The Fallacies of Electrification & The Truth of Bioheat® Fuel

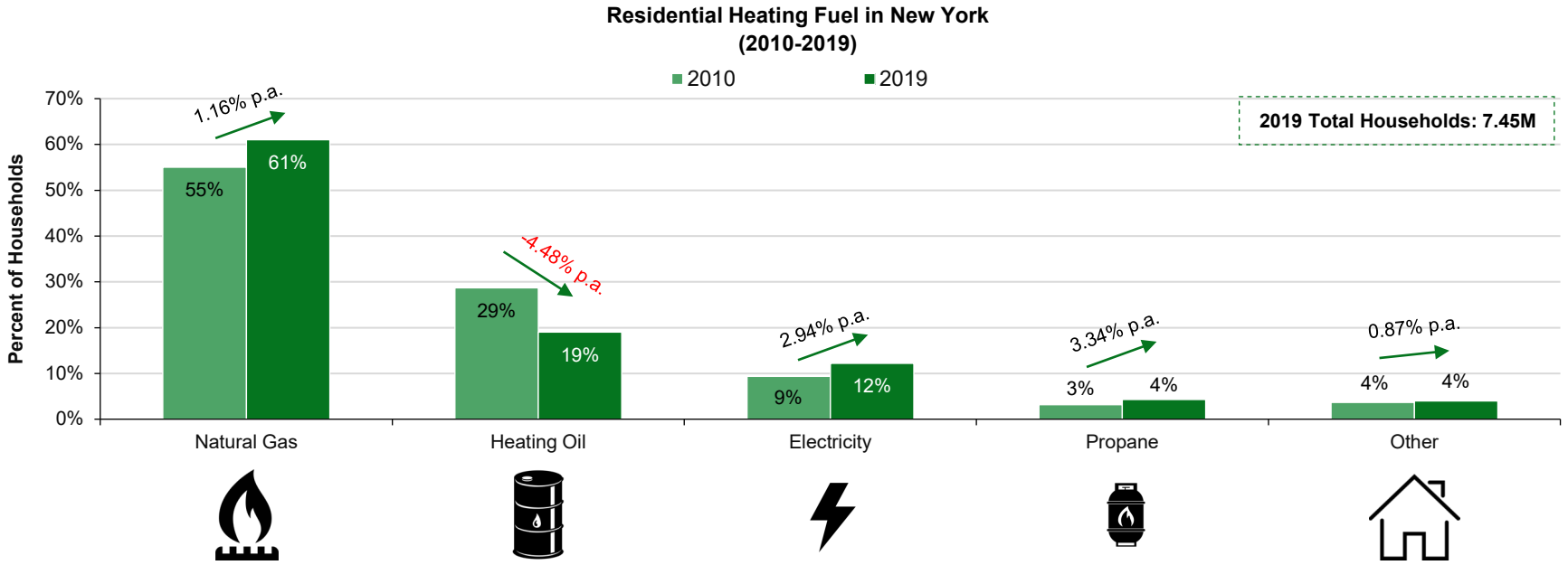
Report Prepared For:

EMPIRE STATE ENERGY ASSOCIATION
ESEA

September 28, 2021

New York Residential Heating Fuel

Most residences in New York use natural gas and heating oil for their heating needs, but electricity has grown quickly due to utility incentive programs and state government subsidies



Analysis

- ✓ From 2010–2019 the residential heating landscape has experienced significant change:
  - ✓ Heating oil has steadily lost market share
  - ✓ Natural gas has steadily grown to three times the share of any other heating technology, while also accounting for the majority of electricity generation
  - ✓ Electricity has grown to 12% of the residential heating market, benefiting from state government subsidies and utility rebate programs
  - ✓ Propane and other heating technologies has slightly grown and still has a small percent of the market share
  - ✓ The accuracy of the Census bureau data has been questioned, specifically when a home uses more than one heating technology to meet their annual heat load
    - ✓ Some homes use heat pumps and a supplementary heat source to heat their homes in the winter
    - ✓ Other homes use heat pumps for one or more rooms, while using another technology to heat the rest of the home
  - ✓ The NYSERDA ASHP program's objective was to increase electrification in residential buildings in New York from 2017-2019

Source: U.S. Census Bureau, 2010 & 2019 ACS 1-Year Estimates, New York, Occupied Housing Units, House Heating Fuel

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Northeast Electrification Programs

Many northeast states and utilities provide rebates for the installation of cold climate air-source heat pumps in homes and buildings

Northeast State Programs

- ✓ NYSERDA
- ✓ MassCEC
- ✓ Mass Save
- ✓ Efficiency Maine
- ✓ Vermont Department of Public Service
- ✓ Efficiency Vermont
- ✓ Burlington Electric Department

Northeast Utility Programs

- ✓ NYS Electric Utilities
- ✓ Energize CT (Avangrid)
- ✓ Energize CT (Eversource)
- ✓ National Grid Rhode Island

Building Electrification Initiative

Cities committed to accelerate the transition of building systems away from fossil fuels and toward high efficiency electric options.

Northeast Participants:

- ✓ Burlington, VT
- ✓ New York City, NY
- ✓ Boston, MA

Electrification Program Numbers

- ✓ Programs to promote electrification of space heating in homes and buildings, primarily using high-efficiency heat pumps, are rapidly growing. Current year budgets are nearly $110 million, up 70% from 2019.
- ✓ In areas with high use of delivered fuels (fuel oil and propane), many programs target customers using these fuels because the economics of electrification in these situations are often better than when displacing natural gas. Likewise, a few programs are encouraging all-electric new construction.
- ✓ Of the 22 programs nationally, 19 are funded by utility ratepayers.

Source: ACEE: Programs to Electrify Space Heating in Homes and Buildings, June 2020

Clear Path to Net Zero

State policymakers envision a renewable electric future for vehicles and heating

Why Electrification?

- ✓ Clear and accepted narrative
- ✓ Easy to understand
- ✓ Undisputed path to net-zero emissions
- ✓ Utilities have spent significant time and money educating state and federal policymakers that electrification is the only way to a zero-carbon future
- ✓ The electricity industry is consolidated, and the companies are large.
- ✓ State legislatures face pressure from the public, who is mostly unaware of the benefits of bioheat®

Source: DES Research & Analysis

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Case Study

New York Air-Source Heat Pump Installations 2017-2019

Report Prepared For:

EMPIRE STATE ENERGY ASSOCIATION ESEA

September 28, 2021

Disclaimer

This study was created by Diversified Energy Specialists, Inc. and is intended for public distribution. All data was obtained from the public New York State data website.

NYSERDA offered a residential ASHP rebate program from 2017-2019 which provided rebates for ASHP installations in New York, providing nearly $14,950,000.00 in incentives. **"Air source heat pumps have been an efficient source of cooling for years but advances in technology now allow them to effectively address heating needs in cold climates, helping customers lower their energy costs and reduce greenhouse gas emissions. NYSERDA launched the Air Source Heat Pump Program to expand the adoption of advanced ASHPs and encourage wider use for space heating and cooling."** The New York State Public Service Commission allocated funding for this program through the Clean Energy Fund to expand the ASHP market in New York and to support installations for customers who pay for the System Benefits Charge surcharge on their electricity bills.

All data collected by NYSERDA was obtained from applications for rebates within the program. All data was self-reported by the ASHP installer with assistance from the homeowner.

This presentation is up to date as of September 28, 2021.

NYSERDA 2017-2019 ASHP Program

Each participating installer was eligible to apply for and retain a $500 'Participating Installer Incentive' for each qualified and installed ASHP system, while additional 'Site Owner Incentives' were available for installations determined to be a 'Whole-House Solution'

Whole-House Solution ASHP System

Whole-House Solution ASHP System: An ASHP System installed as a home's primary heating source, designed with a full-load heating capacity between 90% and 120% of peak heating load, corresponding to the approved heat load calculation determined by utilizing a Manual J or an equivalent energy simulation program or calculator. These ASHP systems must include at least one of the following configurations as defined by the Northeast Energy Efficiency Partnership:

- ✓ Singlezone Ducted, Centrally Ducted
- ✓ Multizone All Ducted
- ✓ Multizone All Non-ducted that includes two or more indoor heads
- ✓ Multizone Mix of Non-ducted and Ducted that includes two or more heads

ASHP Systems and for integrated controls; all Site Owner Incentives must be passed on or otherwise credited to the site owner in their entirety. The program provides flexibility to participating contractors to decide how best to use each of their qualifying $500 Participating Installer Incentives to help grow that portion of their business.

