

# One City: Built to Last

**Promoting Air Source Heat Pumps in  
New York City**

**Aaron Ordower  
NYC Mayor's Office of Sustainability**

**October 4, 2018**



**Mayor's Office of  
Sustainability**



New York City  
has committed  
to reduce  
greenhouse gas  
emissions by  
**80% by  
2050**  
(80 x 50)

# New York State: Reforming the Energy Vision



**40% reduction**

in greenhouse gas emissions from 1990 levels by 2030



**50% electricity**

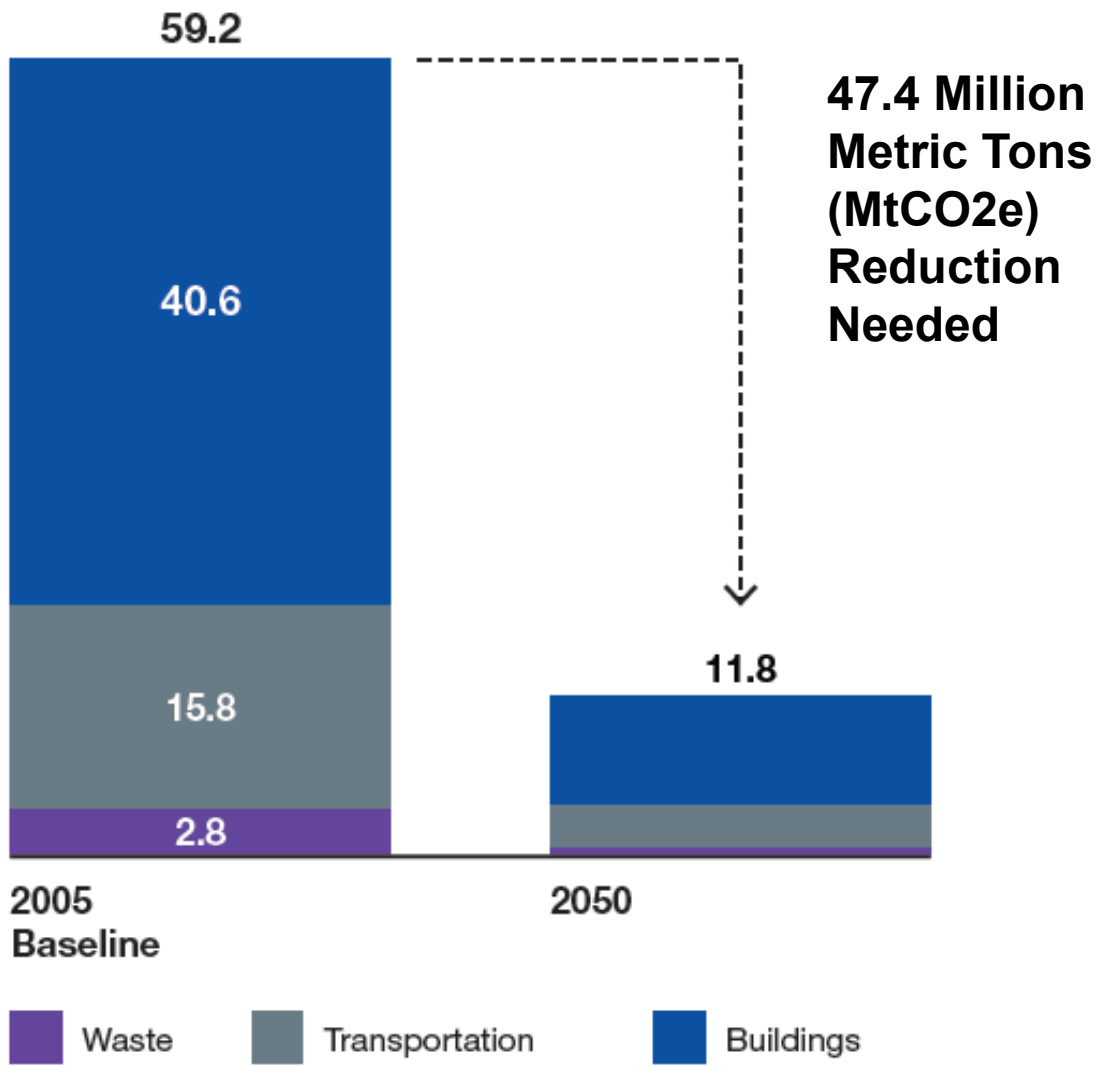
consumed must come from renewable energy resources by 2030



**600 trillion Btu increase**

in statewide energy efficiency compared to  
forecasted primary energy use in 2030

# New York City's 80 x 50 Commitment

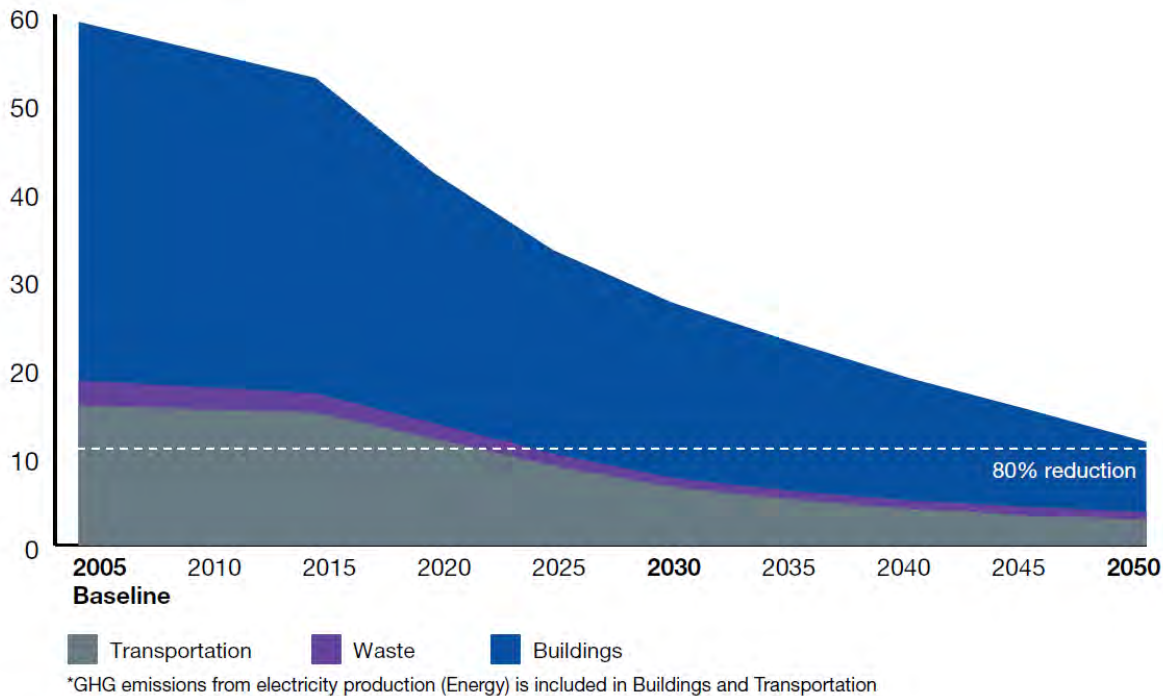


\*GHG emissions from electricity production (Energy) is included in Buildings and Transportation

# Getting to 80 x 50

Achieving 80 x 50 will require aggressive movement on all strategies across energy supply, buildings, transportation, and waste.

## A Roadmap to 80 x 50 (MtCO<sub>2</sub>e)



## GHG Emissions Reductions Relative to 2005

	2030	2050
<b>Buildings</b>	-52%	-82%
<b>Transportation</b>	-58%	-82%
<b>Waste</b>	-64%	-68%
<b>Total</b>	<b>-54%</b>	<b>-80%</b>

### Full Suite of Strategies Include:

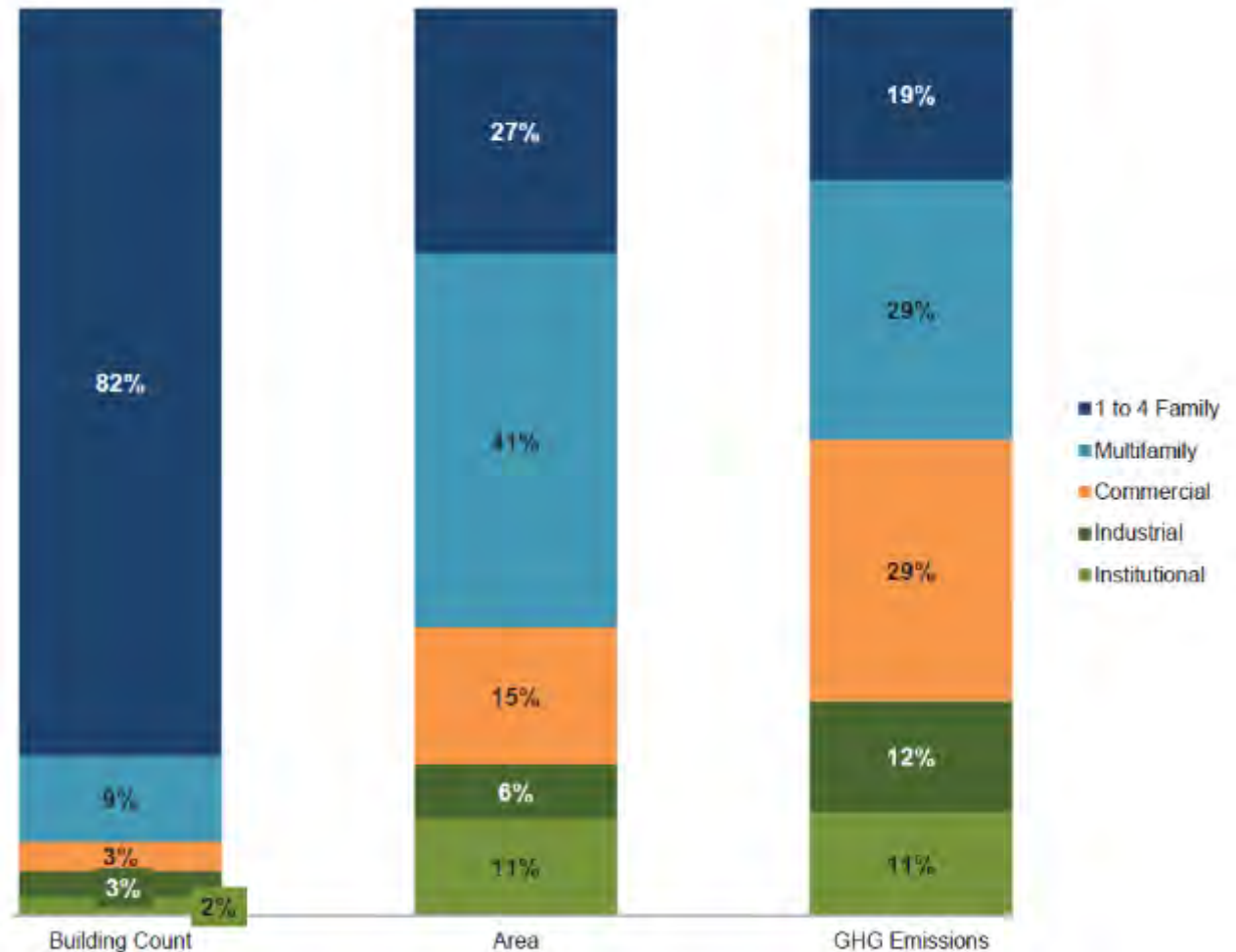
- 70-80% renewables-based electric grid
- Deep energy retrofits in 100% of buildings, with 50-60% implementing high efficiency electric heating systems
- Install roughly 7 GW of distributed solar PV

