Global Industry Foresight 2020

Thriving in a Low-Carbon World

Report Prepared For:

June 18, 2020

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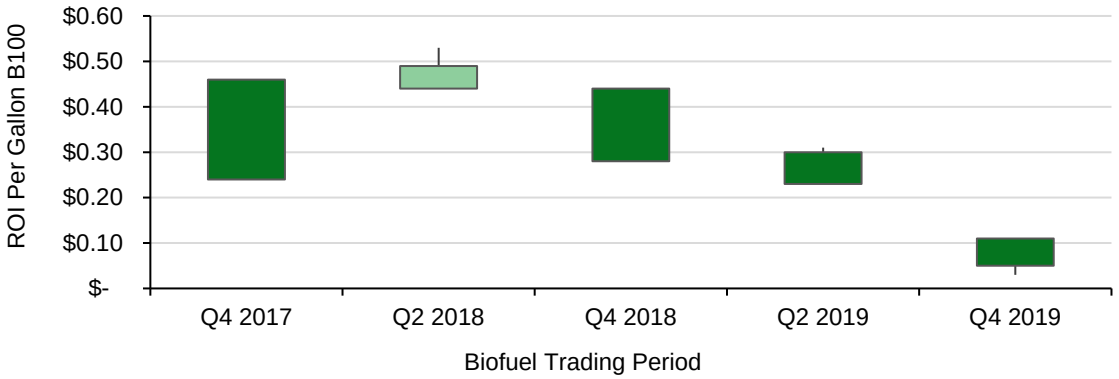
DIVERSIFIED ENERGY SPECIALISTS

Massachusetts Alternative Portfolio Standard

Although the APS program is considered successful, it has proven that a mandate is necessary for northeast states to meet the 2023 and 2030 goals set forth in the Providence Resolution

2015 - 2017	**8** Distributors	**277M** lbs. of CO2e Eliminated
	14.13M Gallons of B100 Blended	**<1% p.a.** State Blend Level
2018	**47** Distributors	**193M** lbs. of CO2e Eliminated
	9.83M Gallons of B100 Blended	**1.61%** State Blend Level
2019	**73** Distributors	**365M** lbs. of CO2e Eliminated
	18.65M Gallons of B100 Blended	**3.05%** State Blend Level

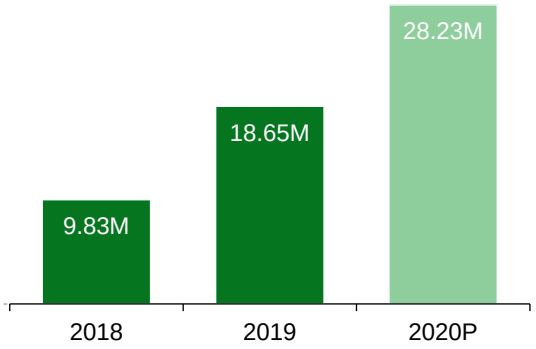
Distributor Market Price
ROI *per Gallon B100*



2020 Program Review

- Completed the end of 2020
- Increase obligation, increase credit price
- Feedstocks
- Biofuels cap
- Biofuel mandate changes
- Exempt load
- Yearly data release

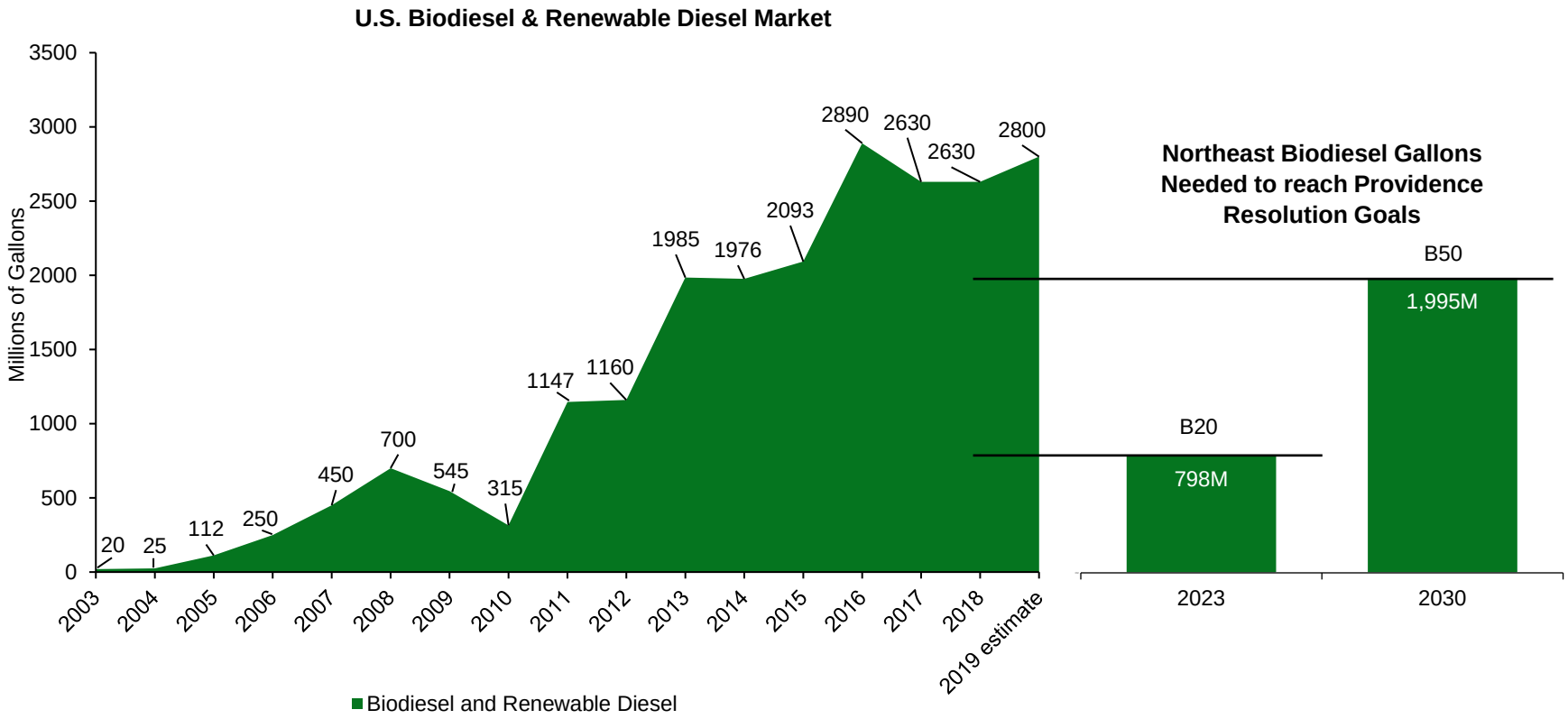
Biofuel Gallons Reported in the MA APS
(2018-2020P)



Source: DES Research & Analysis

U.S. Biodiesel Production

The domestic biodiesel and renewable diesel market should continue to experience growth with increasing demand pressure in both the transportation and heating sectors