Whole-House Solution Incentives

NYSERDA will pay out incentives according to the following table:

Qualifying Equipment	Participating Installer Incentive	Site Owner Incentive
2-Ton Whole-House Solution ASHP System	$500	$1,500
3-Ton Whole-House Solution ASHP System	$500	$2,500
4-Ton Whole-House Solution ASHP System	$500	$3,500
5-Ton Whole-House Solution ASHP System	$500	$4,500
Other than Whole-House Solution ASHP System[4]	$500	$0
Qualifying Control/Thermostat		
Integrated Control Package	$0	$500
Dual Fuel Thermostat	$0	$50

Target Market Segment(s) – Study Scope

- ✓ "The target market includes residential, multi-family, commercial, and institutional buildings owners/managers/developers that have a stronger value proposition, such as sites that currently use oil and propane, or have limited access to natural gas, as these represent high value use cases across market segments based on project economics. Due to the newness of the market, NYSERDA did not limit the offering to any particular market segment, allowing the strongest value proposition use case(s) to emerge"
- ✓ This scope of this study was limited to residential single-family detached homes that were determined by Diversified Energy Specialists to be a whole-home solution, inclusive of supplementary heating sources. The methodology of determining whether an application was considered a whole-home solution for this study is outlined on the next slide

Source: Diversified Energy Specialists Research & Analysis; NYSERDA

Whole-Home Solution: Filter

An application qualified to be a whole-home solution in this data set if it was rewarded a total NYSERDA incentive equivalent to a whole-home solution (1) and either the applicant self-reported that the ASHP system provided 100% of the heating load for the home's conditioned square footage (A) or NYSERDA qualified the system as a whole-home solution (B)

1 Total NYSERDA Incentive

- ✓ Less than 1,000 sq. ft. (≥ $1,500)
- ✓ 1,000 – 1,500 sq. ft. (≥ $1,500)
- ✓ 1,500 – 2,000 sq. ft. (≥ $2,500)
- ✓ 2,000 – 2,500 sq. ft. (≥ $3,500)
- ✓ 2,500 – 3,000 sq. ft. (≥ $4,500)
- ✓ 3,000+ sq. ft. (≥ $5,000)

A Applicant / Installer Self-Reported

Percentage of residences square footage to be conditioned by the ASHP system
(100% / Less than 100%)

OR

B NYSERDA

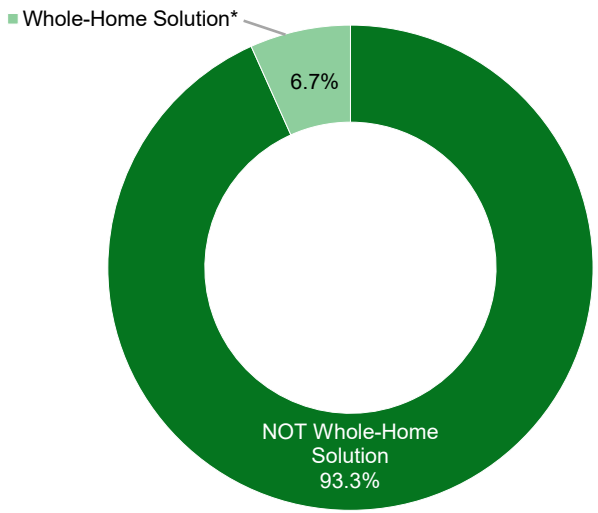
Whole-Home Solution ASHP System
(True / False)

Source: Diversified Energy Specialists Research & Analysis; NYSERDA

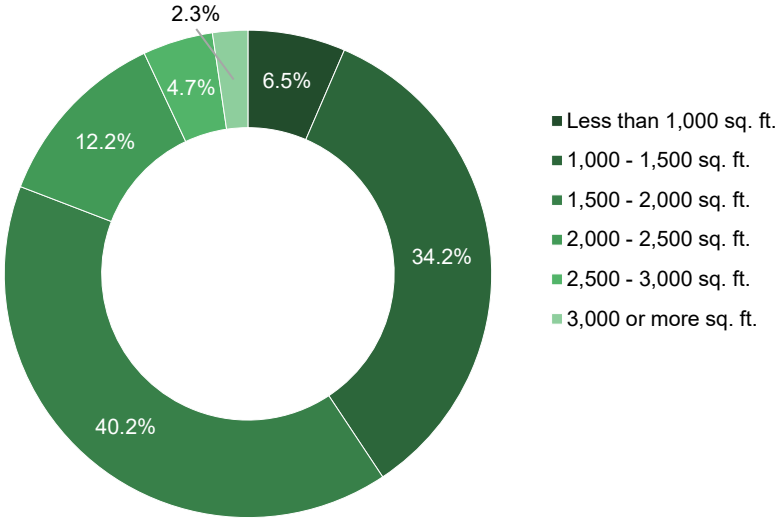
Applications for Single-Family Detached Homes

From 2017-2019, NYSERDA received 9,730 applications for rebates for ASHP installations. 5,756 of those applications were from single-family detached homes

Applications for Single-Family Detached Homes
(n=5,756)



Whole-Home Solution by Sq. Ft. Conditioned Space
(n=386)



Assumptions

*Applications from single-family detached homes were determined to be a whole-home solution by Diversified Energy Specialists if:

- ✓ NYSERDA rewarded a full-load incentive for the ASHP system, AND
  - ✓ The applicant self-reported that the ASHP system provided 100% of the residence conditioned square footage, OR
  - ✓ NYSERDA qualified the system as a whole-home solution

Analysis

- ✓ In the three years (2017-2019) of the NYSERDA rebate program, 386 ASHP systems were installed in single-family detached homes in New York with the capacity to be a whole-home solution
  - ✓ This equates to 0.005% of residences in New York
- ✓ The median square footage of conditioned space in the 386 applications determined to be whole-home solutions was estimated to be 1,663 square feet, which is 101 square feet below the median residence size in NY

Source: Diversified Energy Specialists Research & Analysis; NYSERDA

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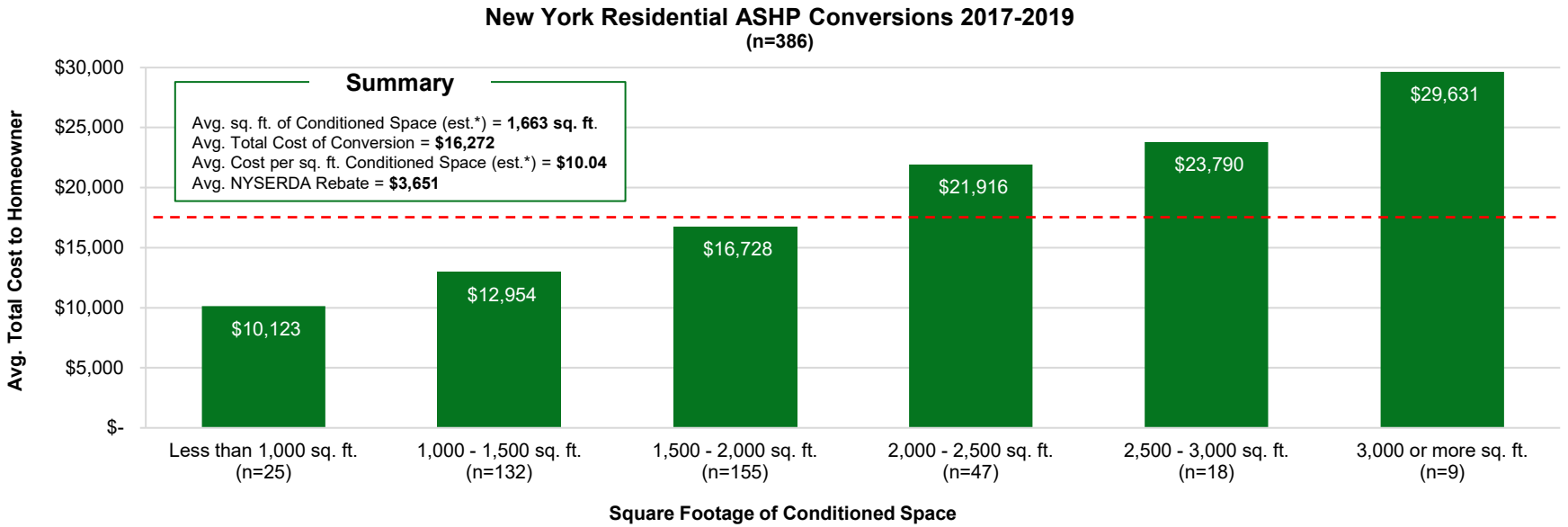
Whole-Home ASHP Conversions



Median Size of Residence in New York = **1,764 sq. ft.**
Median Residence Conversion Cost (est.*) = **$17,286**

Assumptions

- ✓ Applications that NYSERDA reported giving an incentive less than a full load incentive were excluded. Full load incentive qualified as:
  - ✓ Less than 1,000 sq. ft. ≥ $1,500
  - ✓ 1,000 – 1,500 sq. ft. ≥ $1,500
  - ✓ 1,500 – 2,000 sq. ft. ≥ $2,500
  - ✓ 2,000 – 2,500 sq. ft. ≥ $3,500
  - ✓ 2,500 – 3,000 sq. ft. ≥ $4,500
  - ✓ 3,000+ sq. ft. ≥ $5,000
- ✓ Applications that NYSERDA reported as being a whole-home solution were included if they received a full load incentive.
- ✓ Applications that self reported being a whole-home solution were included if they received a full load incentive.
- ✓ Applications listing ground-source heat pumps as their primary heating system were excluded.