# Key Findings about Building Energy Use

Building Uses by Building Count, Floor Area, and GHG Emissions

**Greatest absolute number of buildings:** 1-4 family homes

**Greatest share of GHG emissions:** Commercial and multifamily buildings

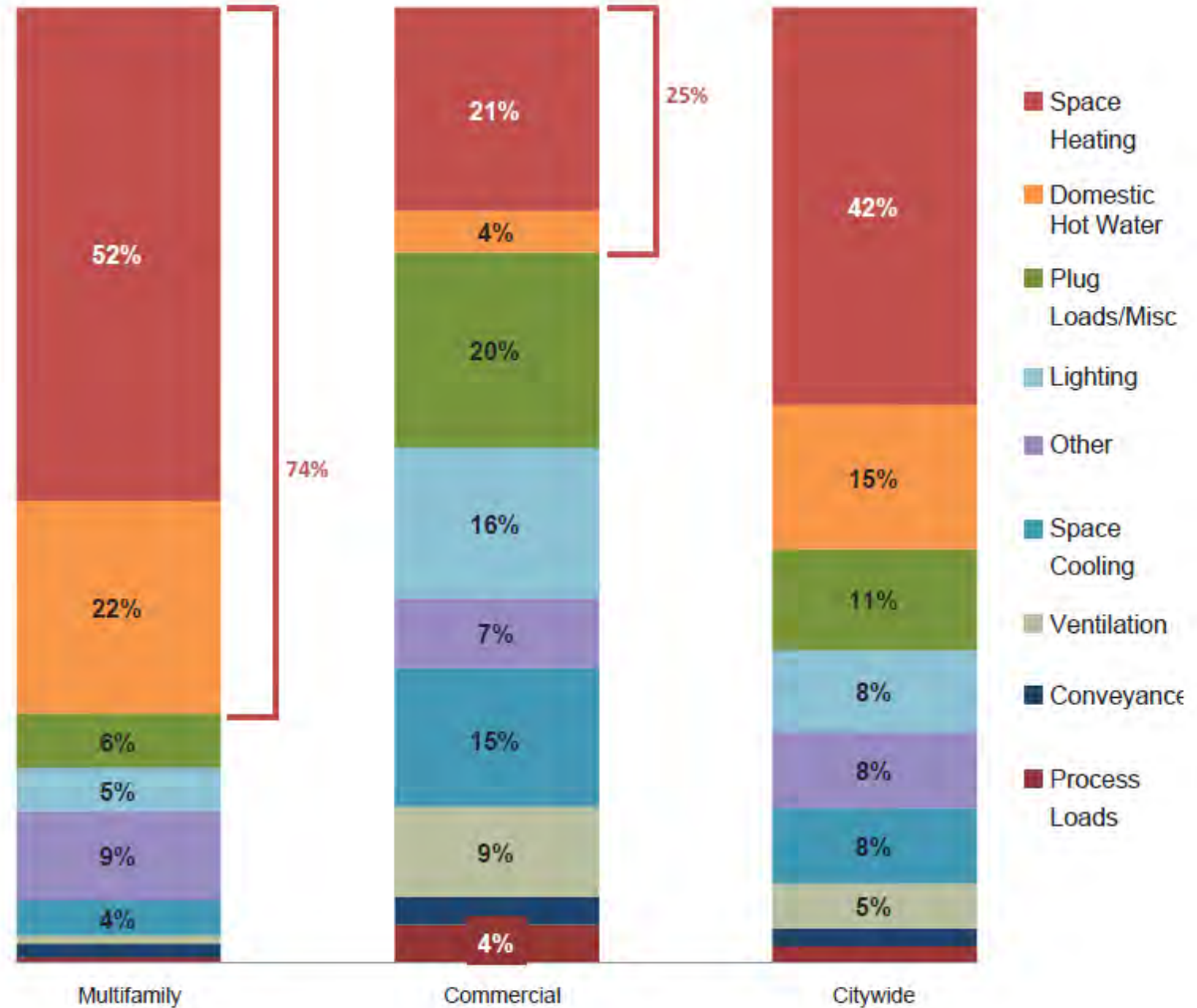


Source: PLUTO and 2015 GHG Inventory

# Key Findings about Building Energy Use

The energy used for **space heating** and **domestic hot water (DHW) production** accounts for the majority of building-based emissions

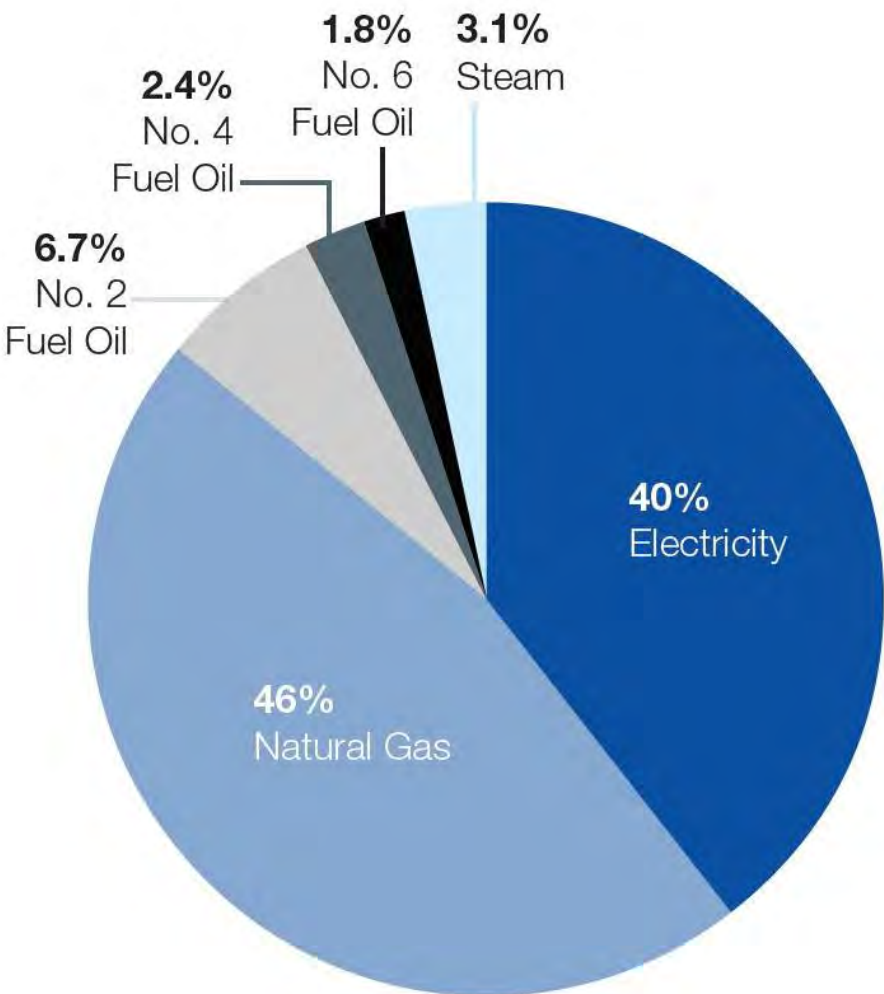
## Building GHG Emissions by End Use



# Building Energy Use by Fuel Type

**Fossil fuels dominate** energy use and GHG emissions from New York City's buildings.

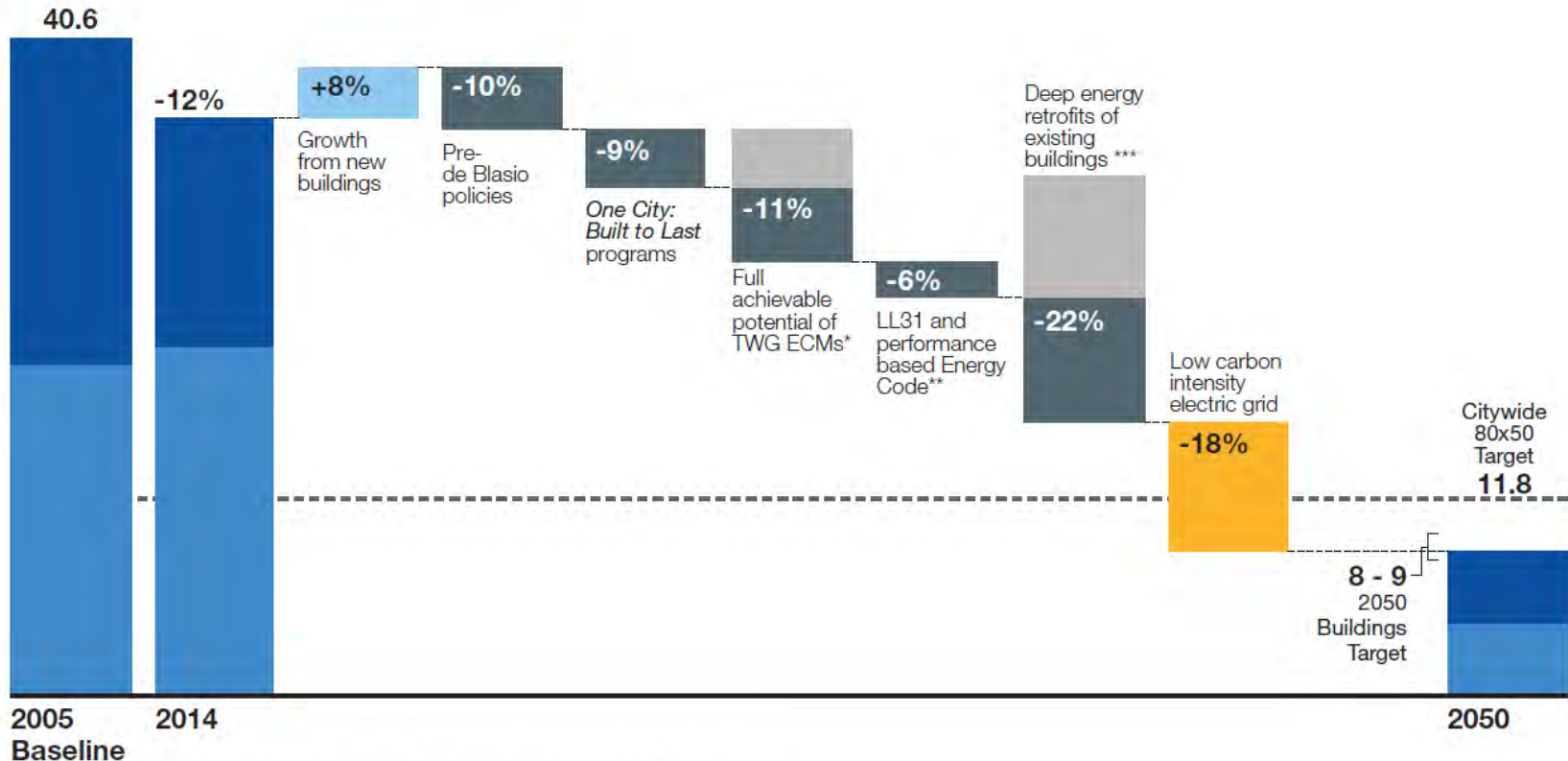
Sources of NYC Building-based Emissions by Fuel Type





# A Buildings Pathway to 80 x 50

Nearly every building will need to complete a deep energy retrofit, and many will need to move away from fossil fuel-based heating and hot water systems.