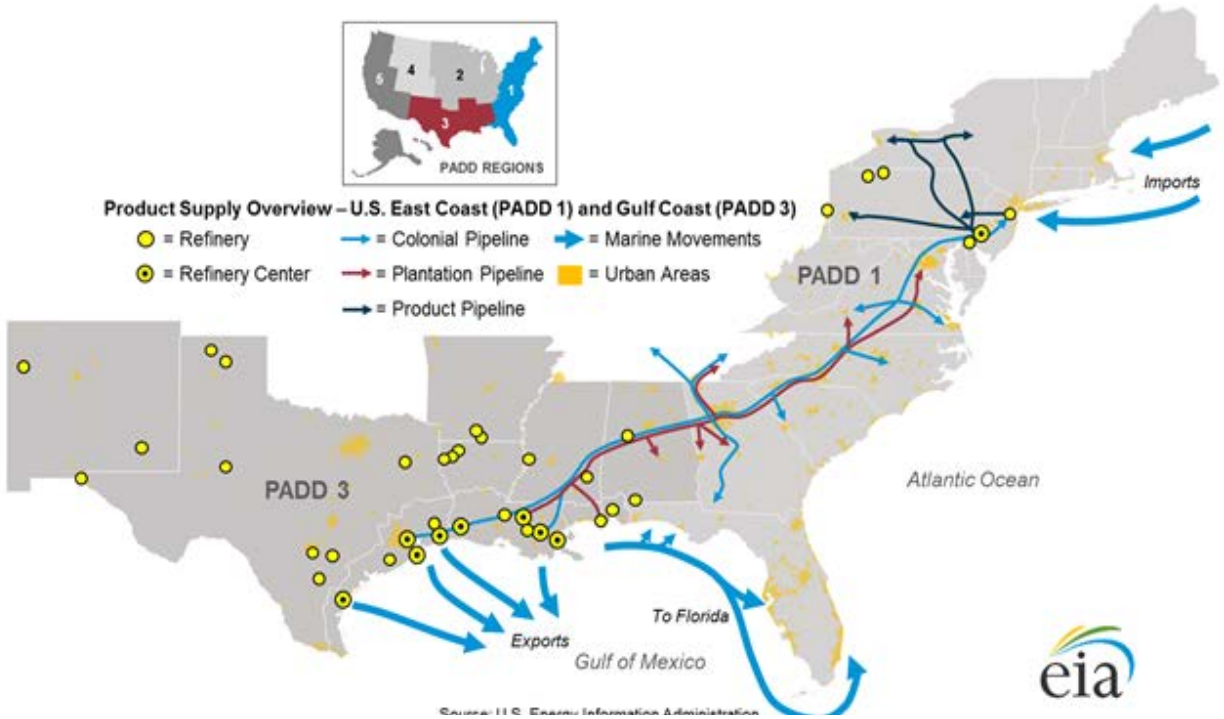


Source: EPA EMTS – Volumes reported under the RFS in the D4, D5, and D6 categories; EIA; DES Research & Analysis

Northeast Biodiesel Supply Chain

As the Northeast heating oil industry transitions to higher biodiesel blends, the domestic supply will be transported from PADD II and PADD III

Figure 3. U.S. East Coast (PADD 1) and Gulf Coast (PADD 3) transportation fuels product flows



- 57% of domestic biodiesel production capacity is concentrated in PADD II, while 25% is concentrated in PADD III
- Approximately 197 MGY of production capacity in PADD I
- Rail, Barge, Pipeline, Truck
- Optimize efficiencies to secure ratable and competitive low-carbon liquid fuels
- California navigated similar challenges, moving from 25 MGY - >600 MGY

Source: EIA; Nazzaro Group

Optimizing the Rail

To meet the Providence resolution of a 20% blend by 2023, the heating oil industry will have to utilize the rail to transport biodiesel from PADDs II & III to the Northeast

Challenges
• Rail Sidings In PADD I
• Transloading Capability
• Heat
• Storage – Heated Storage
• Deployment To Regional Terminals
• Central Location to Storage and Terminals

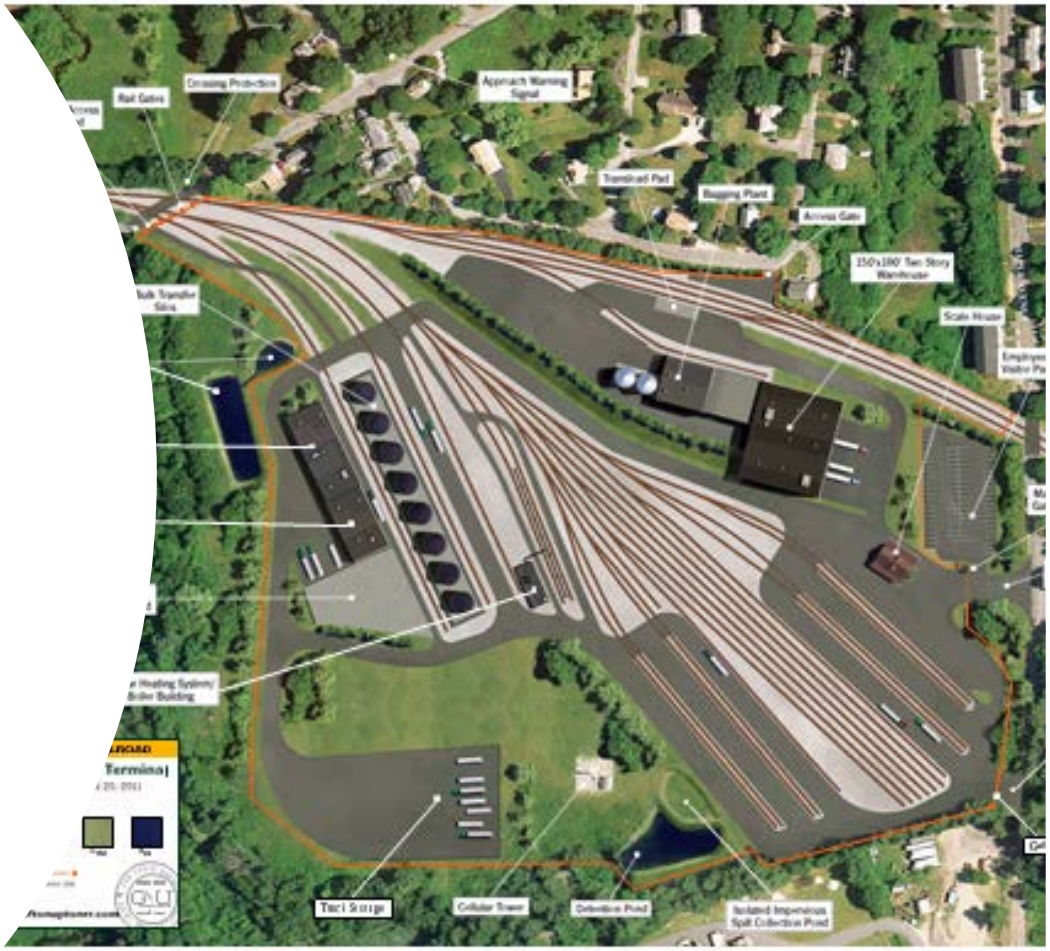
Supplying 50% of our B20 by 2023 goal on the rail