*Estimated cost per sq. ft. was assumed to be 750 sq. ft. for residences reported under 1,000 sq. ft. and 3,500 sq. ft. for residences reported over 3,000 sq. ft. The remaining buckets were assumed to be the median (e.g. 1,000-1,500 sq. ft. was assumed to be 1,250 sq. ft.)

Source: Diversified Energy Specialists Research & Analysis; NYSERDA, U.S. Census Bureau

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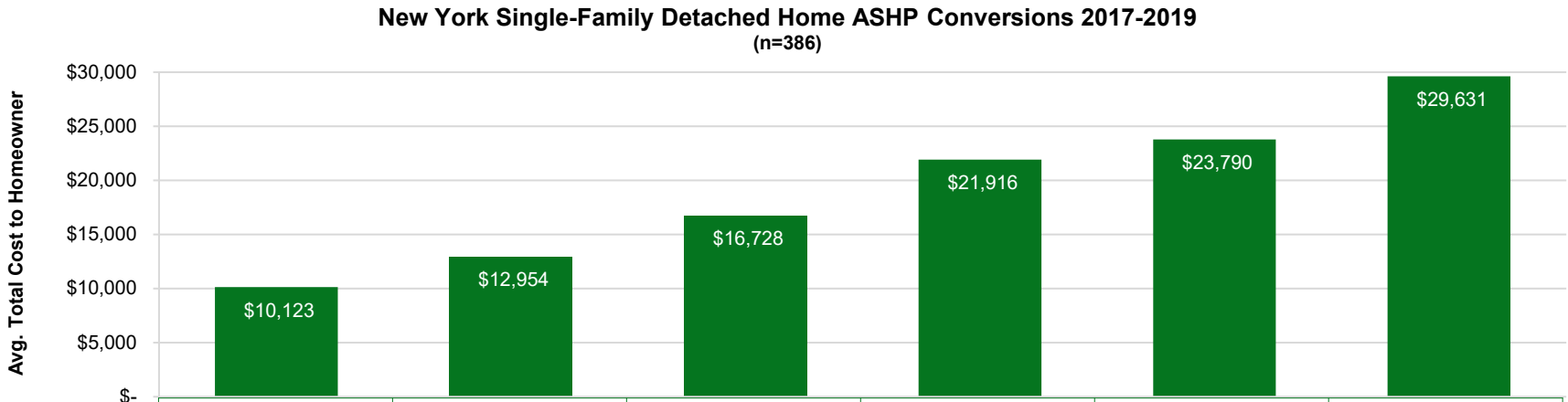
Whole-Home ASHP Conversions



	Square Footage of Conditioned Space					
	Less than 1,000 sq. ft. (n=25)	1,000 - 1,500 sq. ft. (n=132)	1,500 - 2,000 sq. ft. (n=155)	2,000 - 2,500 sq. ft. (n=47)	2,500 - 3,000 sq. ft. (n=18)	3,000 or more sq. ft. (n=9)
Avg. Rebate	$2,200	$2,843	$3,820	$4,865	$5,756	$6,083
Range Low	$3,500	$3,200	$4,500	$8,000	$6,700	$17,437
Range High	$25,825	$27,216	$41,301	$39,482	$37,370	$64,461
Legacy Heat Source Natural Gas	24%	27%	29%	30%	28%	11%
Legacy Heat Source Oil	20%	28%	27%	34%	50%	22%
Legacy Heat Source Electric*	28%	23%	23%	19%	6%	33%
Legacy Heat Source Propane	24%	16%	19%	17%	11%	33%
Legacy Heat Source Wood	4%	5%	2%	0%	6%	0%
Legacy Heat Source Other	0%	2%	0%	0%	0%	0%

*Electric is either a conversion from electric resistance heating, an air-source heat pump upgrade or new-build construction

Source: Diversified Energy Specialists Research & Analysis; NYSERDA

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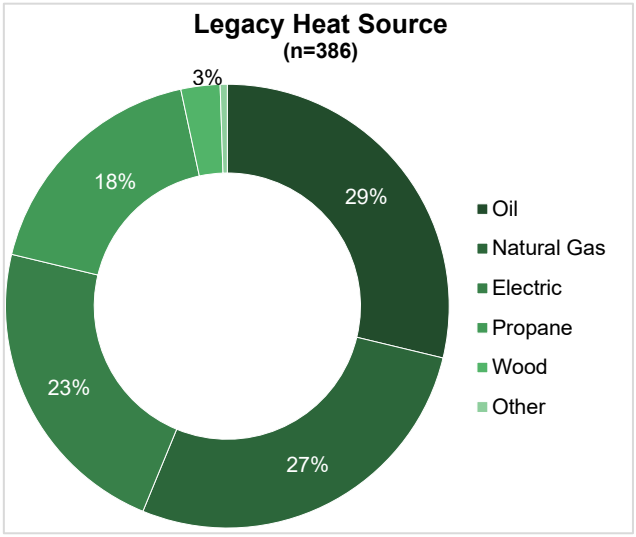
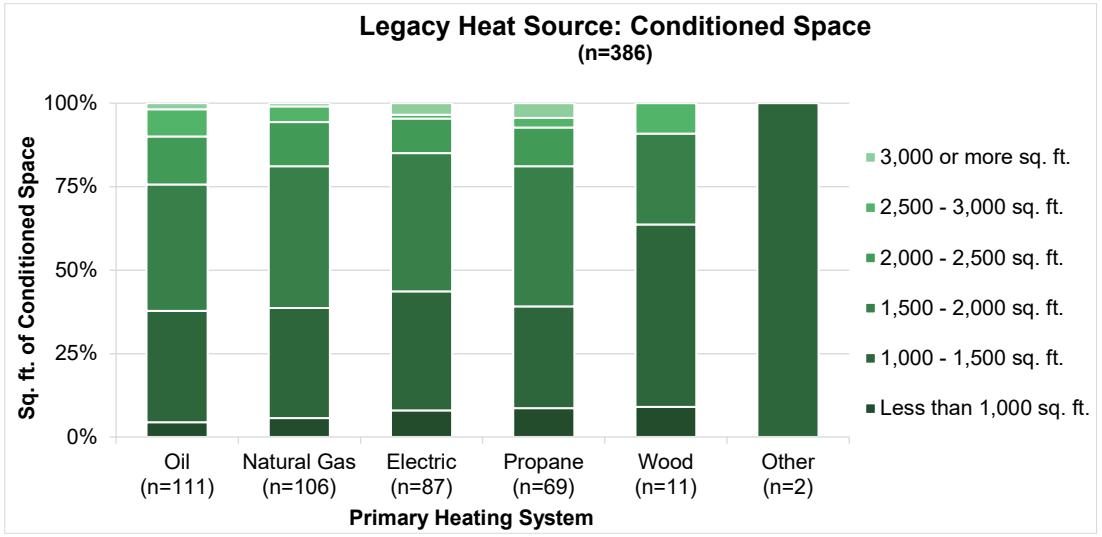
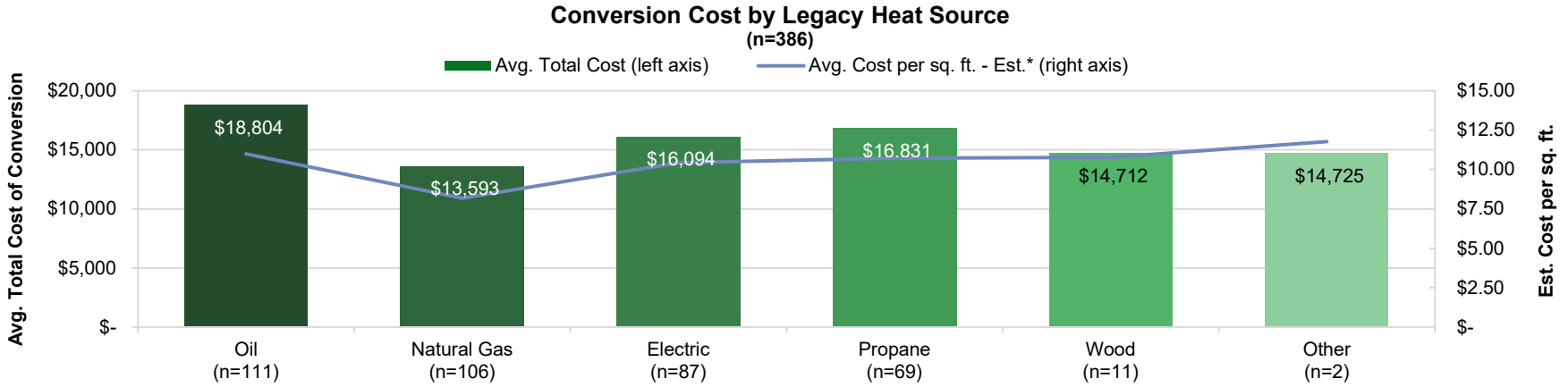
Conversion Cost: Legacy Heat Source