All percent reductions are relative to the 2005 Buildings emissions baseline

- Electricity
- Other Fuels
- One City Built to Last* Overlap

- \* Full implementation of TWG ECMs includes 100% overlap with *One City: Built to Last* initiatives
- \*\* Assumes a 50% reduction from ASHRAE 2013 standards for new construction and substantial renovations in public buildings beginning in 2017, and a 70% reduction from ASHRAE 2013 standards implemented in 2022 for both public and private buildings.
- \*\*\*Includes 100% overlap with *One City Built to Last* initiatives and TWG ECMs. 50-60% of buildings implement strategies that include high efficiency electric technologies for heat and hot water.

# Deep Energy Retrofit Paths

Models of deep energy retrofit paths show that **40-60 percent energy reductions are possible using existing technologies and strategies.**

## Eight Key Building Typologies



Commercial,  
Pre-war,  
≤ 7 Stories

Citywide Building Area: 2.7%  
Citywide Building-based GHG: 5.4%



1-4  
Family  
Home

Citywide Building Area: 25.7%  
Citywide Building-based GHG: 18.9%



Commercial,  
Pre-war,  
> 7 Stories

Citywide Building Area: 2.7%  
Citywide Building-based GHG: 5.5%



Multifamily,  
Pre-war,  
≤ 7 Stories

Citywide Building Area: 15.8%  
Citywide Building-based GHG: 11.5%



Commercial,  
Post-war,  
> 7 Stories

Citywide Building Area: 0.7%  
Citywide Building-based GHG: 1.3%



Multifamily,  
Post-war,  
> 7 Stories

Citywide Building Area: 5.9%  
Citywide Building-based GHG: 4.3%



Commercial,  
Very Large

Citywide Building Area: 5.9%  
Citywide Building-based GHG: 11.7%

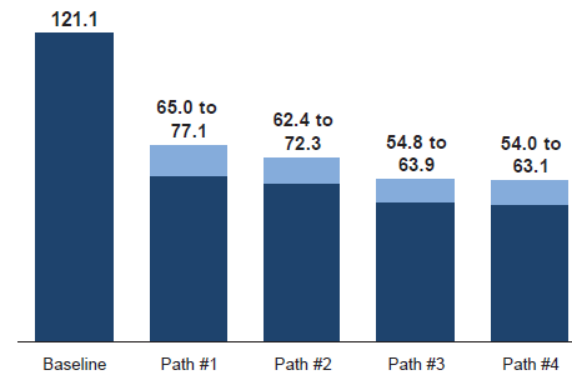


Multifamily,  
Post-1980,  
> 7 Stories

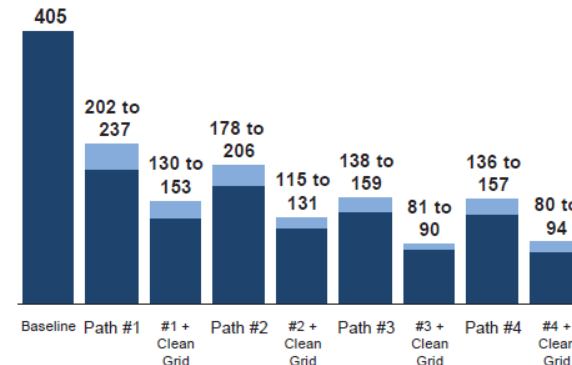
Citywide Building Area: 3.3%  
Citywide Building-based GHG: 2.4%

## Sample Deep Retrofit Path Results Multifamily, Post-War, > Seven Stories

Path Source EUI Reduction (kBtu/SF)



Path GHG Emissions Reduction (MtCO<sub>2</sub>e)



# Proposed Energy Performance Mandate

To accelerate the transition away from fossil fuels by 2030 or 2035 large and mid-sized buildings must:

- Comply with **on-site fossil fuel intensity caps**, at roughly the current median
- **Future whole building energy use intensity threshold**, to be determined with industry input

**7% citywide GHG reduction**

**Cleaner air**

**16% reduction in fossil fuel use**

**Lower energy costs**

**17,000 direct jobs created**

**Improved housing quality**



# New Efficiency: New York

2025 statewide energy  
efficiency target

# 185 TBtu

end-use savings  
in buildings  
and industrial sector

below 2025 forecast

delivering **nearly  
one-third**  
of the greenhouse gas  
emissions reductions  
needed to meet  
**40% reduction  
by 2030**

equivalent to fueling  
and powering more than  
**1.8 million  
New York  
homes** by 2025

2025 statewide electric  
efficiency target

# 30,000 GWh

end-use savings  
in buildings  
and industrial sector

below 2025 forecast

\$36.M in investments

Training for 19,500 workers

100,000 heat pump deployments by 2025

# New York City's Energy Efficiency Programs

The City has created a suite of programs to help decision-makers understand their buildings' energy use and make voluntary upgrades.





**Free, personalized advisory services** to streamline the process of making energy efficiency improvements

- Increase demand for efficiency upgrades
- Trusted advisor to buildings
- Unique insights into building needs
- Complement existing market resources



# Free Help. Simple Fixes. Big Results.

The NYC Retrofit Accelerator's Efficiency Advisors will:

- **Work with you one-on-one** to understand your needs
- **Connect you with qualified contractors** to do the job
- **Find cash incentives and financing** to help pay for your upgrades
- **Train your building staff** so your building continues to run efficiently
- Support you **every step of the way** from project start to finish

**GET IN TOUCH  
TODAY!**

[nyc.gov/RetrofitAccelerator](https://nyc.gov/RetrofitAccelerator)  
[info@nycretrofit.org](mailto:info@nycretrofit.org)  
212-656-9202



# The High Performance Retrofit Track

- Pilot deep energy retrofits in real buildings
- Create capital plans that integrate energy efficiency
- Provide free technical assistance through the Retrofit Accelerator
- Develop a pathway for implementation across larger portfolios







# Defining a High Performance Retrofit

- Deep energy retrofit that includes upgrades to all major systems
- Key Heating and DHW Strategies:
  - Optimization of existing distribution (including tenant engagement and O&M)
  - Hydronic Conversion
  - High Efficiency Electric Heating
  - High Efficiency Electric DHW
- Includes work on at least two major systems, starting within 2-3 years

# High Performance Track Services

- Create capital plans that integrate energy efficiency
- Identify high performance technologies
- Deploy intern capacity
- Train decision makers on high performance retrofits
- Support implementation of resident engagement





# Program Resources

- Deep Energy Retrofit Plan Analysis (DERPA) tool
- High Performance Technology Primers
- Participant Profiles
- Case Studies (e.g. Pursuing Passive)
- [nyc.gov/RetrofitAccelerator](https://nyc.gov/RetrofitAccelerator)

# High Performance Retrofit Track Participants



Memorial Sloan Kettering  
Cancer Center

# 1-4 Family Residential ASHP Program

- Planned NYC program to scale mini-splits in 1-4 family homes
- Preliminary analysis: 176,000 1-4 family homes identified as good candidates for ASHP
  - Largely Staten Island and the Bronx
  - Suitability based on owner-occupancy, building and fuel type



# Thank You

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[nyc.gov/retrofitaccelerator](http://nyc.gov/retrofitaccelerator)

[nyc.gov/twg](http://nyc.gov/twg)

[nyc.gov/80x50](http://nyc.gov/80x50)



**NYSERDA**

# **Clean Heating & Cooling Building Energy NYC**

October 4, 2018

Scott Smith

# Barriers to Clean Heating and Cooling Adoption

- **High first costs and insufficient return on the additional investment above the cost of a regular heating & cooling system**
- **Low fossil fuel costs**
- **Limited training available for installers, designers, architects, and engineers**
- **Lack of consumer knowledge and awareness**
- **Lack of affordable financing solutions**



# RH&C Policy Framework & Investment Plan

(Options to Advance Industry Growth and Markets in New York)

- **RH&C Policy Framework Published February 7, 2017**
  - Constitutes the first step in a longer-term effort to stimulate the RH&C market in New York State
  - It sets out options for policies and market-based strategies for the next few years and concepts for longer-term action
- **Policy Framework's Three Pillars**
  - Reducing Technology Costs and Lowering Barriers
  - Renewable Heating & Cooling Mandates
  - Incentives
- **Clean Energy Fund (CEF) Investment Plan, RH&C Chapter Approved May 8, 2017**
  - This first phase of RH&C initiatives under the CEF will advance timely interventions focusing on reducing soft costs
  - Over \$30 million being invested in this first phase to support ground source heat pump installations

# CH&C Programs Launched since June 2017

- **Air Source Heat Pumps (ASHP) Program [PON 3635 \$10.95M]**
  - NYSERDA will provide up to \$10.95 million in incentives to participating installers for the installation of program qualified ASHP systems in residential sites to include single-family and multifamily buildings through 2020. Incentives of \$500 per installed program qualified ASHP system are available only to participating installers on a first-come, first-served basis, up to \$500,000 per participating installer.
  - 198 Participating Installers
- **Ground Source Heat Pumps (GSHP) Rebate Program [PON 3620 \$15M]**
  - Offers \$15 million to support the installation of ground source heat pump systems at residential, commercial, institutional, and industrial buildings. Funding is available only to eligible designers and installers of renewable heating and cooling systems that have been approved by NYSERDA through June 2019.
  - 68 Participating installers
- **Clean Heating & Cooling Communities Campaigns [PON 3922 / \$2 Million available in second round, \$8 Million total investment]**
  - Support for communities to increase customer awareness of CH&C technologies, reduce installed costs, and jump-start the market by implementing multi-year campaigns consisting of community-based outreach and education focused on CH&C.
  - Retained consultant to provide technical assistance to communities
- **Geothermal Clean Energy Challenge [\$3.5 Million Available]**
  - NYSERDA and NYPA will identify the best candidates for large, multi-building geothermal ground-source heat pump installations by providing free technical assistance and financial support. Open only to qualified colleges and universities, K-12 schools, State and local governments, and hospitals in New York State.

# Round 1 CH&C Community Campaigns

- 8 community teams selected in Round 1 from across the state
  - Over 1.2 Million homes
  - 37% oil, propane, and electric heating
- Contracted with Cadmus to provide technical assistance to communities
- Contracted with Faraday to develop a customer targeting tool
- Contracted with KSV to develop marketing toolkit
- First campaigns beginning this fall

# Round 1 CH&C Community Campaigns



# Round 2 CH&C Community Campaigns

## PON 3922

- Category A: Community Campaign Proposal (required)
  - Multiple awards of up to \$200,000 each
- Category B: Workforce development and training Proposal (optional)
  - Multiple awards of up to \$50,000 each
- Category C: LMI household participation (optional)
  - More than one award of up to \$250,000
- Proposals due October 30<sup>th</sup>, 2018
- Really want to see proposals from NYC!