399M gal/B100

14,250 Rail Cars

From PADDs II & III to PADD IA & IB

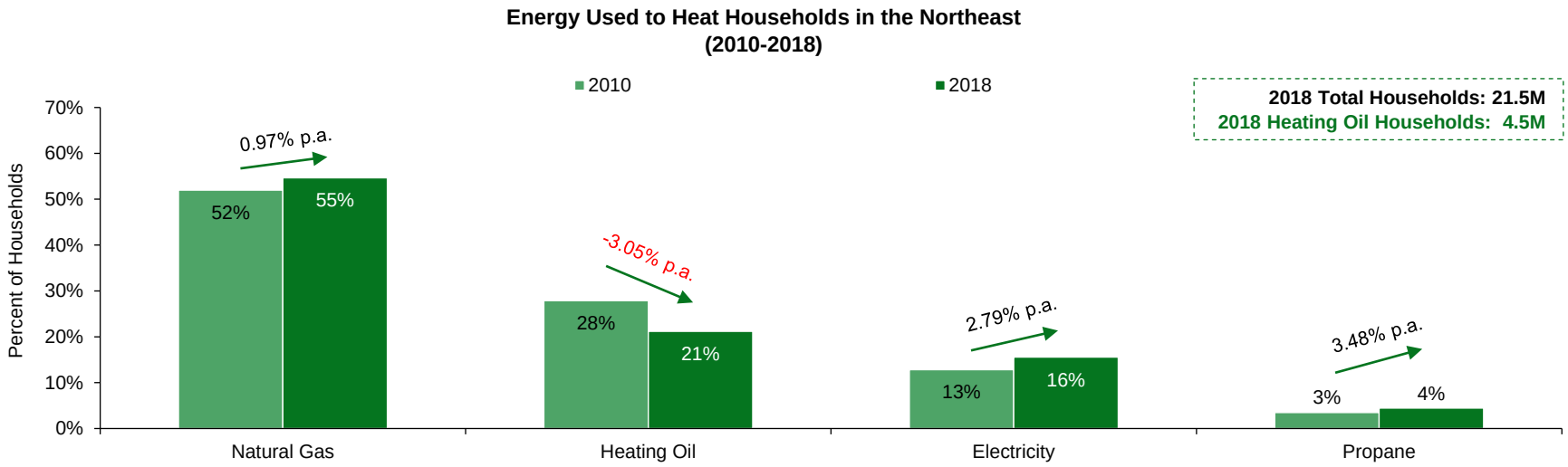
Seasonal Concentration November-March

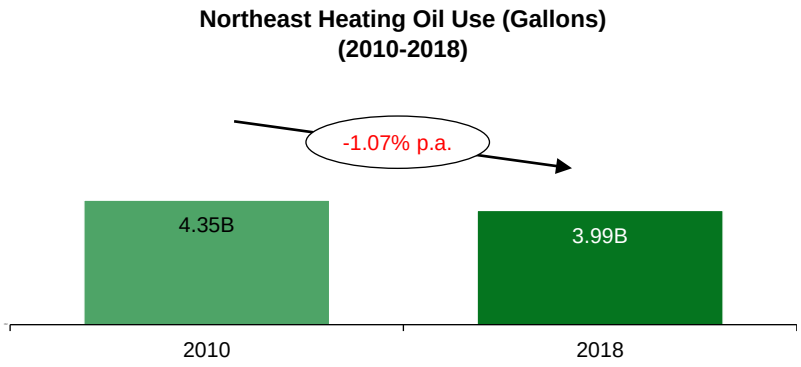


Source: Nazzaro Group; DES Research & Analysis

Northeast Heating Fuels – Market Trends

The heating oil industry has lost substantial market share and gallons over the last decade





- The heating oil industry has lost significant market share over the last decade due to cost, electrification policy, and the transition away from high carbon fuels
- Biodiesel blends will lower the carbon intensity of heating oil, combat electrification policy, and can be a useful marketing tool

Source: United States Census Bureau, American Community Survey; EIA; DES Research & Analysis

Competition

The carbon intensity of thermal heating fuels in the Northeast will most likely be the differentiating factor in future market share

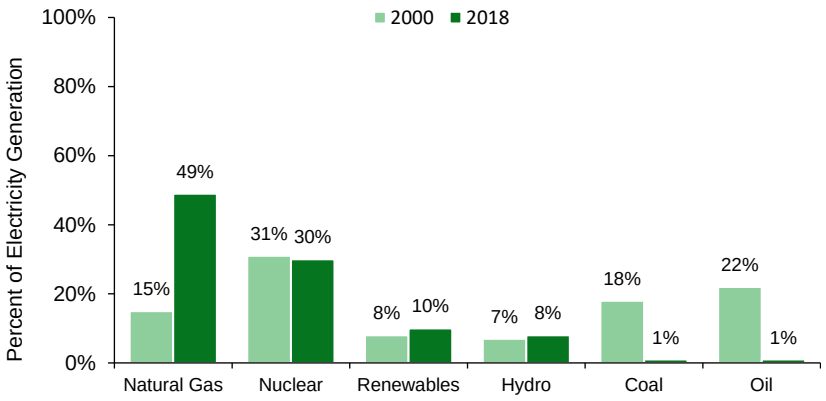
	Heating Oil / Biodiesel	Natural Gas	Electricity	Propane
Carbon Reduction	• A 66-72% reduction from SME biodiesel can be further decreased with the use of renewable energy in farming, processing plants, and the transportation process	• A small supply of renewable natural gas could become available, but even the highest estimates only project 25% of the supply from renewable natural gas	• Electricity can reduce its carbon intensity over time with the addition of renewable generation sources and has net-zero carbon goals	• Propane does not have the ability to reduce its carbon intensity currently
Economics	• Unique ability to use biodiesel as a “drop-in” fuel that will require few equipment and infrastructure improvements until higher blends are achieved	• Requires significant infrastructure improvements that will increase pricing and have little effect on the carbon intensity of natural gas	• The large capital investment into Infrastructure that is required to reduce the carbon intensity of electricity will increase the price over time • Conversion cost will remain a concern	• Propane should not experience any significant price increases
Competition	• Biodiesel blends of 30-50% can compete with cold climate heat pumps in the Northeast • 5-25% biodiesel blends can achieve a better carbon score than natural gas • 5-10% biodiesel blends can achieve a better carbon score than propane	• Lower carbon intensity than propane • Natural gas will struggle to compete with biodiesel blends and electric heat pumps • Methane is 84 times worse than carbon over a 20-year lifecycle analysis	• Cold climate heat pumps will continue to reduce its carbon intensity beyond other competitors • Biodiesel will pose a threat to cold climate heat pumps as we near 2030 • Cold climate heat pumps will continue to struggle providing heat in cold temperatures	• Propane will not be able to compete with other thermal heating fuels due to its inability to lower its carbon intensity