The legacy heating technology can impact the price of conversion







*Estimated cost per sq. ft. was assumed to be 750 sq. ft. for residences reported under 1,000 sq. ft. and 3,500 sq. ft. for residences reported over 3,000 sq. ft. The remaining buckets were assumed to be the direct middle (e.g. 1,000-1,500 sq. ft. was assumed to be 1,250 sq. ft.)

Source: Diversified Energy Specialists Research & Analysis; NYSERDA

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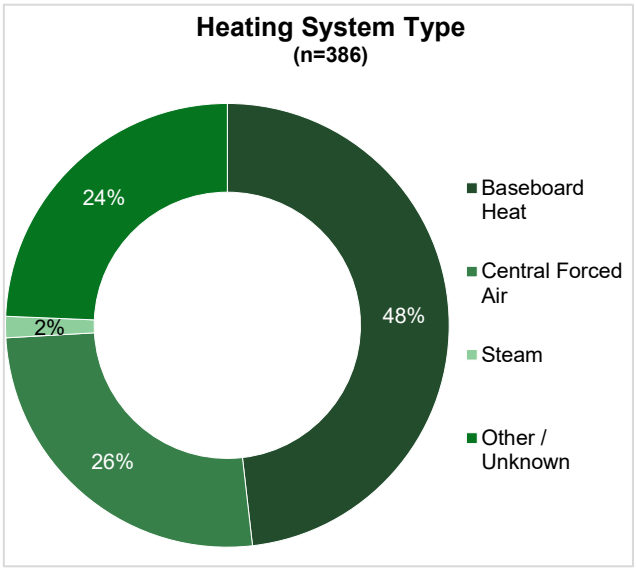
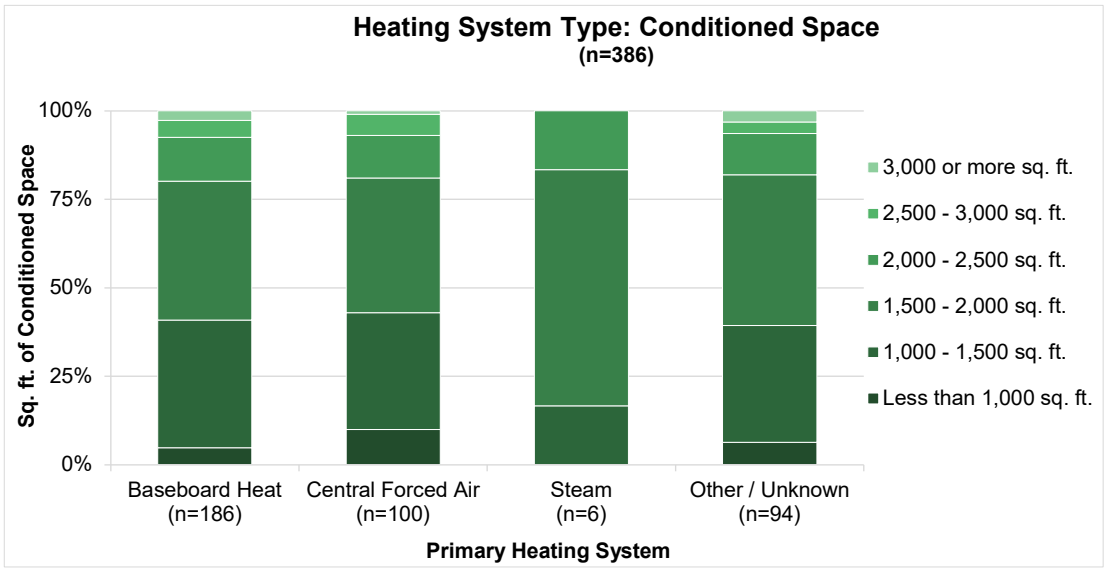
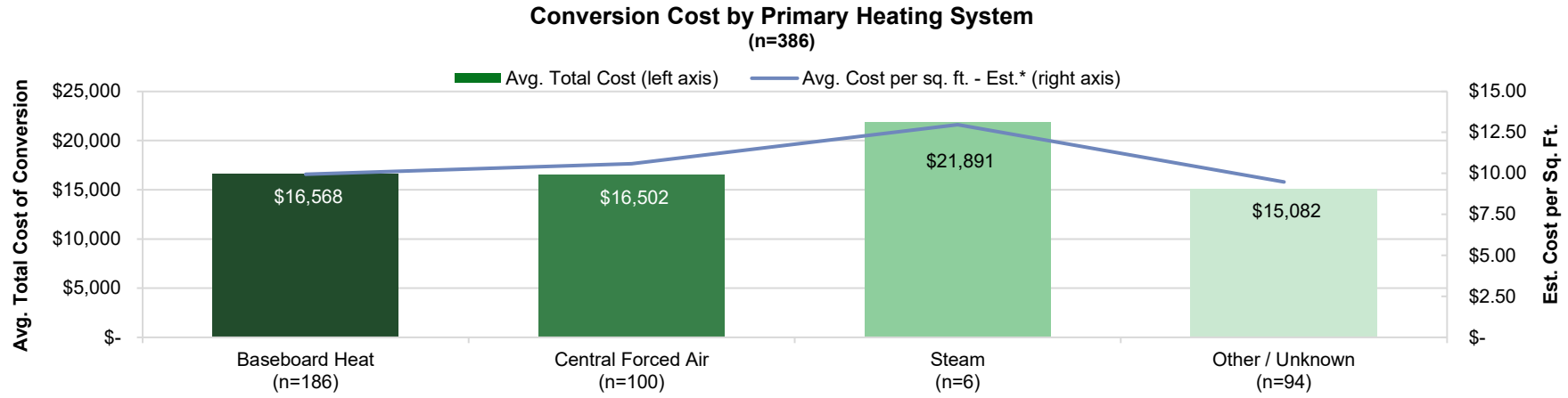
Conversion Cost: Heating System Type







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Source: Diversified Energy Specialists Research & Analysis; NYSERDA

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New York Median Household Income by County