## CH&C Programs Launched since June 2017 cont.

- **Cooperative Advertising and Training for CH&C Partners [PON 3694 / \$2 Million]**
  - NYSERDA has made \$2 million available to support advertising, special promotions and/or events, including training, for eligible HVAC technologies. Incentives up to 50 percent of the total cost for educational and marketing promotion opportunities to eligible participants, such as HVAC manufacturers, HVAC distributors/vendors and HVAC installers participating in PON 3653: Air-Source Heat Pump Program, PON 3620: Ground-Source Heat Pump Rebate or Renewable Heat New York
- **NEXTGEN HVAC Technology Challenges [PON 3519 / \$15 Million Available in 4 Rounds]**
  - Several heat pump related categories
- **Financing Solutions**
  - Conduct financial solutions market research for CH&C technologies (focus in financing and investing)
  - Federal tax credit of 30% residential and 10% commercial for geothermal installations reinstated
  - Green Jobs Green NY Loan Program now available to eligible GSHP installers
- **Marketing & Outreach**
  - Developing clean heating & cooling messaging with marketing consultants KSV
  - Developing customer targeting tool to identify high potential customers

## Performance Validation and Demonstration Projects

- Ground Source Heat Pumps
  - ~50 existing residential systems statewide
  - ~45 additional residential systems on Long Island
- Air Source Heat Pumps
  - 20 residential replacements in Brooklyn and Queens
  - 20 residential displacements in the Hudson Valley

## Performance Validation and Demonstration Projects

- Air Source Heat Pumps (Cont.)
  - 5 residential air to water systems in Tompkins County
  - 5 residential low capacity gas furnace/ASHP hybrids in Central NY
  - 2 VRF systems
    - One commercial in Westchester
    - One Multifamily building in NYC



# Performance Validation and Demonstration Projects

- Goals:
  - Determine what information the market needs on technical and economic performance
  - Collect performance information that can be communicated accurately and confidently
  - Disseminate the information to the market and make data available to create change

# Thank You

**Scott Smith**

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**518-862-1090 ext. 3344**



# DOWNSTATE AIR SOURCE HEAT PUMP DEMONSTRATION

THE LEVY PARTNERSHIP  
CENTSIBLE HOUSE

BUILDING ENERGY NYC - OCTOBER 4, 2018

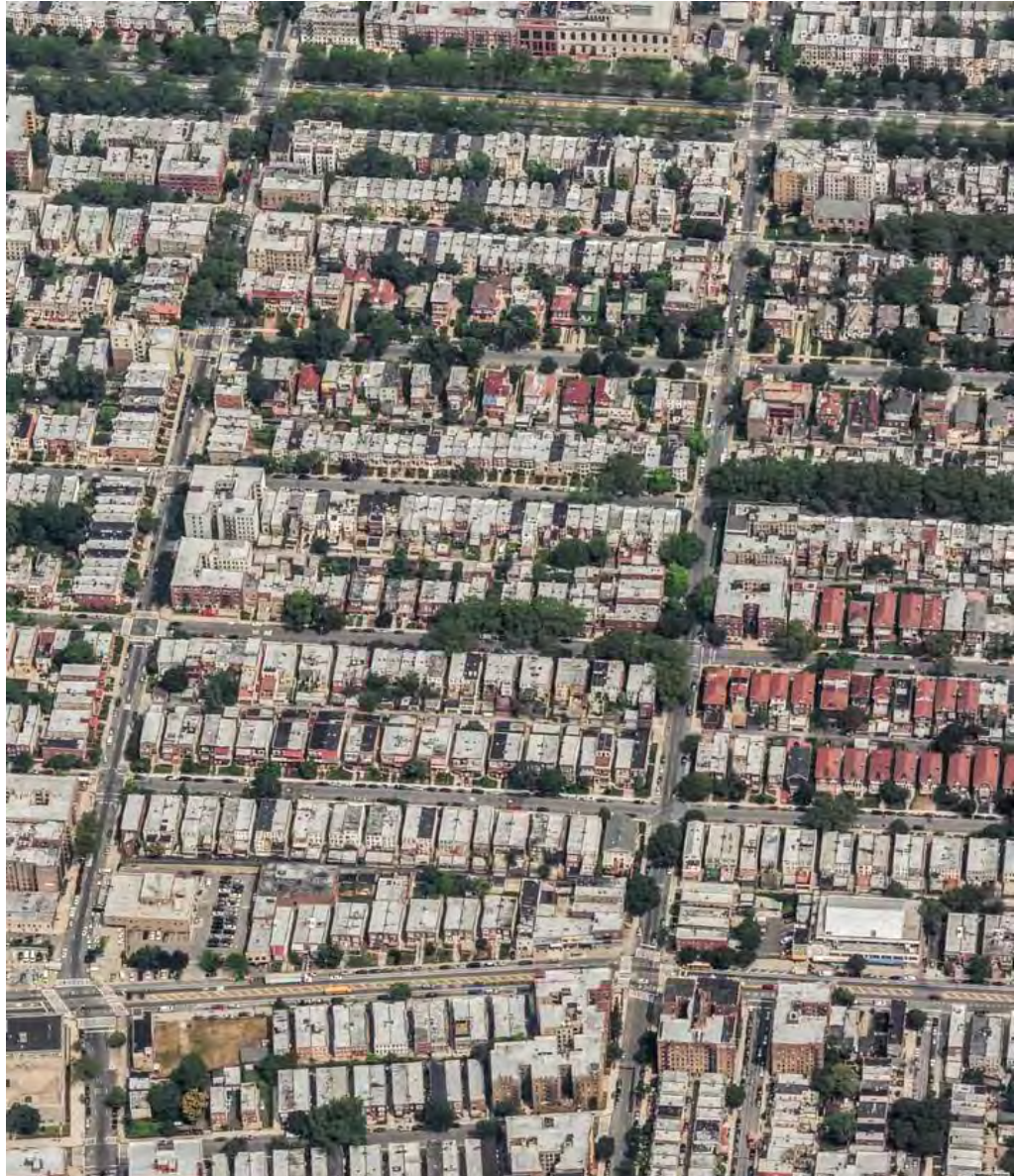


# DOWNSTATE DEMO

- 20 Sites
- Brooklyn, Queens, Bronx, Yonkers

## **Goals:**

- Understand and demonstrate viability costs and savings
- Increase awareness, and confidence
- Market exposure
- Provide resources for NYSERDA to promote benefits





# RETROFIT SCOPE

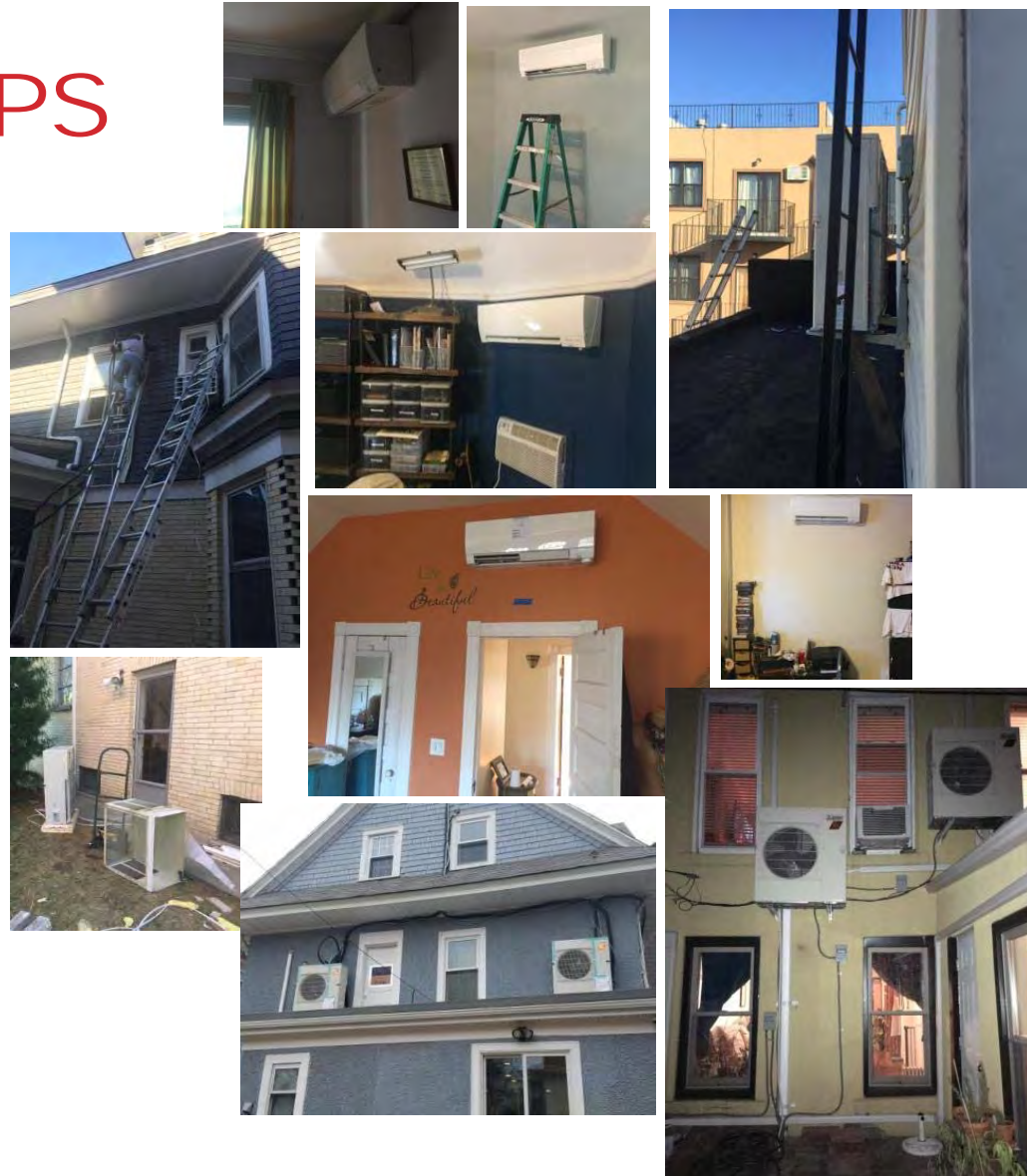
- Full boiler replacement
- Some weatherization
- Low-ambient equipment (NEEP cold climate air source heat pump listing)



# HEAT PUMPS

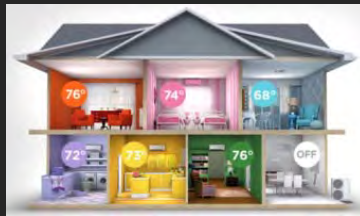
- 3-4 condensing units
- 6-12 air handlers
- Wall mounted mini and multi-splits
- A few ducted units
- Mostly Mitsubishi/Fujitsu equipment

Mitsubishi	Fujitsu
Outdoor unit	Outdoor unit
MXZ3C24NAHZ	AOU12RLS3H
MXZ4C36NAHZ	AOU18RLXFZH
MXZ3C30NAHZ	AOU24RLXFZH
MXZ5C42NAHZ	AOU36RLXFZH
MXZ4C36NAHZ	AOU36RLAVM
Indoor units	Indoor units
MSZFH06NA	ASU7RLP1
MSZFH09NA	ASU9RLP1
MSZFH12NA	ASU12RLP1
MSZFH15NA	ASU18RLP1
MSZFH18NA	ASU24RLP1



# ECONOMICS

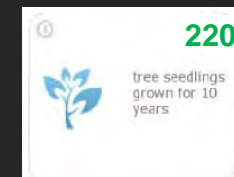
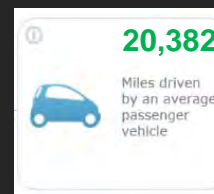
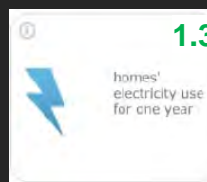
- \$15,000 to \$50,000 project value
- Up to \$8,000 in incentives/discounts/rebates special to demo
- Energy savings: slightly negative up to \$2,795
- Reason for purchase – increase home value, “central” cooling and solve poor heating distribution issues



## INCREASED COMFORT

## PREMIUM VALUE

- A comprehensive approach to improve energy efficiency returns more sustainable benefits.
- Able to set room temperature individually.
- Homes with central AC and improved air sealing and insulation have attractive payback during resale, Benefits could range from high retention of investment value to increased equity.