Source: DES Research & Analysis

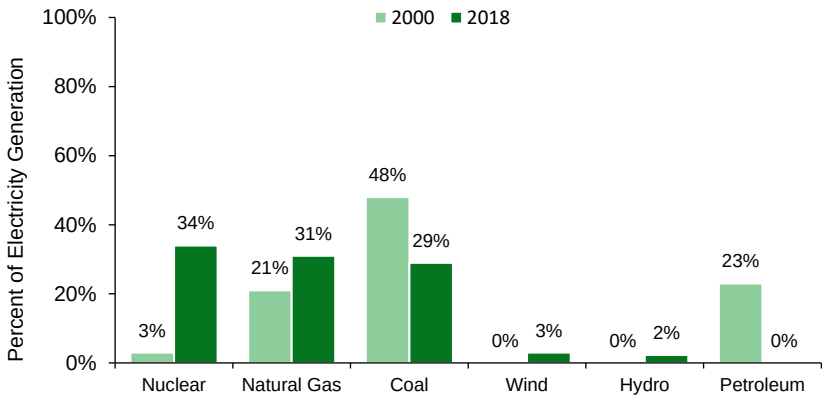
Electricity Generation Mix

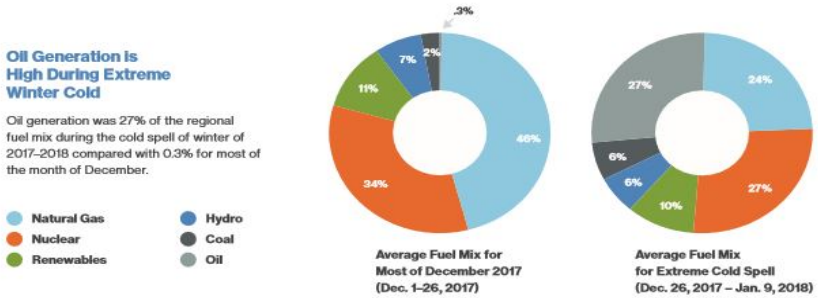
The carbon intensity of a 50% biodiesel blended heating oil can compete with the carbon intensity of cold climate heat pumps in the Northeast

NE-ISO Electricity Generation (2000-2018)



PJM Electricity Generation (2000-2018)



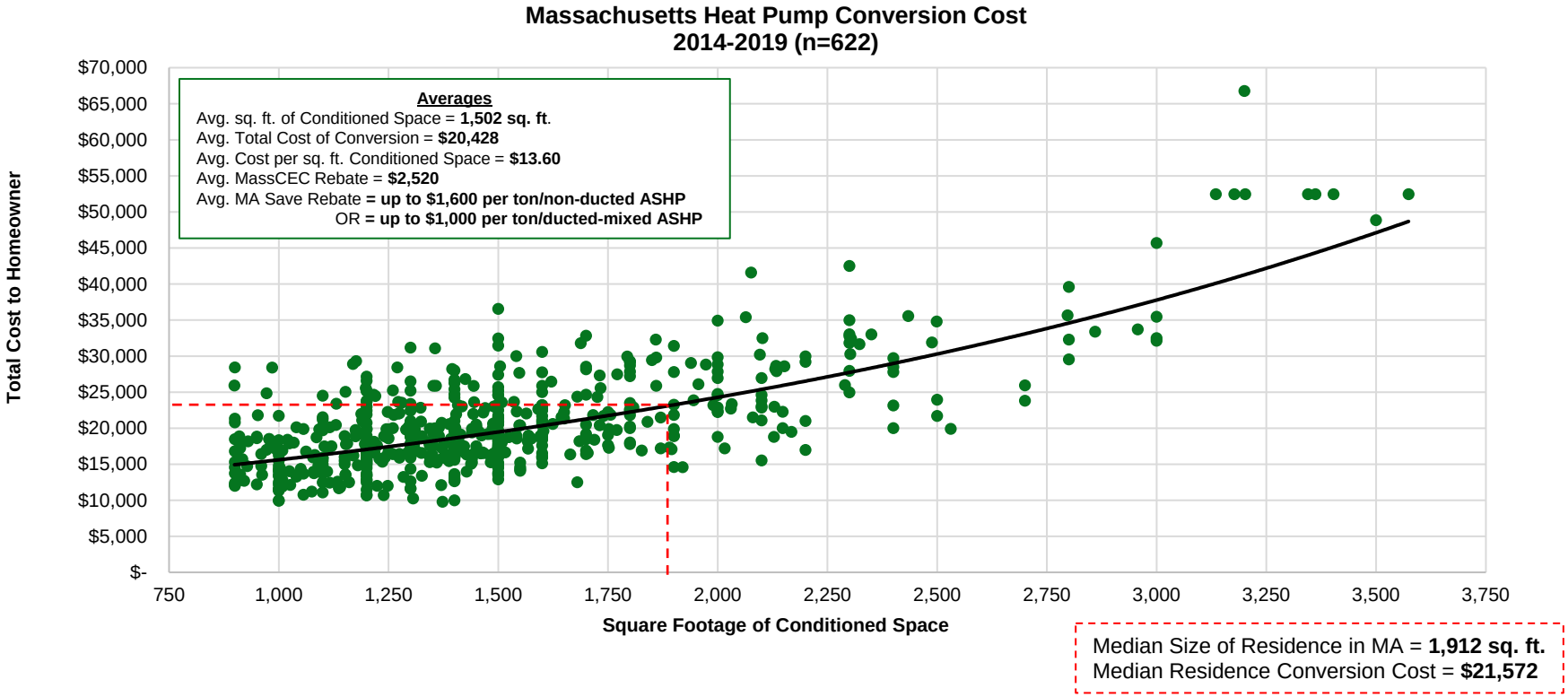


- Cold climate heat pumps and a 50% biodiesel blend both reduce carbon intensity by roughly 40%
- Heat pumps cannot sufficiently heat most northeast residences in temperatures under 17ºF
- Cold-climate heat pumps have a negative impact on grid operations and cost.
- As conversions to cold climate heat pumps and electric vehicles occur, the additional load will increase the winter peak load, increase the price of electricity, and increase the carbon intensity of electricity

Source: ISO-NE; PJM; DES Research & Analysis

Conversion: Cost

The cost of converting to an electric air-source heat pump system in Massachusetts is substantial and isn't affordable for most low- and middle-class residents



Median Size of Residence in MA = **1,912 sq. ft.**
Median Residence Conversion Cost = **$21,572**