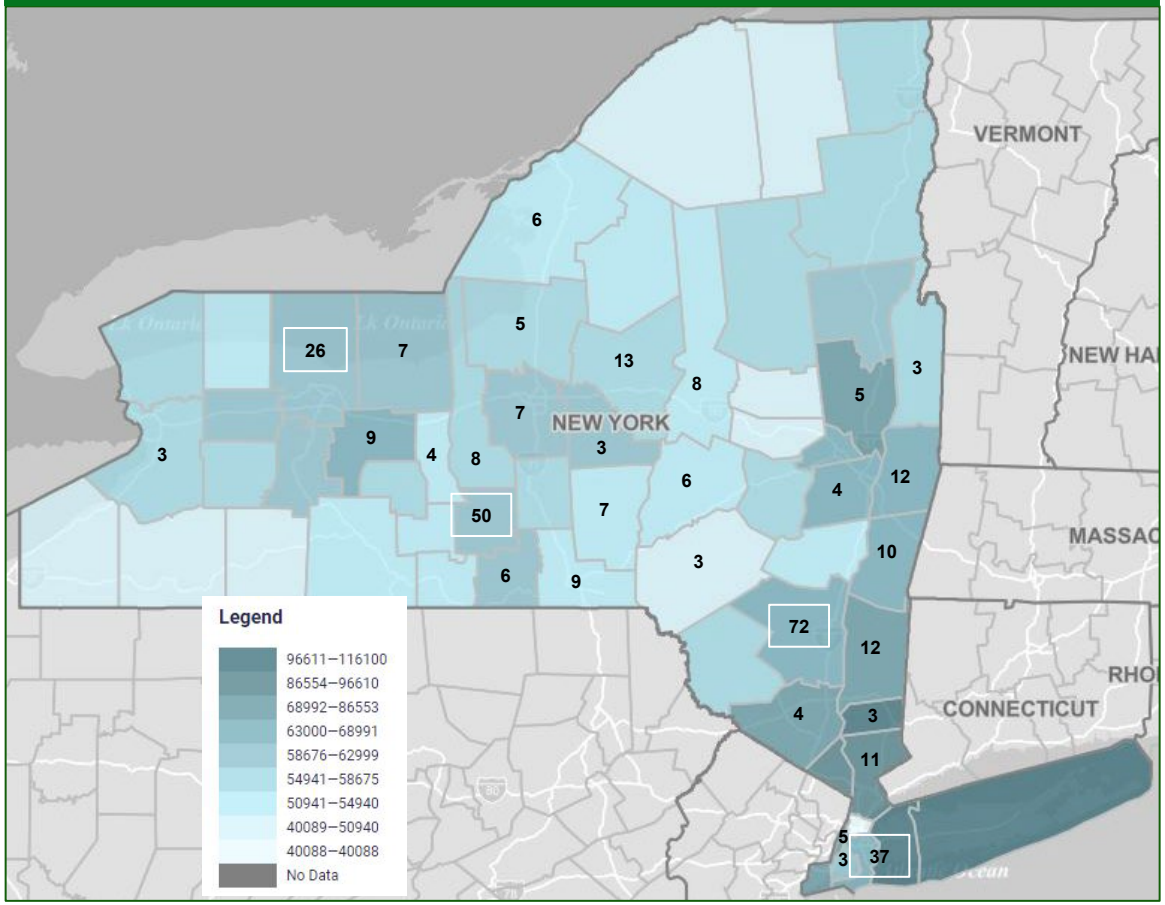
Most conversions appear to occur in higher income counties in New York

Analysis

The map displays numbered labels for counties with 3 or more whole-home ASHP installations and white borders for counties with 20 or more installations

- ✓ The high cost of installing a whole-home ASHP system is a barrier to entry for environmental justice populations
- ✓ The consolidation of whole-home ASHP installations in high-income counties has a considerable impact on low-income counties:
  - ✓ ASHP installations increase the cost of electricity for all ratepayers
  - ✓ Widens the greenhouse gas emissions gap between high-income and EJ communities
  - ✓ Improves air-quality in high-income communities, while EJ communities air-quality is unchanged
- ✓ ASHP installations increase the grid load
  - ✓ Increasing the cost of electricity
  - ✓ Increasing the greenhouse gas emissions from electricity
  - ✓ Increasing the amount of renewable electricity generation needed to meet the state's net-zero carbon electricity goal
- ✓ The rebate comes from the system benefit charge, which all ratepayers in the state of New York pay, but only the high-income households can capitalize on these rebates
- ✓ Assumed that the highest income households in each county are the households installing whole-home ASHP systems

Median Household Income by County 2015-2019 (2019 $)



Source: U.S. Census Bureau, 2019 ACS 5-Year Estimates, New York, County, Median Household Income

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Secondary Heat Source

NYSERDA qualifies an installation as a "whole-house solution ASHP system", however, the original heat source is not required to be removed, and thus it can be assumed that most homes use a secondary heat source for a portion of their annual heat load

386 Whole-Home Solution ASHP Systems

Of the 386 whole-home solution ASHP systems Diversified Energy Specialists included in this data set…

- ✓ 55 self-reported that their ASHP system did not provide 100% of their household's annual heat load
- ✓ 81 were determined not to be whole-home solutions by NYSERDA
- ✓ 69 self-reported having an "Other Fuel Type" and 8 self-reported to have an "Other Primary Heating System"
  - ✓ 39 overlap with applications from the first two data points and 30 are unique

- ✓ 166 / 386 homes, or 45.36%, that installed a "whole-home solution ASHP system" used another heating fuel for at least a portion of their annual heat load
- ✓ The remaining 220 applications did not indicate whether a secondary heat source was used, which means we cannot determine whether a secondary heat source was used

NYSERDA Whole-Home Eligibility Issues

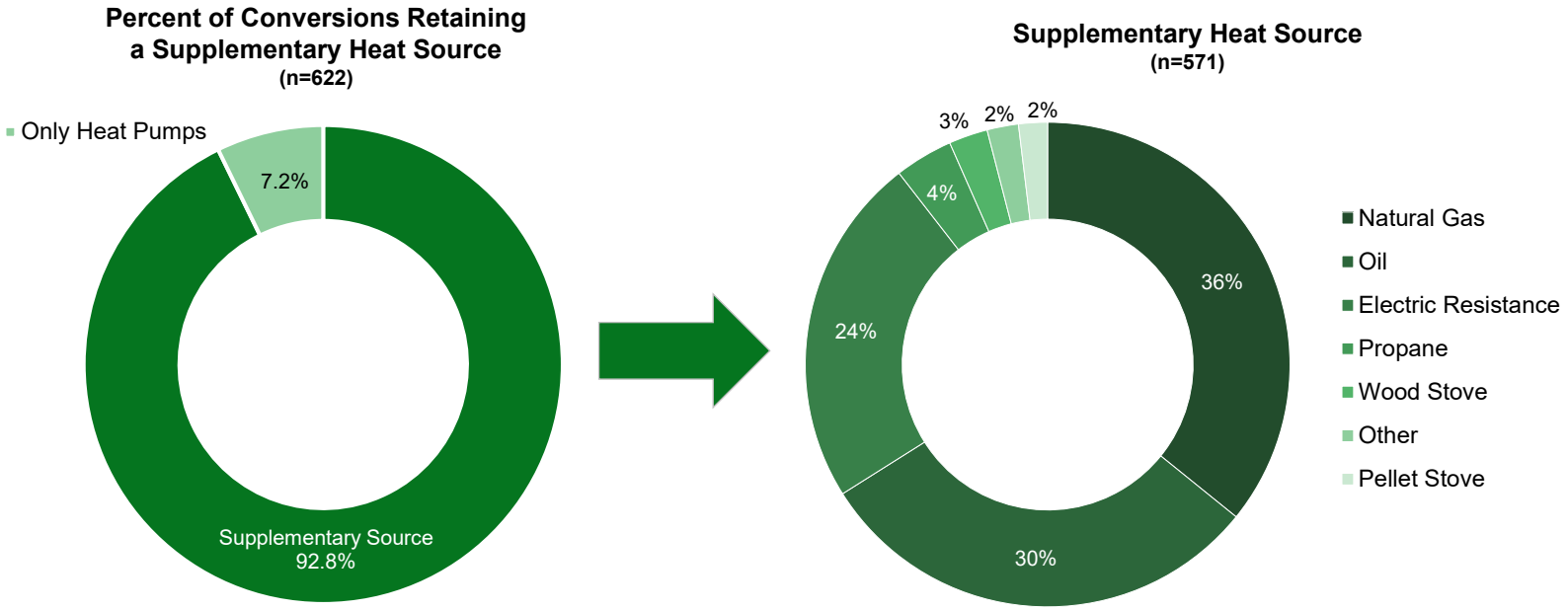
"Whole-House Solution ASHP System: An ASHP System installed as a home's primary heating source, designed with a full-load heating capacity between 90% and 120% of peak heating load, corresponding to the approved heat load calculation determined by utilizing a Manual J or an equivalent energy simulation program or calculator"

- ✓ NYSERDA determined that installations qualified as a "whole-house solution ASHP system" if the system was the home's primary heating source and had a full-load heating capacity between 90% and 120% of peak heating load
  - ✓ NYSERDA could not verify that the system was the home's primary heating source without:
    - ✓ Mandating the removal of the legacy heat source
    - ✓ Metering the ASHP system's usage
  - ✓ All homes that qualified with a full-load heating capacity of 90-99% of peak heating load must have a secondary heat source as backup when the "whole-house solution ASHP system" could not provide enough heat to sufficiently heat the home
  - ✓ An ASHP system can be designed with a full-load heating capacity between 90% and 120% of peak heating load and never used to heat the home. The capacity has no impact on its use
  - ✓ Many field studies have shown that ASHP systems installed with the capacity to provide 100% of the homes annual heat load are only used as air-conditioning systems

Source: Diversified Energy Specialists Research & Analysis; NYSERDA

MA ASHP 2014-2019: Supplementary Heat Source

In the MassCEC ASHP rebate program from 2014-2019, most installers recommended retaining a supplementary source of heat due to the ASHP systems inability to sufficiently heat residences in the cold Massachusetts winters



