating system

MSHPs were being installed in homes with oil and electric resistance heat

Installers frequently recommended MSHPs to customers; most customers (63%) accepted their recommendations indicating the market is ready to accept HPs, subject to installer confidence

Most often recommended heat pumps to homeowners looking for additional heating or cooling and homeowners in existing homes

End Users

Existing system before install:

- 57% working with no need of repair
- 34% in need of major or minor repair
- 4% no longer working

Heating installation characteristics:

- 55% heat spaces also served by other systems
- 25% heat all or most of home
- 9% home's only heating system

Primary heat pre/post install:

- Oil: Pre – 48% / Post – 42%
- Electric: Pre – 22% / Post – 33%
- Natural Gas: Pre – 15% / Post – 13%

What's the story with ASHPs in CT?

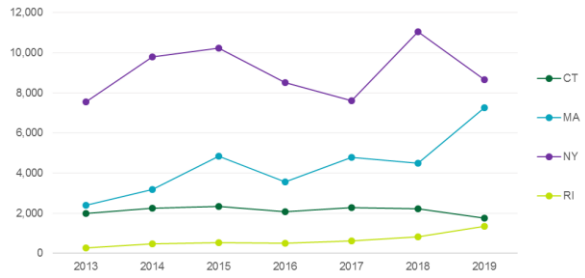
WHAT DID THE CT ASHP MARKET LOOK LIKE COMPARED TO NEIGHBORING STATES FROM 2013 TO 2019?

CT ASHP market size relatively flat from 2013 to 2018, dropped by 21% in 2019

2019 drop contrasted with regional market where periods of growth were higher than in CT

Estimated average SEER and HSPF for CT ASHPs increased but was lowest in the region in 2019, showing room for shift to inverter-driven systems

Regional Estimated Annual Equipment Unit Sales for ASHPs (2013-2019), HARDI



What's the story with ASHPs in CT?

WHAT DID THE CT ASHP MARKET LOOK LIKE COMPARED TO NEIGHBORING STATES FROM 2013 TO 2019?

The proportion of high-efficiency equipment in Connecticut was less than the proportion in surrounding states from 2013 to 2019, but ASHPs inherently less efficient than ductless

2020 Program Incentives	**ASHP split system:** $500 SEER: 16.0 / HSPF: 10.0 (2021 – HSPF: 9.5)
	ASHP displacing ER heat: $1,000 SEER: 16.0 / HSPF: 10.0
Distributor and Installer Feedback	ASHPs were a small portion of HP sales; ducted, inverter driven models replacing traditional non-inverter systems

Proportion of Annual ASHP Units Sold by Efficiency (SEER and HSPF)

What's the story with GSHPs in CT?

WHAT DID THE CT GSHP MARKET LOOK LIKE FROM 2017 TO 2019?

Small, niche market

- <200 installs each year
- Over one-half in new homes
- High savings, high upfront costs
- Interviewees report no significant changes

Estimated program market share down, but small market denominator

- Ranges: 46-69% in 2017 to 29%-51% in 2019

Expensive, with limited program funding

- Program Incentives: $750 - $1,500/ton, downstream, $15k max
- Inconsistent funding outside program (CEFIA and federal tax credits)

GSHP Market Size
(Ranges based on different data sources)

Year	High: Based on CT, MA, and RI Data	Middle (Average)	Low: CT Data Only
Residential retrofit			
2017	78	66	59
2018	42	29	22
2019	49	36	29
New construction			
2017	85	68	52
2018	92	72	53
2019	95	73	52
Total GSHP market			
2017	164	135	111
2018	133	102	75
2019	144	110	81

What's the story with Heat Pumps in CT?

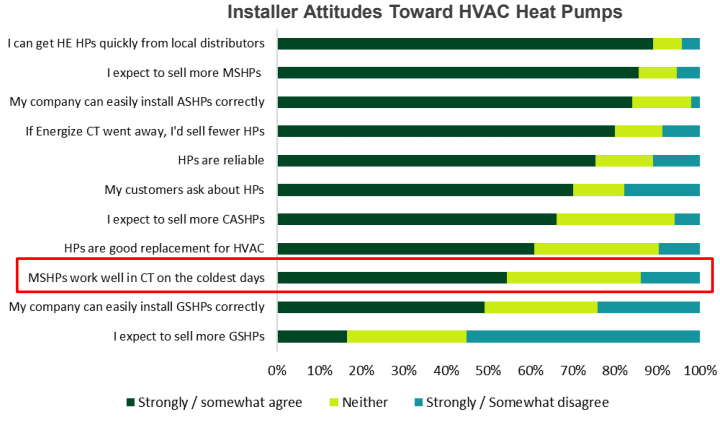
WHAT ARE HEAT PUMP BARRIERS TO ADOPTION IN CT?