# SITE 3

## Envelope Improvements

Envelope Improvement	Details
Air sealing	Reduce overall air leakage of heated area by 43%, from 15,731 CFM50 to 9,000 CFM50
Rim joist insulation	Upgrade 180 sqft of rim joist to 2" High Density Foam, 0.5" wood siding, R-15
Attic knee wall insulation	Upgrade 703 sqft of wall to gyp board 2x4 24" OC, 1" fiberglass, 2" air, Steel R-5

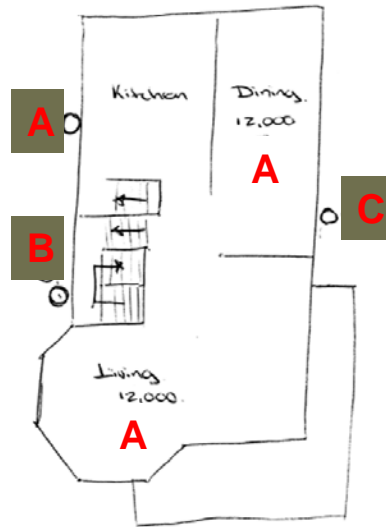
## Costs

Item	Cost
Heat pump equipment (7 zones)	11,156
Heat pump labor	13,500
Total heat pump	24,656
Cost per ton	4,086
Cost per zone	3,522
Envelope materials + labor	12,992
<b>Total job</b>	<b>37,648</b>

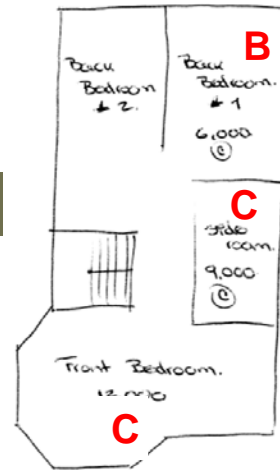


# SITE 3

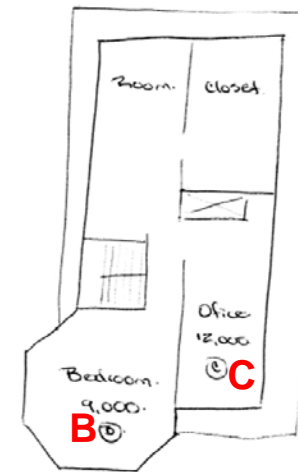
Floor	Room	Outdoor unit			Indoor units		
		Model	Cooling	Heating	Model	Cooling	Heating
1st	Living Room	MXZ-3C24NAHZ	22,000	25,000	MSZ-FH12NA	12,000	13,600
	Dining Bedroom				MSZ-FH09NA	12,000	13,600
	<b>Total</b>				<b>Indoor unit total</b>	<b>24,000</b>	<b>27,200</b>
Attic	Front Room	MXZ-3C24NAHZ	22,000	25,000	MSZ-FH12NA	12,000	13,600
2nd	Back Bedroom				MSZ-FH06NA	6,000	8,700
<b>Total</b>	<b>Total</b>				<b>Indoor unit total</b>	<b>18,000</b>	<b>22,300</b>
2nd	Front Bedroom	MXZ-3C30NAHZ	28,400	28,600	MSZ-FH12NA	9,000	10,900
Attic	Office				MSZ-FH12NA	12,000	13,600
2nd	Side Bedroom				MSZ-FH09NA	9,000	10,900
<b>Total</b>	<b>Total</b>				<b>Indoor unit total</b>	<b>30,000</b>	<b>35,400</b>
Total Cap Outdoor			<b>72,400</b>	<b>78,600</b>			
RHVAC load calc			<b>82,230</b>	<b>99,462</b>			



1st Floor

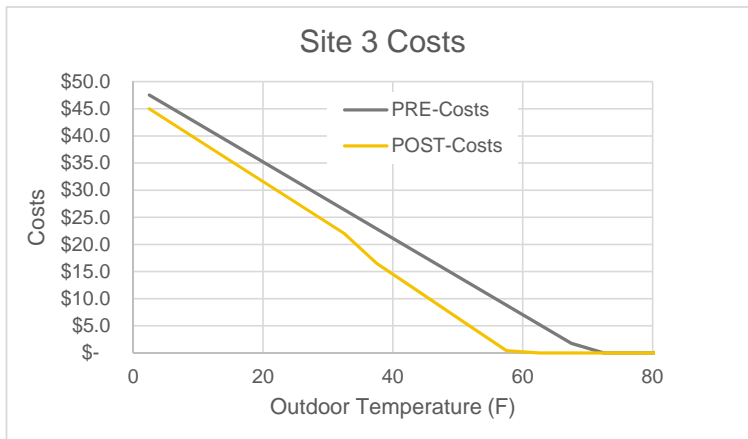
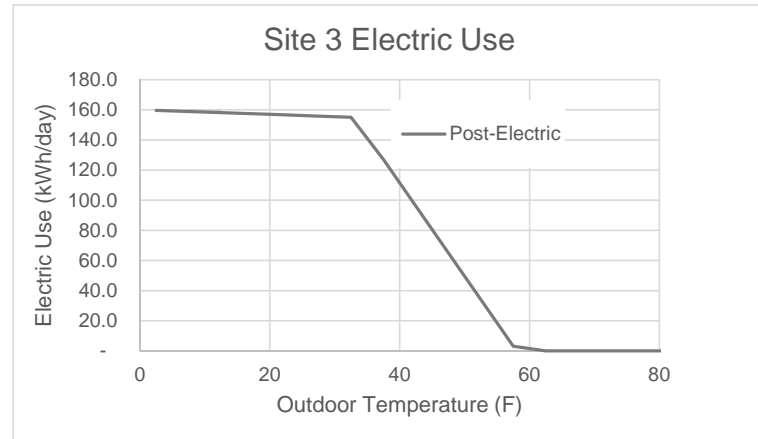
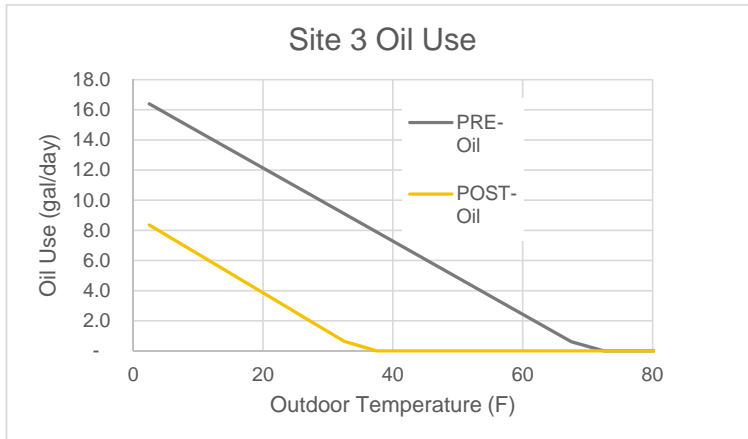


2nd Floor



Attic

# SITE 3



	PRE	POST	Savings
<b>Costs</b>	\$4,475	\$2,882	\$1,594
<b>Oil (Gal/yr)</b>	1,543	114	1,429
<b>Electric (kWh/yr)</b>		19,619	
<b>Implied COP</b>			2.5

# SITE 5

## Envelope Improvements

Envelope Improvement	Details
Air sealing	Reduce overall air leakage of heated area from 2 ACH to 0.75 ACH
Rim joist insulation	Upgrade 136 square feet of existing rim joist to 2" High Density Foam, 1.5" Wood, 0.5" Wood, Siding, R-15

## Costs

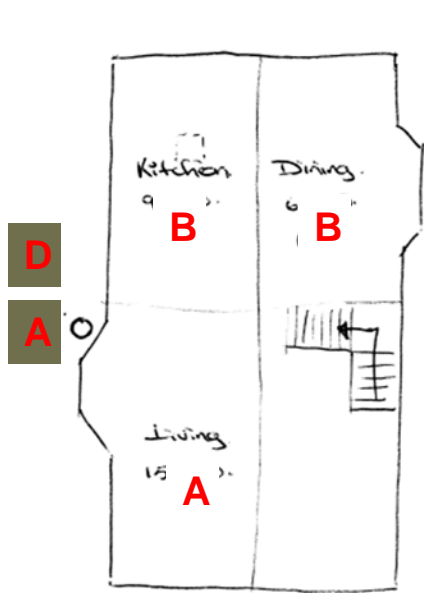
Item	Cost
<b>Total job (10 zones)</b>	57,690



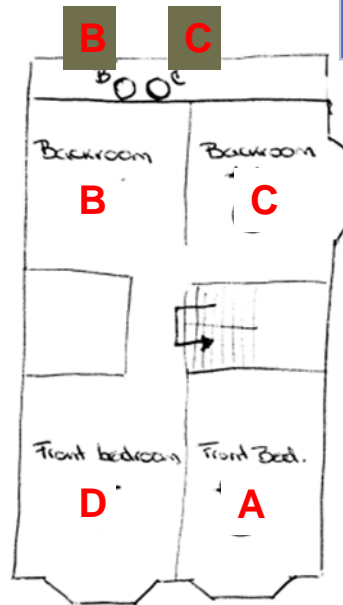
# SITE 5

Floor	Room	Outdoor unit			Indoor units		
		Model	Cooling	Heating	Model	Cooling	Heating
1st	Living Room	MXZ-3C24NAHZ2 A			MSZ-FH15NA	15,000	18,000
2nd	Front Bedroom 1				MSZ-FH06NA	6,000	8,700
	<b>Total</b>			22,000	25,000	<b>Indoor unit total</b>	<b>21,000</b>
1st	Dining Room	MXZ-3C24NAHZ2 B			MSZ-FH06NA	6,000	8,700
	Kitchen				SLZ-KA09NAR1.TH	9,000	10,900
2nd	Back Bedroom 2				MSZ-FH06NA	6,000	8,700
	<b>Total</b>		22,000	25,000	<b>Indoor unit total</b>	<b>21,000</b>	<b>28,300</b>
2nd	Back Bedroom 1	MXZ-3C24NAHZ2 C			MSZ-FH06NA	6,000	8,700
Attic	Back Bedroom-1				MSZ-FH06NA	6,000	8,700
	Back Bedroom 2				MSZ-FH06NA	6,000	8,700
	<b>Total</b>		22,000	25,000	<b>Indoor unit total</b>	<b>18,000</b>	<b>26,100</b>
Attic	Front Room	MXZ-3C24NAHZ2 D			MSZ-FH09NA	9,000	10,900
2nd	Front Bedroom 2				MSZ-FH06NA	6,000	8,700
	<b>Total</b>		22,000	25,000	<b>Indoor unit total</b>	<b>15,000</b>	<b>19,600</b>

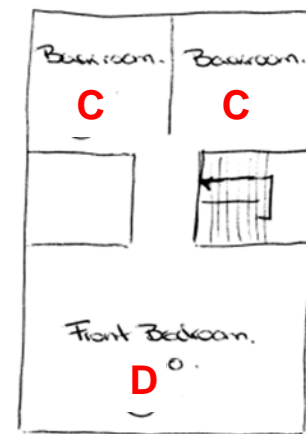
Total capacity		Calculated loads	
Cooling	Heating	Cooling	Heating
88,000	100,000	67,176	80,226



1st Floor.