Analysis

- ✓ 92.8% of homeowners who converted to an ASHP system have either kept their legacy heat source installed or installed a secondary heat source, knowing that ASHPs 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 assumed that a supplementary heat source was used

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

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Case Study: Applications Excluded From Data Set

Applications that did not receive a full load incentive were excluded from the data set, despite some of them reporting the highest total cost of installation in the program

Example #1

- ✓ Less than 1,000 sq. ft.
- ✓ Total project Cost: **$21,129**
- ✓ Total NYSERDA incentive: $500
- ✓ Self-reported percent of residences square footage conditioned by the ASHP unit: **50%**
- ✓ NYSERDA whole-home solution? No
- ✓ Primary heating fuel: Natural Gas
- ✓ Primary heating system: Baseboard Heat
- ✓ Retrofit (building built 1951-1960)

Example #2

- ✓ 1,000 – 1,500 sq. ft.
- ✓ Total project Cost: **$22,200**
- ✓ Total NYSERDA incentive: $1,000
- ✓ Self-reported percent of residences square footage conditioned by the ASHP unit: **25%**
- ✓ NYSERDA whole-home solution? No
- ✓ Primary heating fuel: Oil
- ✓ Primary heating system: Hot Water
- ✓ Retrofit (building built 1951-1960)

Example #3

- ✓ 1,500 - 2,000 sq. ft.
- ✓ Total project Cost: **$37,602**
- ✓ Total NYSERDA incentive: $500
- ✓ Self-reported percent of residences square footage conditioned by the ASHP unit: **50%**
- ✓ NYSERDA whole-home solution? No
- ✓ Primary heating fuel: Propane
- ✓ Primary heating system: Central Forced Air
- ✓ Retrofit (building built 1961-1970)

Example #4

- ✓ 2,500 - 3,000 sq. ft.
- ✓ Total project Cost: **$39,000**
- ✓ Total NYSERDA incentive: $1,000
- ✓ Self-reported percent of residences square footage conditioned by the ASHP unit: **85%**
- ✓ NYSERDA whole-home solution? No
- ✓ Primary heating fuel: Propane
- ✓ Primary heating system: Central Forced Air
- ✓ Retrofit (building built 1981-1990)

Example #5

- ✓ 2,500 - 3,000 sq. ft.
- ✓ Total project Cost: **$29,720**
- ✓ Total NYSERDA incentive: $500
- ✓ Self-reported percent of residences square footage conditioned by the ASHP unit: **40%**
- ✓ NYSERDA whole-home solution? No
- ✓ Primary heating fuel: Oil
- ✓ Primary heating system: Baseboard Heat
- ✓ Retrofit (building built 1991-2000)

Example #6

- ✓ 3,000 or more sq. ft. (less than 4,000 sq. ft.)
- ✓ Total project Cost: **$42,675**
- ✓ Total NYSERDA incentive: $500
- ✓ Self-reported percent of residences square footage conditioned by the ASHP unit: **65%**
- ✓ NYSERDA whole-home solution? No
- ✓ Primary heating fuel: Natural Gas
- ✓ Primary heating system: Baseboard Heat
- ✓ Retrofit (building built 1921-1940)

Analysis

- ✓ **Example 1:** It cost over $21k to heat 50% of this less than 1,000 sq. ft. home
- ✓ **Example 2:** This project cost over $22k to heat 25% of this 1,000 – 1,500 sq. ft. home
- ✓ **Example 3:** This ASHP system cost over $37k to heat 50% of this 1,500 – 2,000 sq. ft. home
- ✓ **Example 4:** Heating 85% of this 2,500 – 3,000 sq. ft. home cost $39k
- ✓ **Example 5:** It cost nearly $30k to heat 40% of this 2,500 – 3,000 sq. ft. home
- ✓ **Example 6:** Heating 65% of this 3,000 – 4,000 sq. ft. home cost over $42k

Source: Diversified Energy Specialists Research & Analysis; NYSERDA

Key Takeaways

These programs are not working as intended and could be labeled a misuse of system benefit charge funds

- ✓ Only 0.005% of residences in New York converted to whole-home ASHP systems through the NYSERDA rebate program from 2017-2019
  - ✓ Most of the applications determined to be “whole-home” solutions were actually partial-home solutions. Most homes had an alternative heat source, which provided an unknown percentage of the annual heat load
  - ✓ Without program requirements mandating the removal of the household's legacy heat source, not allowing a supplementary heat source, or mandating metering of the ASHP systems’ usage, homeowners will continue to take advantage of ASHP rebate programs and install systems that are only used for air-conditioning
- ✓ Field studies show that homeowners are choosing to not use their ASHP systems to heat their home in the winter, regardless of the systems capacity. While an increasing amount of taxpayer and ratepayer dollars are being earmarked for ASHP programs each year, one must question whether this money is being misused
  - ✓ This consumer behavior could be due to:
    - ✓ The high cost of electricity on cold winter days
    - ✓ ASHP systems operability issues in cold temperatures, resulting in the inability to comfortably heat a home on cold winter days
    - ✓ ASHP installers recommending that homeowners retain their legacy heat source and use their legacy heat source when they want to stay warm in the winter
- ✓ Whole-home ASHP systems are expensive
- ✓ ASHP installations increase the winter grid load and winter peak load, which:
  - ✓ May Increase the cost of electricity for all ratepayers
  - ✓ Increases the amount of renewable electricity generation needed to meet the goal of zero-carbon electricity

Source: Diversified Energy Specialists Research & Analysis

Case Study

Massachusetts Air-Source Heat Pump Installations

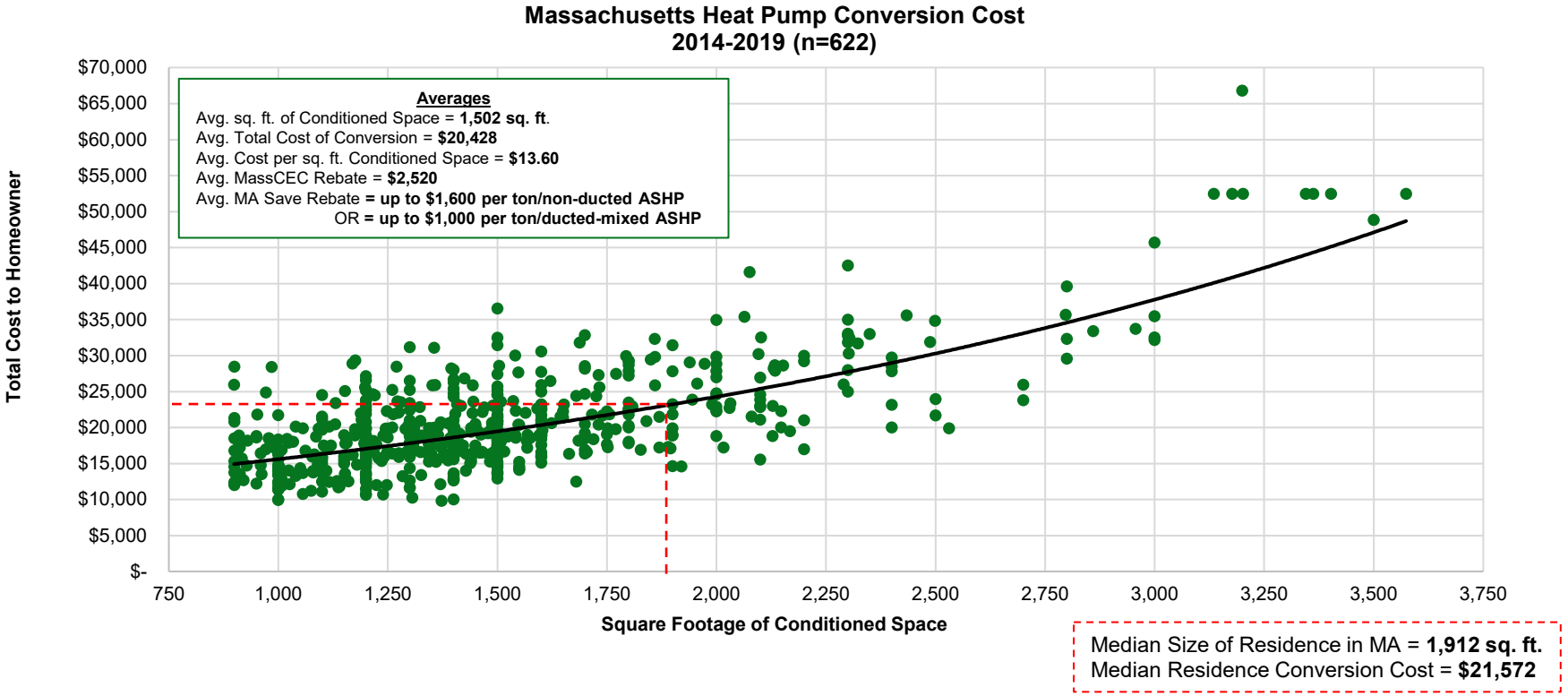
Report Prepared For:

EMPIRE STATE ENERGY ASSOCIATION
ESEA

September 28, 2021

Conversion: Cost – Massachusetts Rebate Program

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



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

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MassCEC Whole-Home Heat Pump Pilot: 2019-2021

The Massachusetts Clean Energy Center whole-home pilot program provided validation into previous cost studies on the installation of residential air-source heat pumps

Program Requirements

- ✓ May 2019 to June 2021
- ✓ The pilot program required that the air-source heat pump system must be capable of heating the entire home and be in use throughout the heating season
- ✓ For existing homes, the program only served installations displacing natural gas.
- ✓ For new construction, the homes could not include any fossil fuel appliances for other uses like hot water and cooking.