Installers and Distributors

Most contractors with HP experience report they are **available**, **reliable**, and increasingly **popular**

Some installers still skeptical about whole home / cold weather performance

Low consumer awareness



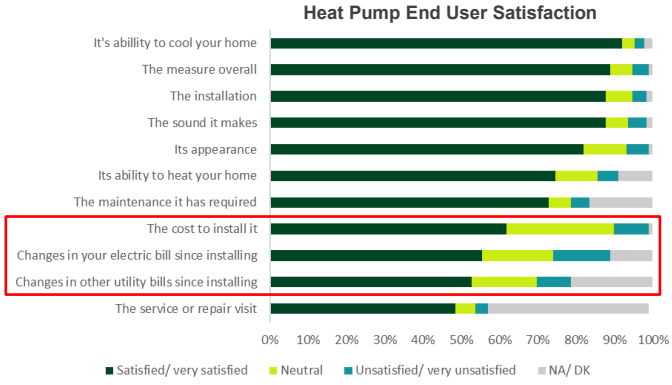
What's the story with Heat Pumps in CT?

WHAT ARE HEAT PUMP BARRIERS TO ADOPTION IN CT?

End Users

Overwhelmingly positive satisfaction metrics, overall (89%) and for potential problem areas

Largest issue is cost and electric and utility bill savings not meeting expectations



What's the story with Heat Pumps in CT?

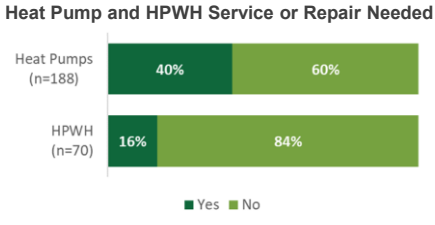
WHAT DO END USERS IN CT THINK ABOUT HP AND HPWH RELIABILITY?

End Users

Service: regular preventative maintenance or tune-up

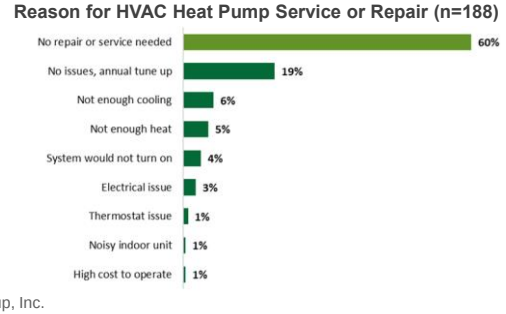
Repair: fixing a problem

40% of HVAC heat pump users and 16% of HPWH users reported having service or repair since install



Among those reporting repair or service, over one-half were annual tune ups with no actual problem reported

The most common issues were not enough cooling or not enough heat; for 4% of end users the system would not turn on (for various reasons)



What's the story with Heat Pumps in CT?

Frequency and Cost of Repairs and Service

End Users

Customers experienced limited need for repair visits, particularly for HPWHs

Service visits:

35% of MSHP users	13% of HPWH users
Avg service cost: $248	Avg service cost: $205

HVAC HP users who needed repairs had between 1 and 2 repair visits per year since install (<1 visit across all customers)

HPWH users with repair visits: <1 visit per year since install (0.1 across all HPWH customers)

Nearly half (47%) of MSHP end users needing repairs reported paying nothing out of pocket

		Customers w/ Repair Visits	All Customers
Customers w/ Repair Visits	MSHP (n=170)	-	26%
	ASHP (n=12)	-	33%
	GSHP (n=6)	-	33%
	HPWH (n=70)	-	13%
Avg # of Repairs/Year	MSHP	1.5	0.4
	ASHP	1.2	0.4
	GSHP	1.8	0.6
	HPWH	0.6	0.1
Avg TOTAL Repair Costs	MSHP	$205	$54
	ASHP	$113	$28
	GSHP	$0	$0
	HPWH	$167	$21

What's the story with Heat Pumps in CT?