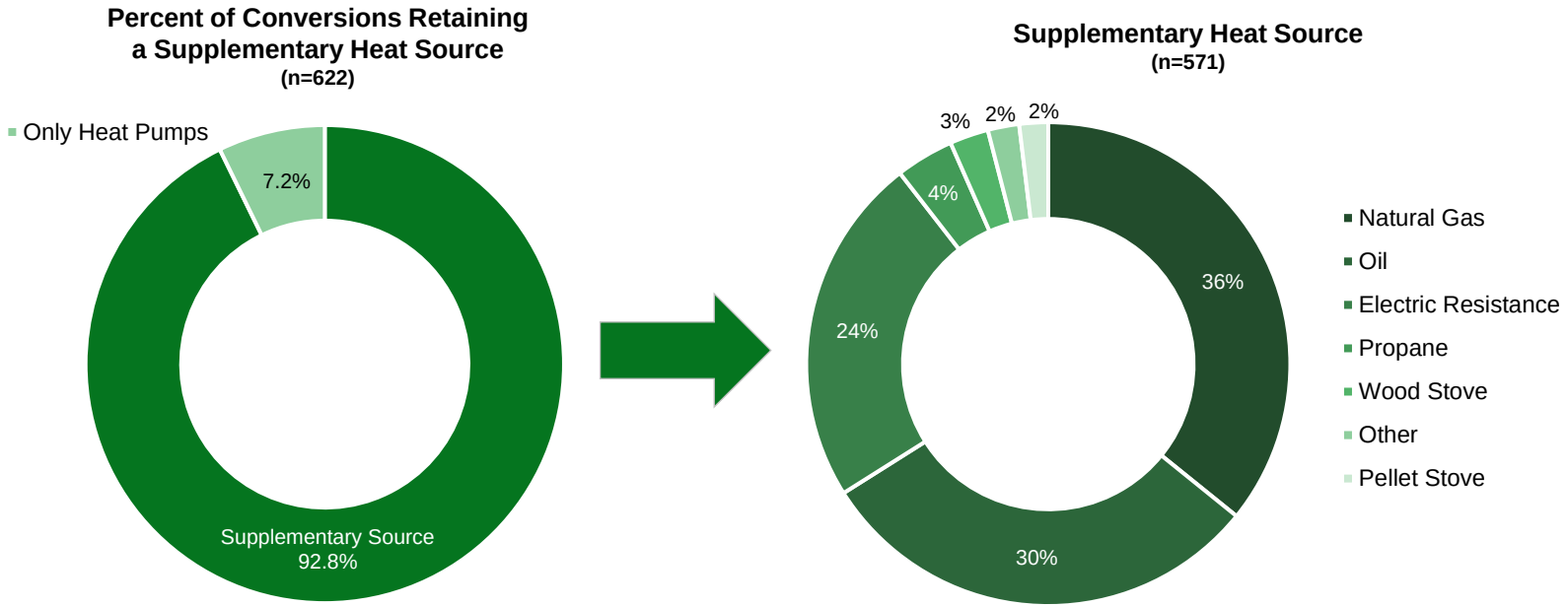
Assumptions

- ✓ Applications that reported a contained space under 900 square feet were excluded
- ✓ Applications that reported the installed heat pump capacity at 5° F (Btu) could not sufficiently provide heat for a minimum of 80% of the residences heat load were excluded. This calculation was based on a 40 Btu per square foot requirement
- ✓ Applications that reported the project as new-build construction or an addition were excluded. Only reports of "existing home" or "retrofit" were included
- ✓ Applications that reported heat pumps as a supplemental heat source were excluded
- ✓ Only applications within 2 standard deviations of the mean were included
- ✓ Any application that did not report square footage of conditioned space, any cost metric, installed capacity at 5° F (Btu), or number of heat pumps were excluded

Source: Diversified Energy Specialists Research & Analysis; MassCEC; MA DOER

Conversion: Supplementary Heat Source

In addition to the high cost of conversion to air-source heat pumps, most installers recommend retaining a supplementary source of heat due to the heat pump systems inability to sufficiently heat residences in the cold Massachusetts winters



Analysis

- ✓ 92% of homeowners who converted to an air source heat pump system have either kept their existed heat source installed for a supplementary heat source or installed a secondary heat source, knowing that air source heat pumps begin to lose efficiency at 47ºF

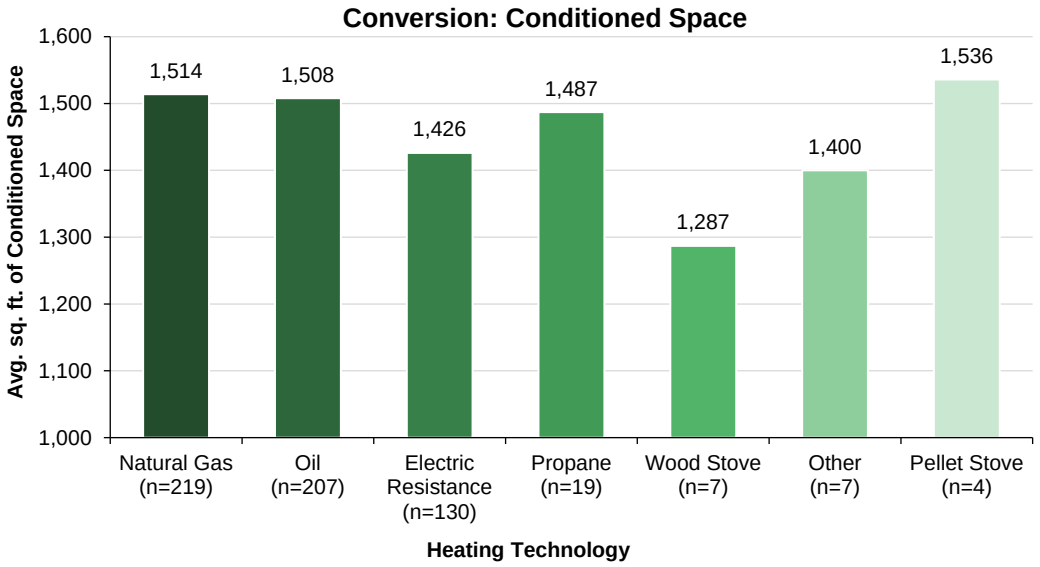
Assumptions

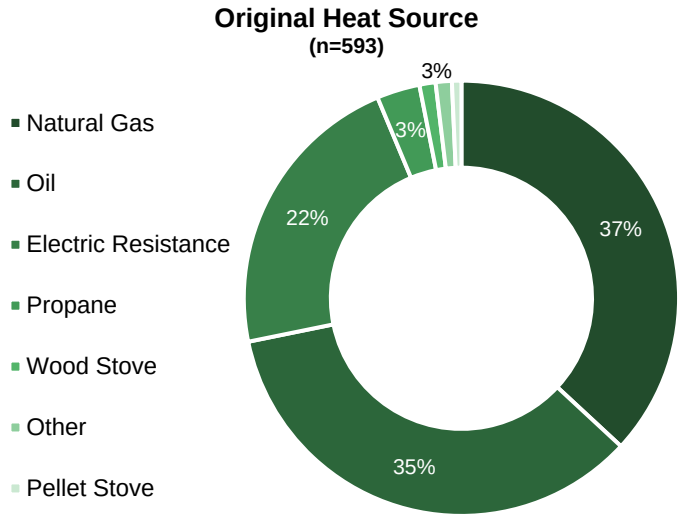
- ✓ Applications that self-reported whether a backup source of home heating would be used were included
- ✓ For applications that failed to report whether a backup source of home heating was used, DES used their self-reported installed capacity at 5° F (Btu) to determine if the heat pump system could sufficiently provide heat for greater than 90% of the residence's heat load. The determination was made based on a 40 Btu per square foot requirement. If the system could not provide sufficient heat for 90% or more of the residences heat load, DES made the assumption that a supplementary heat source was used