Project Type	Number of Projects in Pilot	Average Conditioned Sq. Ft. of Home	Median Project Cost
Existing Building	126	1,674	$20,000
New Construction	31	1,468	$14,000
Gut Rehab	11	1,173	$12,700
Total	**168**	**1,603**	**$18,400**

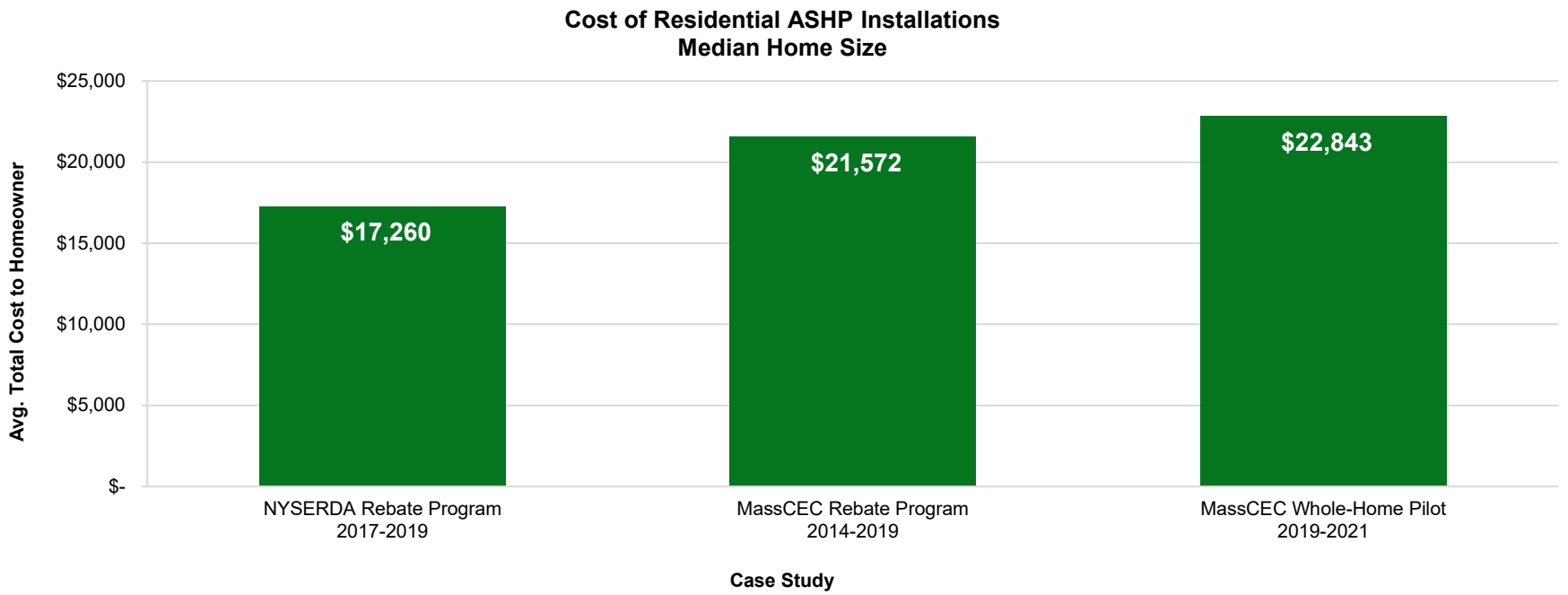
Program Conclusions

- ✓ The program director, Meg Howard, concluded:
  - ✓ **"Costs were higher than we hoped."**
  - ✓ "Of the retrofit projects in our pilot, **25% required an electric service upgrade**, while **38% reported that their natural gas heating system also provided their domestic hot water, which meant that homeowners either had to leave their natural gas boiler in place just to heat their hot water** or else buy a new hot water heater as part of the project."

Source: Diversified Energy Specialists Research & Analysis; MassCEC

Summary: Three Case Studies

The average cost of installing a residential air-source heat pump in all three case studies indicates that the electrification movement will face substantial challenges in the residential thermal sector



Median Size of Residence in MA = **1,912 sq. ft.**
Median Size of Residence in NY = **1,764 sq. ft.**

Source: Diversified Energy Specialists Research & Analysis

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Bioheat® Opportunity

Report Prepared For:

EMPIRE STATE ENERGY ASSOCIATION
ESEA

The materials contained in this document are intended for public distribution.

September 28, 2021

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

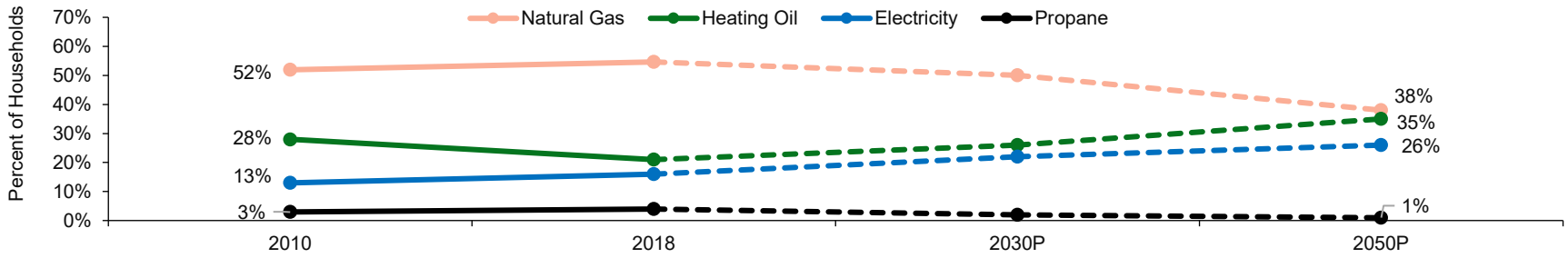
Bioheat® Opportunity

The heating oil industry can rebrand itself as the renewable fuels industry a secure a dominant position in the future energy landscape

Bioheat® Opportunity

- ✓ Increase market share
- ✓ Eliminate fossil fuels, while staying in business
- ✓ Fuel dealers must adapt and become climate change activists
- ✓ Bioheat® can assist states in meeting their 2030 and 2050 greenhouse gas reduction goals at a low cost
- ✓ Gain market share from propane and natural gas

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



Source: DES Research & Analysis

Bioheat® vs. Cold Climate ASHP's

Conversions to cold climate ASHP in New England will impact the price, reliability, and carbon intensity of electricity in the winter

	Bioheat®	Cold Climate ASHP
Pricing	✓ The cost of bioheat® in the winter will slightly exceed a cold climate ASHP system, but that may change due to added grid load	✓ The cost of a cold climate ASHP system historically has been lower than Bioheat®, but successful conversions could change that
Conversion Cost	✓ Bioheat® can reduce GHG emissions without any equipment changes	✓ The cost of converting a home to a cold climate ASHP system averages more than $20,000 per home
Storage	✓ Customers have an average of 15 days of storage in their homes. This will meet the unpredictable demand in cold winter months	✓ Electricity during peak winter loads could be unreliable if conversions to cold climate ASHP's are successful
Current Potential GHG Reduction	✓ Bioheat® can reduce GHG emissions immediately and at a low cost	✓ The cost of reducing GHG emissions from electricity requires a substantial capital investment and takes many years
Reliability / Ability to Heat Home	✓ Bioheat® can successfully and reliably heat a home in the coldest winter temperatures	✓ Cold climate ASHP's are not able to sufficiently heat a home in the coldest winter temperatures and requires a supplemental heat source
Consumer Behavior	✓ Consumers are open to the bioheat® story and prefer to reduce greenhouse gas emissions without facing higher costs	✓ Consumers are choosing not to retrofit their homes with ASHP systems. MA goal of 100k per year, less than 500 in 2020
Marketing / Lobbying	✓ The heating oil industry in the Northeast and is one of the most fragmented energy markets in the country. Marketing needs to reach end users, from their Bioheat® retailer, for true progress to be made. Adoption must start at the retailer level	✓ The Electricity industry is one of the most consolidated energy markets in the country. This consolidation of large companies allows a unifying message to both the public and policy levels

Source: DES Research & Analysis

How Should You Heat Your Home in the Northeast

The 'electrify everything' narrative is driving policy, but is it the best solution?