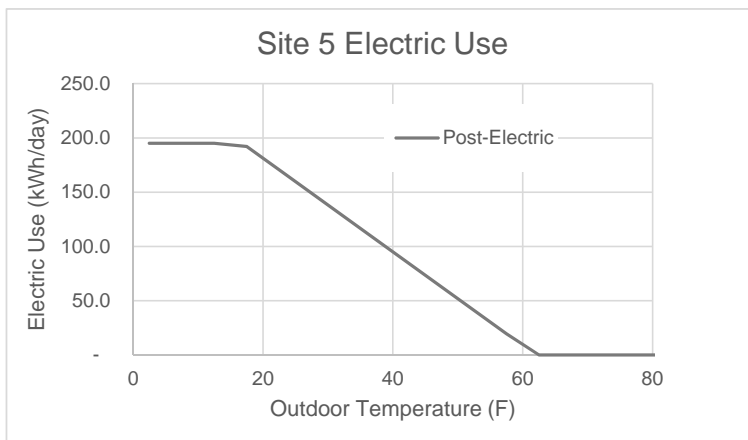
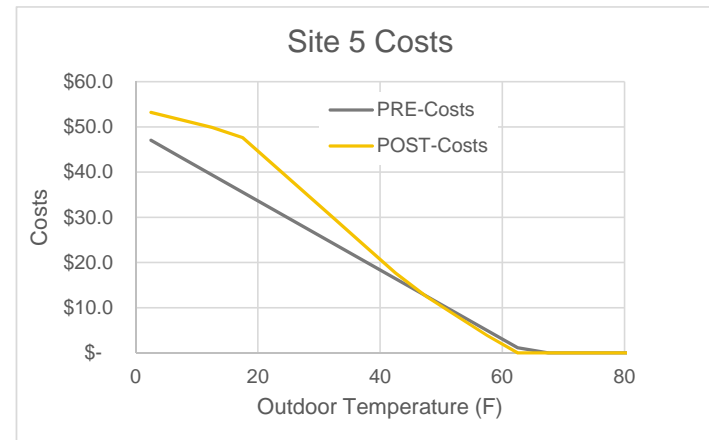
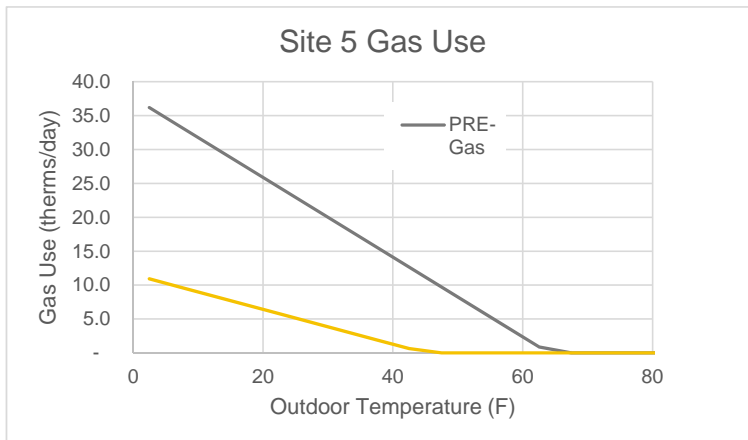


2nd Floor.



Attic.

# SITE 5



	PRE	POST	Savings
<b>Costs</b>	\$3,674	\$4,189	\$(514)
<b>Gas (therms/yr)</b>	2,826	358	2,468
<b>Electric (kWh/yr)</b>		18,616	
<b>Implied COP</b>			3.1

# SITE 10

## Envelope Improvements

Envelope Improvement	Details
Air Sealing	Reduce overall air leakage of heated area from 1.75 ACH to 1.25ACH.
Rim Joist	Upgrade 180 square feet of existing rim joist to 2" High Density Foam, 1.5" Wood, 0.5" Wood Siding, R-15
Second floor attic insulation	Upgrade 320 square feet of existing ceiling to Gyp Bd, 2x6 16" OC, 6" cellulose, R-19

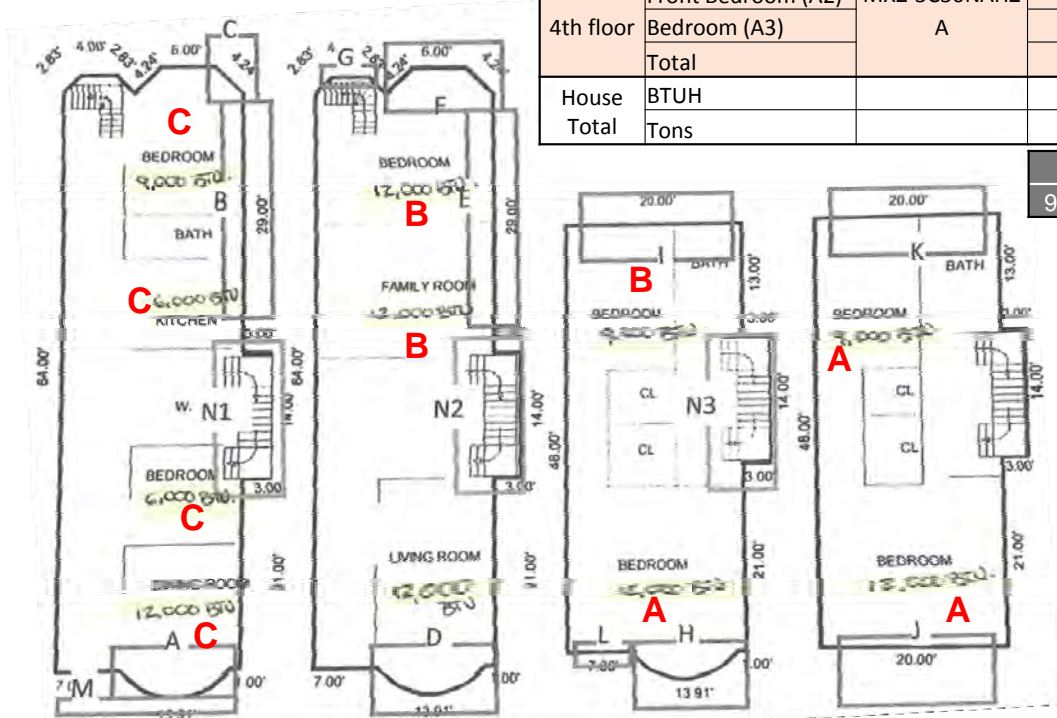
## Costs

Item	Cost
Heat pump equipment (10 zones)	10,783
Heat pump labor	25,000
Total heat pump	35,783
Cost per ton	4,647
Cost per zone	3,578
Envelope materials + labor	10,736
<b>Total job</b>	<b>46,519</b>





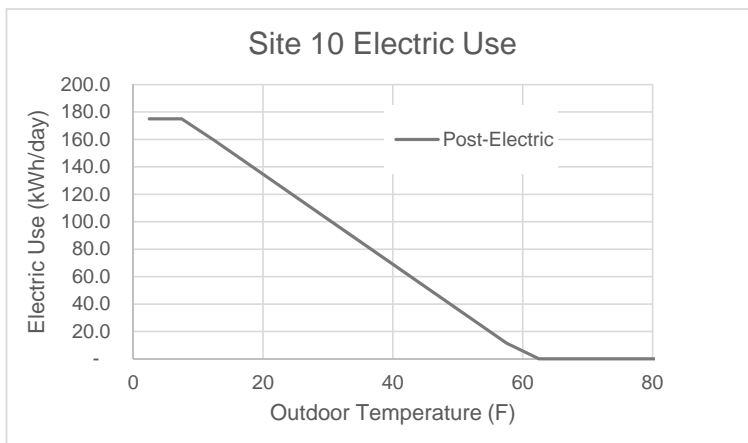
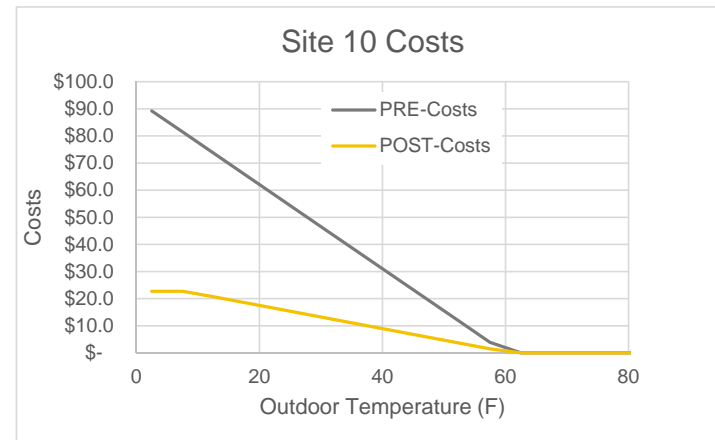
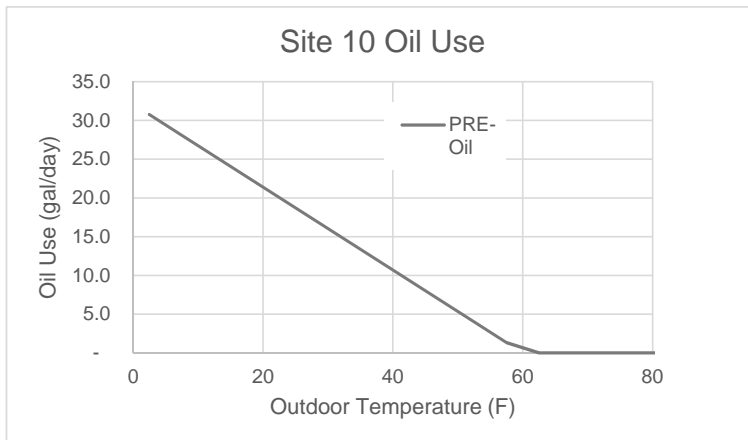
# SITE 10



		Equipment Selection					
		Outdoor unit			Indoor units		
Floor	Room	Model	Cooling	Heating	Model	Cooling	Heating
1st floor	Living Room (C1)	MXZ-4C36NAHZ C			MSZ-FH12NA	12,000	10,900
	Bedroom (C2)		MSZ-FH06NA	6,000	8,700		
	Kitchen (C3)		MSZ-FH06NA	6,000	8,700		
	Back Bedroom (C4)		MSZ-FH09NA	9,000	10,900		
	<b>Total</b>		<b>36,000</b>	<b>45,000</b>	<b>total</b>	<b>33,000</b>	<b>39,200</b>
2nd floor	Dining/Kitchen (B1)	MXZ-3C30NAHZ			MSZ-FH15NA	15,000	12,900
	Back Bedroom (B2)		MSZ-FH12NA	9,000	7,900		
3rd Floor	Bedroom (B3)	B			MSZ-FH09NA	9,000	7,900
	<b>Total</b>		<b>28,400</b>	<b>28,600</b>	<b>total</b>	<b>33,000</b>	<b>28,700</b>
3rd Floor	Front Bedroom (A1)	MXZ-3C30NAHZ A			MSZ-FH12NA	12,000	13,600
	Front Bedroom (A2)		MSZ-FH12NA	12,000	13,600		
4th floor	Bedroom (A3)		MSZ-FH09NA	9,000	10,900		
	<b>Total</b>	<b>28,400</b>	<b>28,600</b>	<b>total</b>	<b>33,000</b>	<b>38,100</b>	
House	BTUH		92,800	102,200		99,000	106,000
Total	Tons		7.7	8.5		8.3	8.8

Loads	
93,273	110,633

# SITE 10



	PRE	POST	Savings
<b>Costs</b>	\$6,055	\$1,758	\$4,297
<b>Oil (Gal/yr)</b>	2,088		2,088
<b>Electric (kWh/yr)</b>		13,521	
<b>Implied COP</b>			5.3

# SITE 12

## Envelope Improvements

Envelope Improvement	Details
Exterior wall insulation	Upgrade 1,160 sqft, from interior, to Gyp Bd, 2x4 16" OC, 3.5" cellulose, 0.75" wood, 4" brick, R-13
Air sealing	Reduce overall air leakage of the heated area from 5,789 CFM50 to 4,300 CFM50