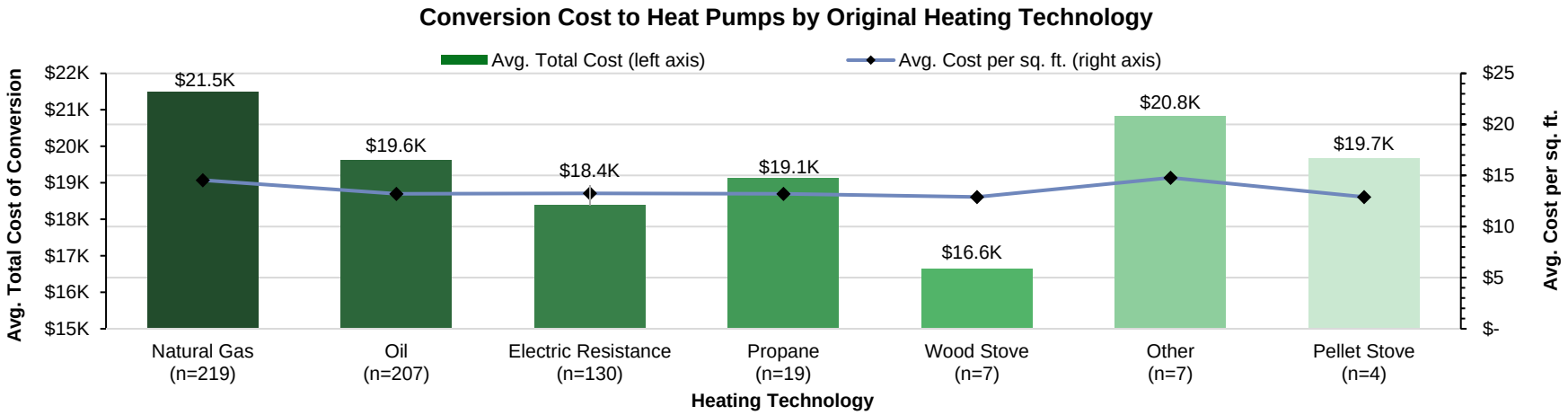
Source: Diversified Energy Specialists Research & Analysis; MassCEC; MA DOER

Conversion: Original Heat Source

The heating technology that is being converted to heat pumps slightly affects the price of conversion



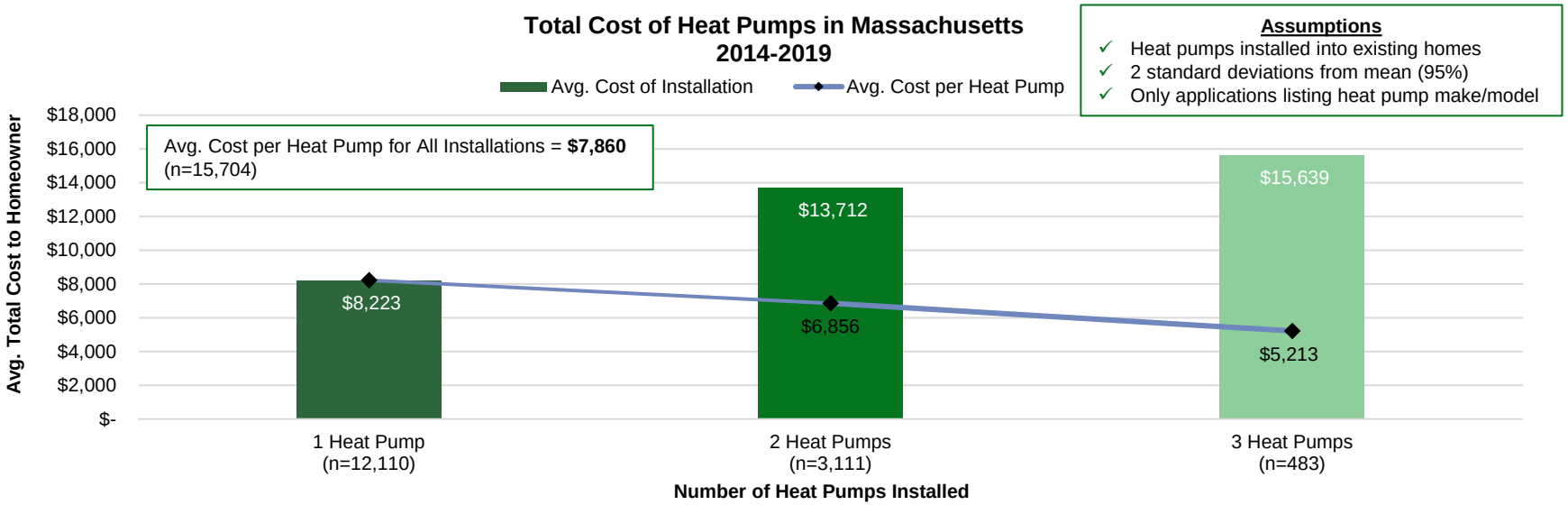


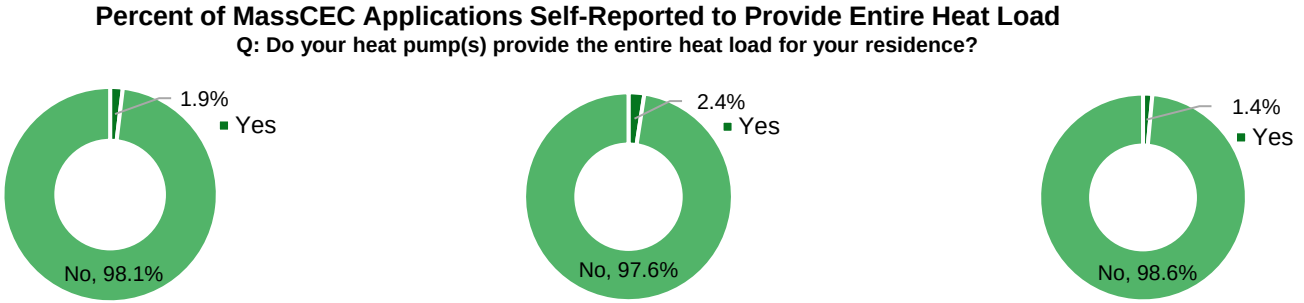


Source: Diversified Energy Specialists Research & Analysis; MassCEC; MA DOER

Supplemental Heat Source: Cost

DES estimates that 96% of the data from the MassCEC rebate program from construction in existing homes was from single or multi-room systems that did not provide sufficient heat for the entire home*