What are do end users and installers in CT think about HP reliability?

End Users

The most common issues identified and repaired were refrigerant leaks (30%) and issues with electrical components (28%)

Three end users reported that the outdoor unit needed to be replaced

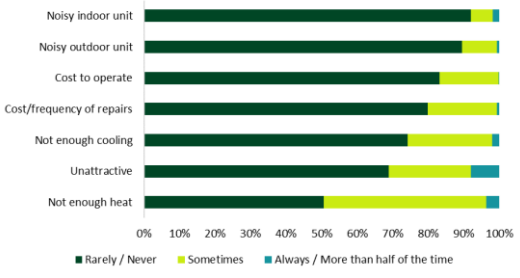
Heat Pump Component Repaired or Replaced (n=50)

Issue or Component	
Refrigerant leak	30%
Electrical components	28%
Plumbing lines, pipes, or fittings	10%
Replaced outdoor unit	6%
Thermostat settings	4%
Thermostat itself	4%
Defrost cycle issues	4%
Filter replacement	4%
Tightening screws or fasteners	4%

Installers

The most common reasons for callbacks were not enough heat and that the customer thought the unit was unattractive

How Often Installers Get Customer Callbacks in the First Year



What's the story with HPWHs in CT?

WHAT DID THE CT HPWH MARKET LOOK LIKE FROM 2016 TO 2019?

Growing market with potential:

- RASS confirmed over half of SF homes could readily accommodate them
- Large portion of market with oil, electric, and propane

Market actors report highly incentive dependent (90+% incentivized)

- Incentives for large tanks temporarily went away
- Sales of large tanks dropped

Program incentives:

- 2019: $750, < 55 gallons
- 2020-2021: $750, <55 gallons; $400 for 55+ (2015 federal mins require HP for 55+)

HPWH Market Size
(Ranges based on different data sources)

Year	High: Based on CT, MA, and RI Data	Middle (Average)	Low: CT Data Only
Residential retrofit			
2016	980	943	906
2017	1,224	1,152	1,079
2018	1,483	1,373	1,264
2019	1,733	1,587	1,441
New construction			
2016	629	497	365
2017	655	561	467
2018	853	766	678
2019	635	528	404
Total HPWH market			
2016	1,609	1,440	1,271
2017	1,879	1,713	1,546
2018	2,336	2,139	1,942
2019	2,368	2,115	1,845

What's the story with Heat Pumps in CT?

WHAT ARE HPWH BARRIERS TO ADOPTION IN CT?

Installers and Distributors

Low customer awareness: 30% of installers said customers ask for them

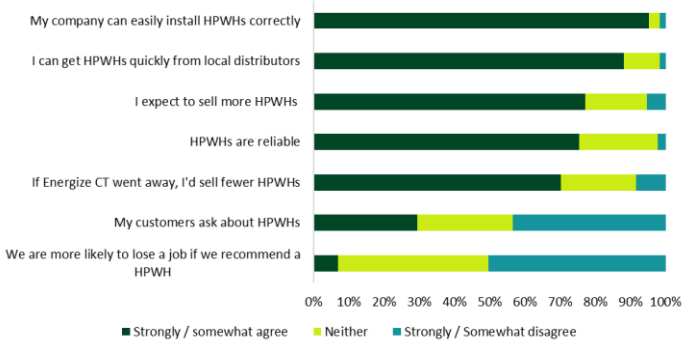
Like-for-like is the easy recommendation

More install barriers than resistance: noise, condensate, makeup air, etc.