## Costs

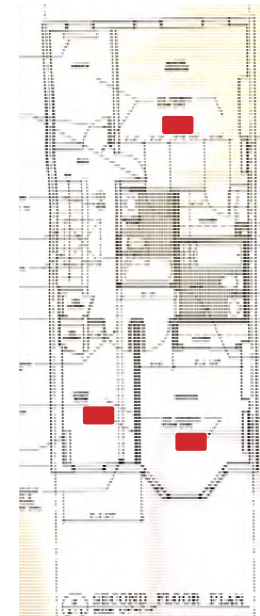
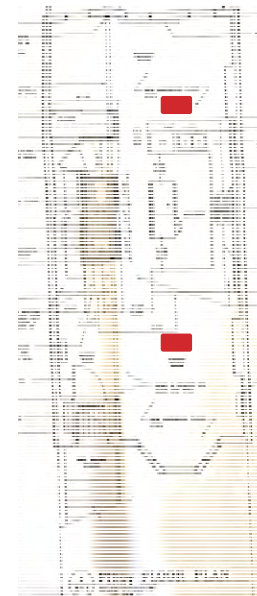
Item	Cost
Heat pump equipment (8 zones)	12,687
Heat pump labor	15,500
Total heat pump	28,187
Cost per ton	4,271
Cost per zone	3,523
Envelope materials + labor	18,943
<b>Total job</b>	<b>47,130</b>



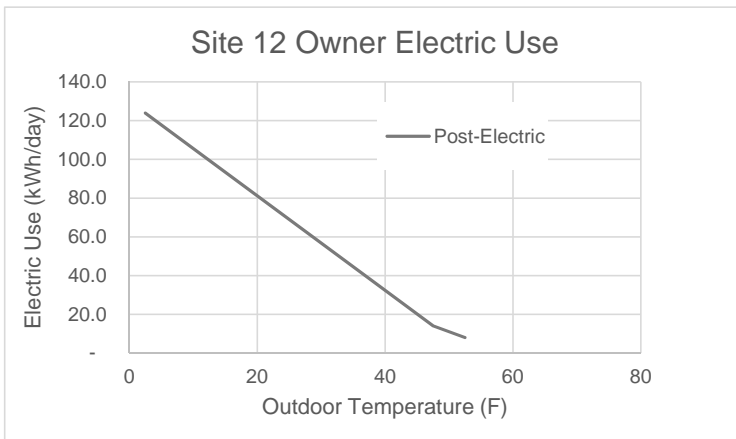
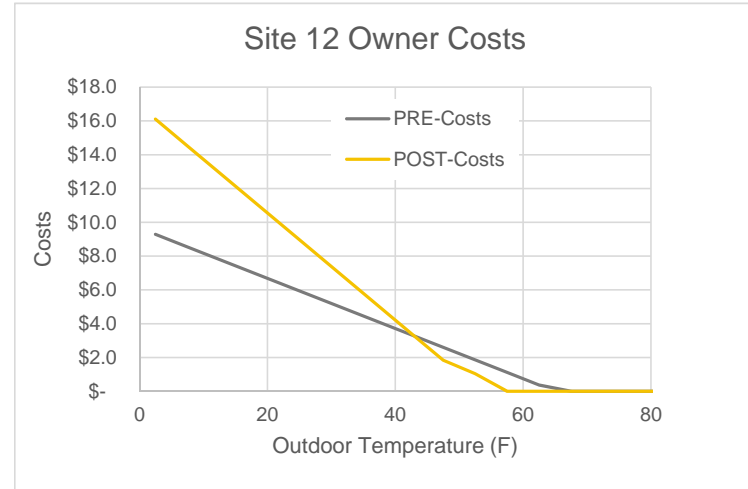
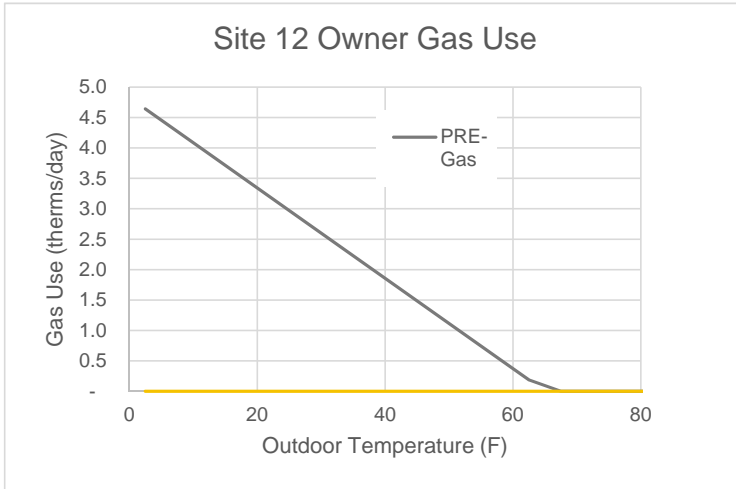
# SITE 12

Floor	Room	Outdoor unit			Indoor units		
		Model	Cooling	Heating	Model	Cooling	Heating
Ground floor	Living Room	MXZ-5C30NAHZ			MSZ-FH12NA	12,000	13,600
	Main Bedroom				MSZ-FH09NA	9,000	10,900
	Baby Bedroom				MSZ-FH06NA	6,000	8,700
	total		28,400	28,600	<b>Indoor unit total</b>	<b>27,000</b>	<b>33,200</b>
2nd	Kitchen-Dining	MXZ-3C24NAHZ2			MSZ-FH15NA	15,000	18,000
3rd	Front Room 2				MSZ-FH09NA	9,000	10,900
			<b>22,000</b>	<b>25,000</b>	<b>Indoor unit total</b>	<b>24,000</b>	<b>28,900</b>
3rd	Front Room 1	MXZ-4C30NAHZ			MSZ-FH06NA	6,000	8,700
	Office				MSZ-FH06NA	6,000	8,700
	Back Room+Bathroom				MSZ-FH12NA	12,000	13,600
	total		<b>28,400</b>	<b>28,600</b>	<b>Indoor unit total</b>	<b>24,000</b>	<b>31,000</b>

	Cooling	Heating
Capacity	78,800	82,200
Calculated	75,623	74,167

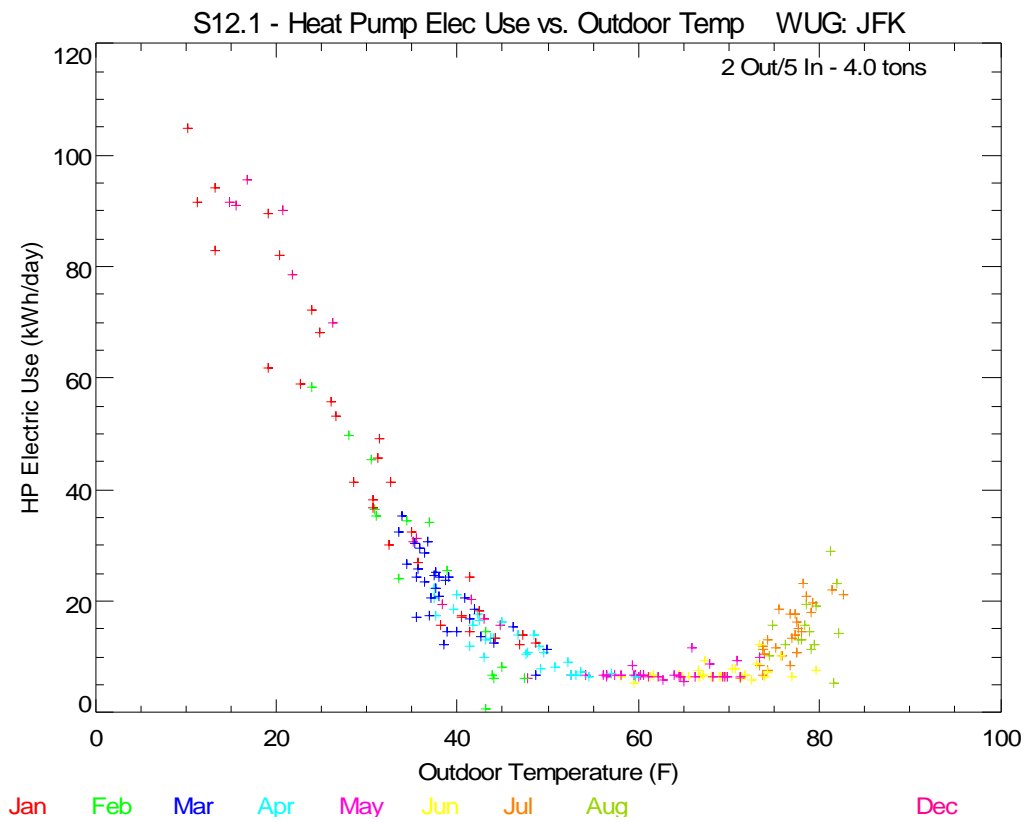


# SITE 12 - OWNER

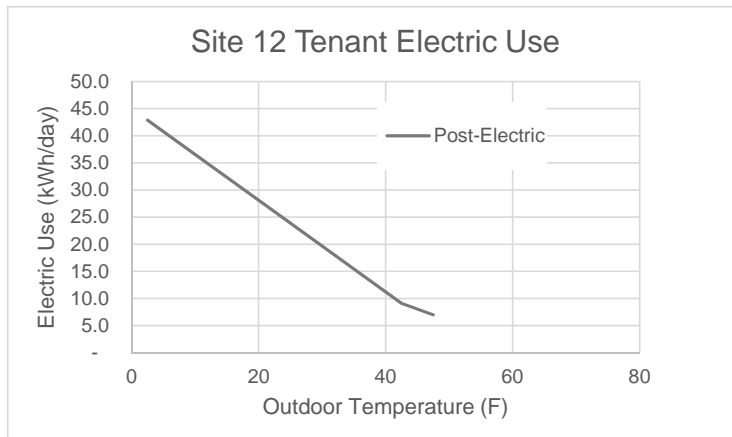
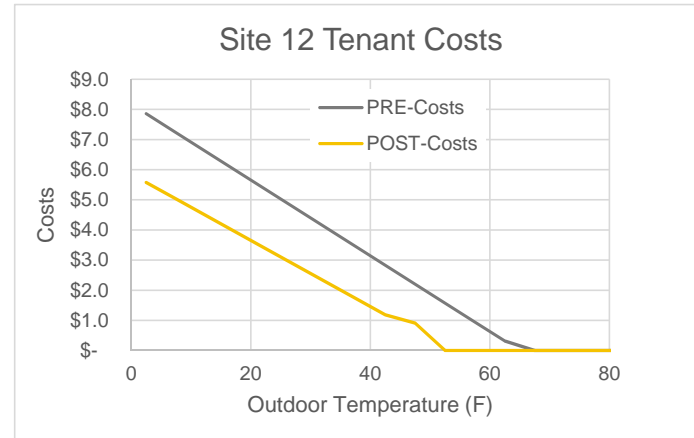
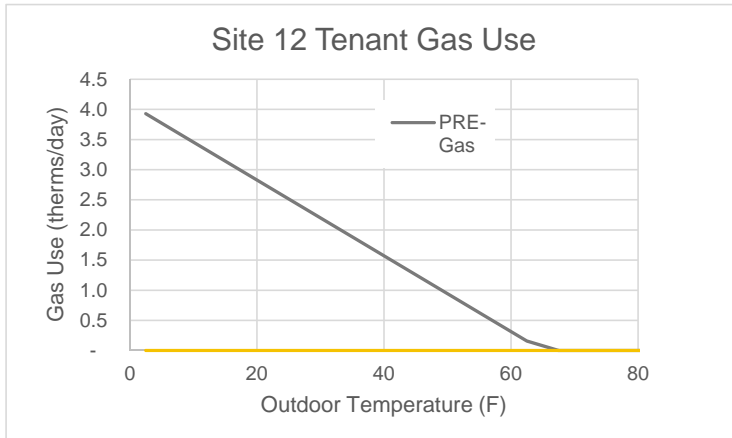