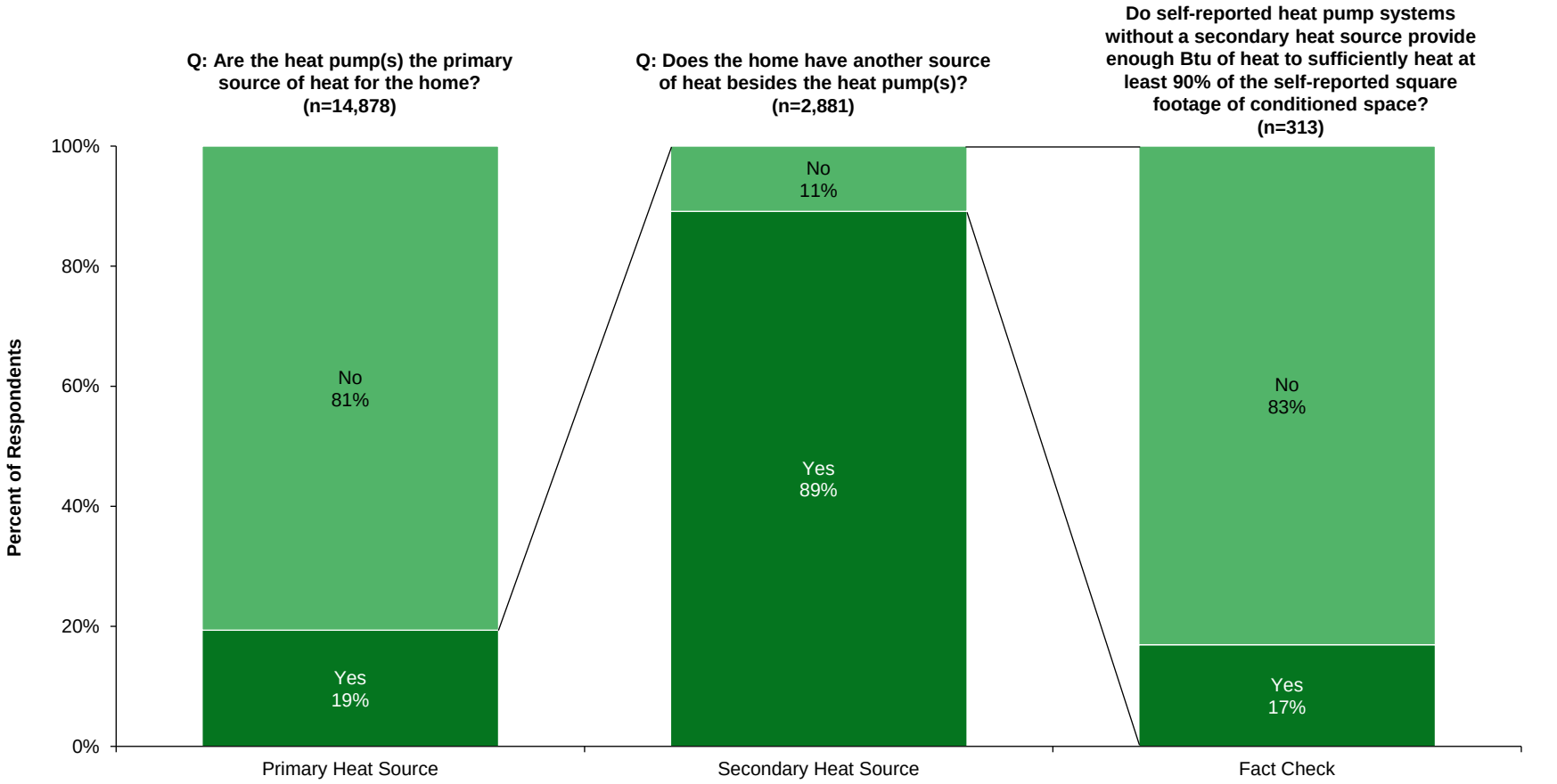


*The average Btu needed to sufficiently heat a home in Massachusetts is 40 Btu per square foot. Of the 16,572 applications of retrofit construction from existing homes, DES estimates that 622 (3.8%) were full conversions (displayed on slide 3). 2 standard deviations from the mean ensured that the above data contains less than 2% full conversions and displays the price of heating less than 90% of a home. Of the less than 2% self-reported to provide the entire heat load for their home above, DES determined that only 17% were accurate based on their self reported Btu output and square footage of conditioned space (see next slide)

Source: Diversified Energy Specialists Research & Analysis; MassCEC

Supplemental Heat Source: Applicable Use

The MassCEC rebate application data shows that air-source heat pumps in Massachusetts are primarily used as a supplemental heat source



Of the applications that self-reported that their heat pump(s) are the residences only source of heat, only 17% reported a Btu output from their heat pump(s) that could provide greater than 90% of their homes heat load. DES fact checked this number using a 40 Btu per square foot requirement

Source: Diversified Energy Specialists Research & Analysis; MassCEC

Conversion | **Supplemental**

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Biodiesel vs. Electrification: Northeast Case Study

Background Information

- One family residence in Methuen, MA
- Square footage of conditioned space: 1,902
- Facility construction type: Retrofit
- Prior Heating System:

In an effort to collect unbiased, randomized, and accurate data, DES recently began marketing its aggregation services to residential heat pump owners in the MA APS. This study on the true cost of converting to a heat pump system began after seeing many false statements and misrepresented data by utility companies. This is one example of a heating oil to heat pump conversion that I've received

Old Heating System

- Prior Heating System:
  - Oil
  - Heating distribution type: Baseboard
  - Did you have a supplementary fuel type?: No

ASHP Installation

- Air Source Heat Pump Renewable Thermal Installation Details:
  - Renewable thermal distribution type: Baseboard
  - Renewable thermal system utilization as percentage of the facility annual heating load: 95%
  - Do you have a supplementary fuel type?: Yes
  - Supplementary fuel type after renewable thermal generation unit installation: Oil
  - Supplementary fuel type utilization as percentage of the facility annual heating load: 5%
  - Installer: NETR LLC
  - Date in service: 6-26-2019
  - Heat pump manufacturer: Mitsubishi Electric Cooling & Heating
- Heat pump model: MXZ-5C42NAHZ
- Heat pump quantity: 5
- Total system cost: $23,046
- Was a rebate received from MassCEC?: No
- Did you receive any additional public funding?: No

Key Takeaways

- $23,046 to convert a 1,902 square foot residence
- 5 air-source heat pumps to condition a 1,902 square foot residence
- The Installer, NETR, instructed the homeowner to keep his heating oil system because the 5 heat pumps couldn't sufficiently heat his home in cold New England winter temperatures
- NETR informed the homeowner that he would need to use oil to sufficiently heat his home at least 5% of the time
- Most studies by utility companies suggest that a conversion from oil to a heat pump system will cost the average homeowner between $4,000 and $10,000