Renewable Liquid Heating Fuels

The truth of Bioheat®:

- Reduce GHG emissions by 66-82% vs. heating oil
- Displace heating oil
- Little additional cost vs. heating oil
- No equipment modifications necessary to heating oil systems up to a 50% blend
- Readily available
- Fast/widespread adoption – fossil fuel displacement
- Delivered by any retailer that blends to their thousands of residential customers immediately
- Delivered by local, family-owned businesses with 24/7 service
- Reduce GHG emissions to EJ communities – at 0 cost to them

Electrification

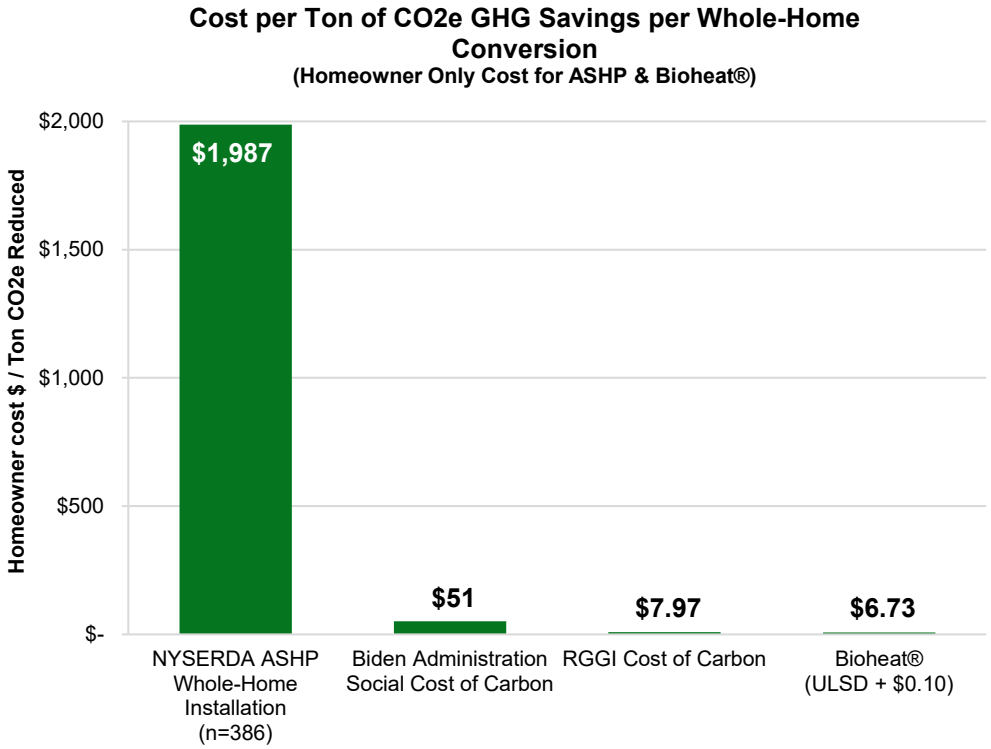
The fallacies of ASHPs:

- High cost of conversion
- Adoption increases the grid load, which:
  - Increases the price of electricity for all ratepayers
  - Increases the carbon intensity of electricity
  - Increases the amount of renewable electricity generation needed to reach a carbon neutral grid
- Need Supplementary heating source
- Adversely impact EJ Communities
- Achieving zero-carbon electricity much more difficult – pushing the goal posts
- Slow adoption / large capital expense / construction project at the individual household level
- Infrastructure upgrades required – T&D

Source: Diversified Energy Specialists Research & Analysis

The Cost of GHG Reduction

Does the homeowner cost per ton of carbon dioxide reduced justify these programs?



Assumptions

- ✓ Electric Grid: 1,433 lbs/MWh – or 420 lbs/MMBtu
  - ✓ Based on 2020 GREET natural gas as long-term marginal electric power and includes transmission and distribution losses
- ✓ Ultra-Low Sulfur Diesel (ULSD): 244 lbs/MMBtu
  - ✓ Based on 2020 GREET Model Calculations
- ✓ Average cost of whole-home conversion: $17,286
  - ✓ Based on median size residence in New York of 1,764 sq. ft.
- ✓ ULSD boiler average efficiency: 78%
- ✓ Heat pump efficiency: COP of 2.01 @ 5°F, COP of 2.47 @ 20°F , COP of 3.09 @ 40°F, and COP of 3.71 @ 60°F
- ✓ Annual Home Heating Load: 100 MMBtu
- ✓ Annual lifecycle GHG CO2e (HHV) emissions for heating one home in tons:
  - ✓ ULSD: 15.6 Tons of CO2e
  - ✓ Whole-home electric heat pump: 6.9 Tons of CO2e
- ✓ No supplemental or backup heat sources were considered
- ✓ Heating oil was used as the baseline fuel

Cost of Carbon

- ✓ Comparing the cost of CO2e reduction in the Regional Greenhouse Gas Initiative (RGGI) for the eastern states of the U.S. and President Biden's estimated social cost of carbon raise many questions about ASHP rebate programs
  - ✓ The Regional Greenhouse Gas Initiative is a cap-and-invest initiative that reduces CO2 emissions from the power Sector
    - ✓ The current market value (June 2021) of 1 Ton of CO2 in the RGGI is $7.97, or 0.4% of the cost of 1 Ton of CO2 reduction in NYSERDA's ASHP rebate program
  - ✓ President Biden directed his team to assess the social cost of carbon. The team put a number on how much damage a metric ton of carbon dioxide emitted today will do in the future, in order to show how much a given climate policy would benefit the economy in the long run
    - ✓ On February 26, 2021, the Biden administration announced an initial estimate of $51.00 per ton of carbon, or 2.6% of the cost of the NYSERDA program

Source: Diversified Energy Specialists Research & Analysis, GREET, NORA, Wired

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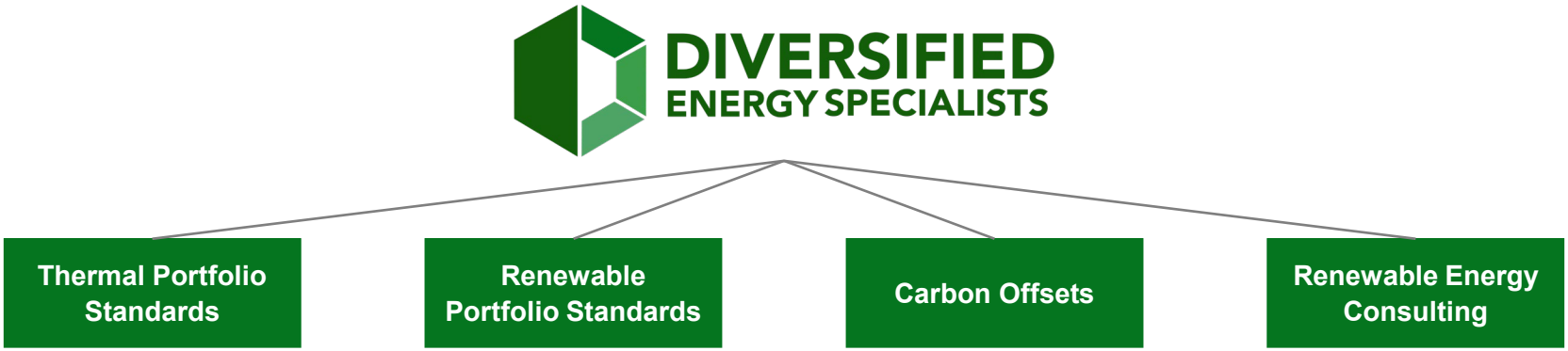
Background & Contact Information



Diversified Energy Specialists

- ✓ Renewable energy consulting
  - ✓ Thermal technologies
  - ✓ Greenhouse gas emissions reduction
  - ✓ Cap-and-trade programs
  - ✓ Rebate programs
- ✓ Environmental markets trading
  - ✓ Renewable portfolio standards
  - ✓ Thermal portfolio standards
  - ✓ Low-carbon fuel standards
- ✓ Carbon offsets
  - ✓ Purchasing
    - ✓ Procurement
    - ✓ Aggregation

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