Clear opportunity: installers can install them easily and they are readily available; only 7% agreed that HPWH recs cause them to lose a job

New tech coming to market in 2022 to assist with retrofits: 120V "plug-in" HPWHs that do not require 240V hardwiring

Installer Attitudes Toward HPWHs



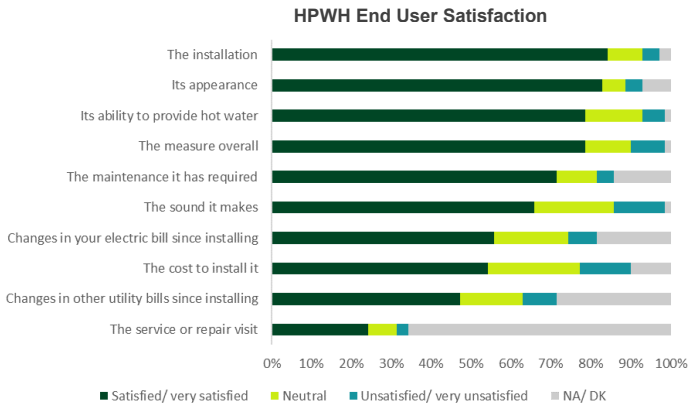
What's the story with Heat Pumps in CT?

WHAT ARE HPWH BARRIERS TO ADOPTION IN CT?

End Users

Overwhelmingly positive satisfaction metrics, overall (79%) and for potential problem areas

Noise and cost the largest negative ratings, but minor issues overall



How cost-effective are these systems?

CUSTOMER COST ASSESSMENT

End Users

MSHP and ASHP pass when offsetting areas with electric resistance + cooling

ASHP pass when replacing ER and CAC, and when in low-cost scenarios for replacing oil boiler and CAC

Highly cost-effective to replace electric and oil water heaters with HPWH

Test Results

Scenario	Type	Tons/ Gall	Cooling (SEER)	Heating (HSPF/ UEF)	Heat Displacement	Heat Replacement Scenario	Baseline Cooling	Baseline Heating	Low End Cost Test	Result	High End Cost Test
A	MSHP	1	20	10.6	Partial	Retro	RAC	Oil Boil	**0.81**	0.62	0.50
B	MSHP	2	17.6	10.6	Partial	Retro	RAC	Oil Boil	**0.80**	0.61	0.49
C	**MSHP**	1	20	10.6	Partial	Retro	RAC	ER	**1.52**	**1.16**	0.93
D	**MSHP**	2	17.6	10.6	Partial	Retro	RAC	ER	**1.50**	**1.14**	0.92
E	MSHP	1	20	10.6	Partial	Retro	None	ER	**1.03**	0.82	0.69
F	MSHP	2	17.6	10.6	Partial	Retro	None	ER	**1.02**	0.81	0.68
G	MSHP	3	17.6	10.6	Full	ROF	RAC	Oil boil	**1.39**	0.97	0.75
H	MSHP	4	17.6	10.6	Full	ROF	RAC	Oil boil	**1.27**	0.91	0.71
I	**MSHP**	3	17.6	10.6	Full	Retro	RAC	ER	**2.27**	**1.73**	**1.39**
J	**MSHP**	4	17.6	10.6	Full	Retro	RAC	ER	**2.27**	**1.73**	**1.39**
K	**MSHP**	3	17.6	10.6	Full	Retro	None	ER	**1.46**	**1.17**	0.97
L	**MSHP**	4	17.6	10.6	Full	Retro	None	ER	**1.46**	**1.17**	0.97
M	ASHP	3	17.6	10.6	Full	ROF	CAC	Oil boil	**1.20**	0.86	0.67
N	ASHP	4	17.6	10.6	Full	ROF	CAC	Oil boil	**1.10**	0.81	0.64
O	**ASHP**	3	17.6	10.6	Full	Retro	CAC	ER	**2.10**	**1.62**	**1.32**
P	**ASHP**	4	17.6	10.6	Full	Retro	CAC	ER	**2.10**	**1.62**	**1.32**
Q	**HPWH**	50	N/A	3.3	Full	ROF	N/A	ER	**14.89**	**7.06**	**4.62**
R	**HPWH**	50	N/A	3.3	Full	ROF	N/A	Oil WH	**>20.00**	**17.68**	**3.74**

Summary of Program Recommendations

- Change program design to focus on both sales and usage of heat pumps
- Include delivered fuels in baseline scenarios
- Increase technical and sales expertise of installers and distributors
- Increase program support and resources to participating distributors
- Work with distributors and retailers to stock HPWHs for same day replacement
- Improve program tracking data quality
- Further investigate opportunities to refine the program(s) and track market progress

Thank you

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