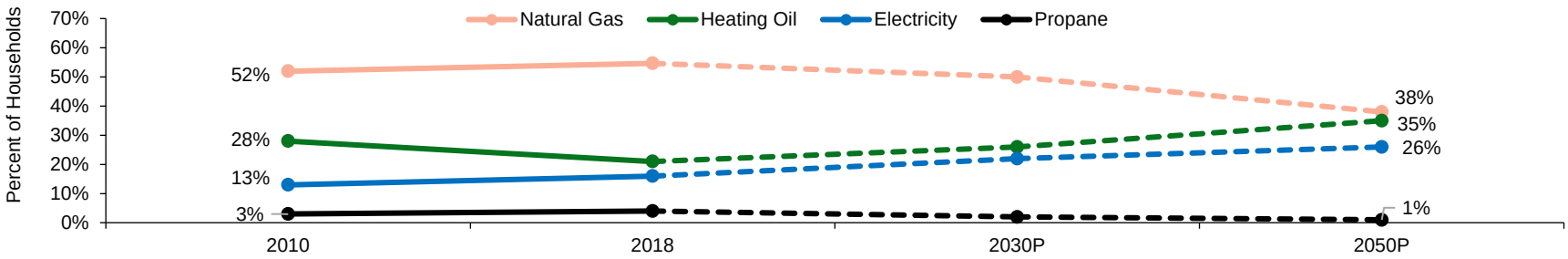
EIA: Average square footage of home in… MA = 2,076. Northeast = 2,232. US = 1,971

Source: Diversified Energy Specialists Research & Analysis

Market Share - Projections

	Carbon Intensity lbs. CO2/MMBtu	2030 CI Reduction est.	2050 CI Reduction est.	Summary
ULSHO	247.6	40-50%	80-100%	If high biodiesel blends are adopted by the heating oil industry, it will begin to gain market share for the first time in decades due to its ability to lower its carbon intensity at a relatively low cost
Natural Gas	171.7	0-5%	15-25%	Natural gas will begin to lose market share to biodiesel blends and cold climate heat pumps due to its inability to reduce its carbon intensity to a significant degree
Electricity	141.8*	40-50%	80-100%	State and federal policy makers view electrification as the future of renewable thermal heating, despite high conversion cost and concerns about cold climate heat pumps ability to provide sufficient heat in cold Northeastern winters
	*Mini-split 17ºF			
Propane	212.1	0%	0%	Propane will lose market share due to its inability to reduce its carbon intensity

Energy Used to Heat Households in the Northeast (2010-2050P)



Source: Argonne National Laboratory; DES Research & Analysis

Carbon Pricing - Case Study

Proposed policy at both the state and federal levels indicate that carbon emissions will be priced into thermal heating fuels in the future

2019 MA H 778 – Fernandez				
	$15 per Metric Ton CO2e (Year 1)		$55 per Metric Ton CO2e (Year 5)	
Natural Gas	$1.35 Per MMBtu	$0.13 Per Therm	$4.95 Per MMBtu	$0.49 Per Therm
ULSHO	$1.54 Per MMBtu	$0.21 Per Gal	$5.65 Per MMBtu	$0.78 Per Gal
B20	$1.30 Per MMBtu	$0.18 Per Gal	$4.75 Per MMBtu	$0.65 Per Gal
B50	$0.93 Per MMBtu	$0.12 Per Gal	$3.40 Per MMBtu	$0.45 Per Gal
B100	$0.32 Per MMBtu	$0.04 Per Gal	$1.16 Per MMBtu	$0.15 Per Gal

Analysis

- This carbon pricing bill failed in Massachusetts last year. Many other states have proposed similar bills
- It is likely that some states in the Northeast will soon face carbon pricing policy. Not only should this garner a sense of urgency from distributors in the industry to reach higher blend levels, but also should be welcomed as an opportunity. Under this failed bill, blends of less than 20% biodiesel would face a lower tax than natural gas. A B50 blend would receive a tax of 31% less than the tax imposed on natural gas. Carbon pricing policies will drive natural gas and propane companies, that cannot reduce their carbon score, out of business

Source: DES Research & Analysis; Argonne Laboratory 20-year atmospheric lifetime without indirect land use

High-Blend Economics

The cost of biodiesel blends is less of a concern than the policies that require a reduction in greenhouse gas emissions from the thermal heating sector

Infrastructure Improvements	Biodiesel Price Increase	Blenders Tax Credit	ULSHO Pricing
Infrastructure improvements will be necessary to meet the demands of a new fuel that has a higher pour point	Demanding a high volume of biodiesel in PADDs IA & IB from PADDs II & III will increase the price of biodiesel	The Federal Blenders Tax Credit will remain until 2022. If the BTC is not reinstated in 2023, biodiesel pricing will increase substantially	The price of ultra-low sulfur heating oil will continue to be volatile, as it always has
• Heated bulk storage tanks will be a focus of those higher up the supply chain, while B100 boilers will be a focus of those lower on the supply chain • Capital investments into infrastructure from producers and wholesalers will increase the price of biodiesel for distributors and end users	• The shift from local supply to PADDs II & III will place additional transportation and storage costs • Competition with the LCFS and West Coast demand for domestically produced biodiesel will increase pricing • Currently, biodiesel is moderately priced in PADD IA & IB and we should expect prices to increase as we transition to higher blends	• If the BTC is not reinstated in 2023, the price of biodiesel will increase by $0.75-1.00 • Without the BTC, many producers struggle to break even with their operations. Despite this, demand for a low-carbon liquid heating fuel will remain and producers will increase their prices	• Whether ULSHO is priced at $30/BBL or $80/BBL, biodiesel will be a necessary addition for the industry to reduce its carbon score • We can expect both heating oil pricing and biodiesel pricing to fluctuate over time, but the goal of reaching net-zero carbon will remain

Conclusion

Price should not be considered when blending biodiesel into home heating oil. Pricing of biodiesel will increase over time, but the cost of delivering a high carbon fuel will be far more expensive. The industry is now faced with an important decision, either swiftly adopt a higher cost low-carbon fuel and meet the greenhouse gas reduction goals of the Providence Resolution or be legislated out of business. The process of being legislated out of business started years ago and state legislatures across the Northeast have unanimously chosen electrification as the future of the thermal heating sector. Our industries ability to reduce the carbon intensity of our fuel is an opportunity that the natural gas and propane industry wished they had. Carbon pricing and other policy will legislate natural gas and propane out of the thermal heating sector. Our ability to adapt and transition to high biodiesel blends will allow us to survive and compete with high-cost conversions to electric heat pump systems. The heating oil industry has all the tools to thrive in a rapidly approaching, low-carbon world and to transition to the renewable liquid fuels industry, now action must be taken.

Source: DES Research & Analysis

Contact Information

Diversified Energy Specialists is a biofuels consulting company and an aggregation of renewable thermal technologies in the Massachusetts Alternative Portfolio Standard

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