	PRE	POST	Savings
<b>Costs</b>	\$750	\$849	\$(99)
<b>Gas (therms/yr)</b>	375		375
<b>Electric (kWh/yr)</b>		6,534	
<b>Implied COP</b>			1.3

# SITE 12 - OWNER

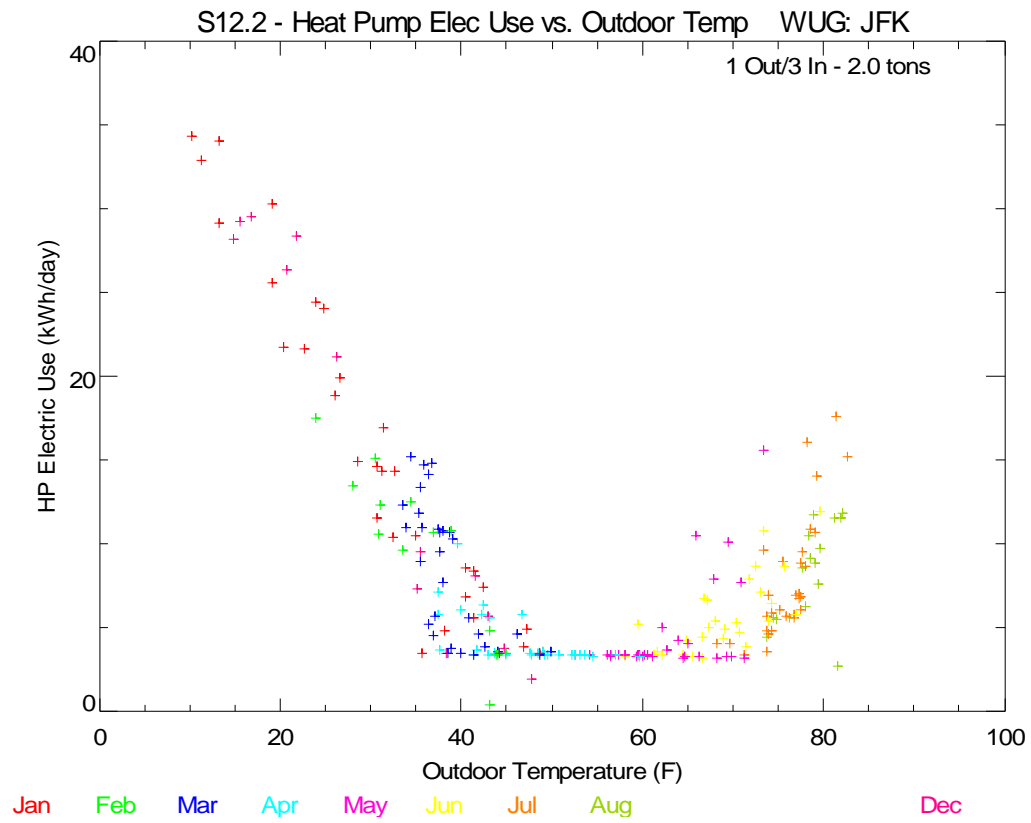


# SITE 12 - TENANT



	PRE	POST	Savings
<b>Costs</b>	\$635	\$290	\$345
<b>Gas (therms/yr)</b>	317		317
<b>Electric (kWh/yr)</b>		2,227	
<b>Implied COP</b>			3.3

# SITE 12 - TENANT





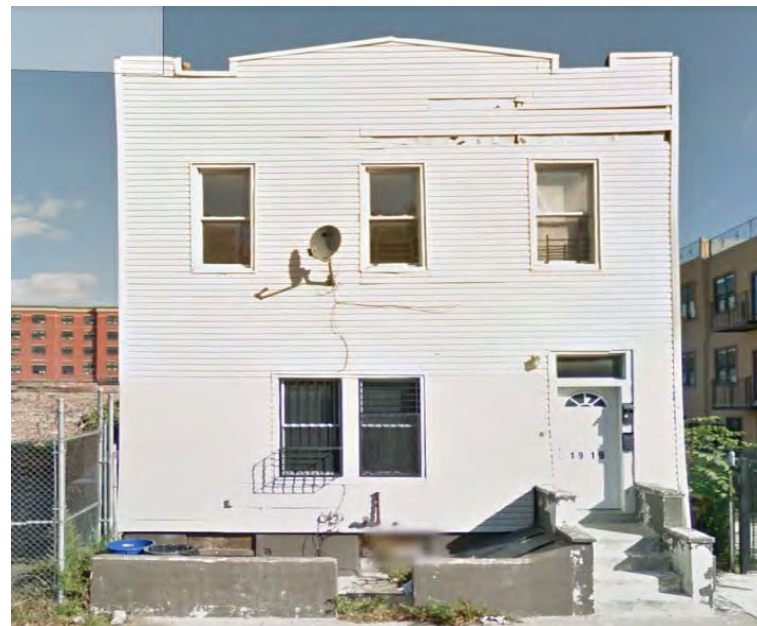
# SITE 19

## Envelope Improvements

Envelope Improvement	Details
Air sealing	Reduce overall air leakage of heated area from 4,742 CFM50 to 3,000 CFM50
Rim Joist Insulation	Rim joist upgrade, 122 sqft, 2" high density foam, 1.5" wood, 0.5" wood, siding, R15

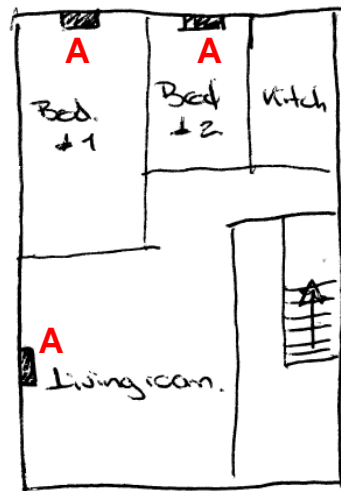
## Costs

Item	Cost
Heat pump equipment (5 zones)	8,405
Heat pump labor	9,000
Total heat pump	17,405
Cost per ton	4,144
Cost per zone	3,481
Envelope materials + labor	21,135
<b>Total job</b>	<b>38,540</b>

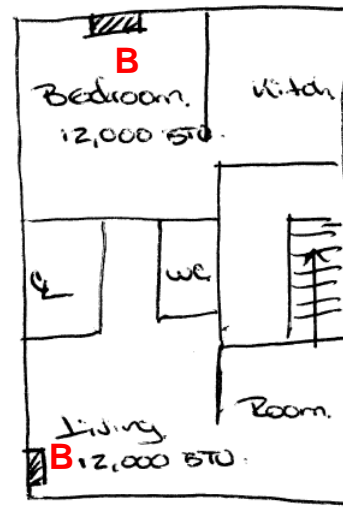


# SITE 19

Floor	Room	RHVAC sizing calcs		Outdoor unit			Indoor units		
		Cooling	Heating	Model	Cooling	Heating	Model	Cooling	Heating
1st	Living Room			MXZ-3C24NAHZ			MSZ-FH06NA	6,000	8,700
	Back bedroom 1						MSZ-FH06NA	6,000	8,700
	Back bedroom 2						MSZ-FH06NA	6,000	8,700
	Total	15,367	23,415		22,000	25,000	indoor unit total	18,000	26,100
2nd	Front Bedrooms			MXZ-3C30NAHZ			MSZ-FH12NA	12,000	13,600
	Back Bedroom						MSZ-FH12NA	12,000	13,600
	Total	22,307	30,197		28,400	28,600	indoor unit total	24,000	27,200
Total	Btu	37,674	53,612		50,400	53,600		42,000	53,300
	Tons	3.1	4.5		4.2	4.5		3.5	4.4



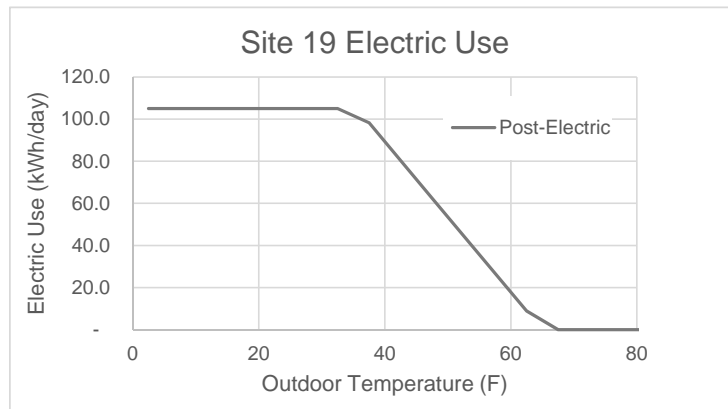
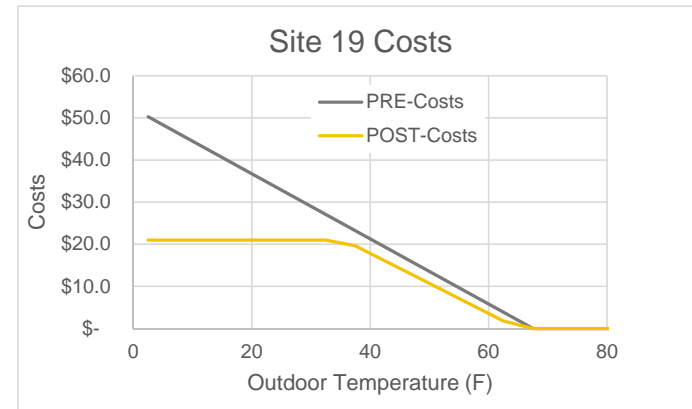
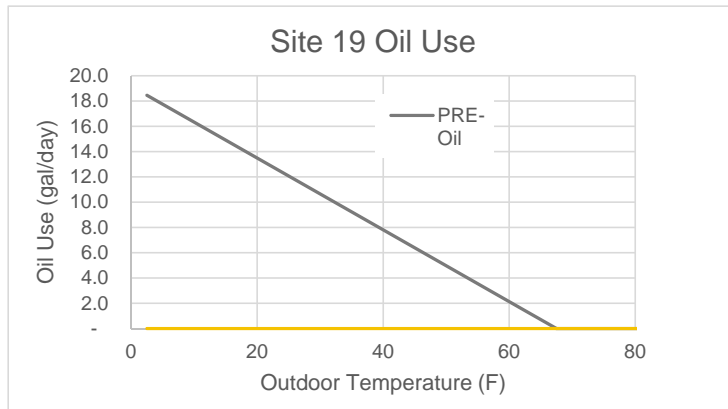
1st Floor



2nd Floor



# SITE 19



	PRE	POST	Savings
<b>Costs</b>	\$4,380	\$3,263	\$1,117
<b>Oil (Gal/yr)</b>	1,608		1,608
<b>Electric (kWh/yr)</b>		16,316	
<b>Implied COP</b>			3.4

# SITE EUG1

## Envelope Improvements

Envelope Improvement	Details
Wall insulation	2.5" polyurethane spray foam on first floor wall
Rim Joist Insulation	Upgraded rim joist in the basement and 2nd floor

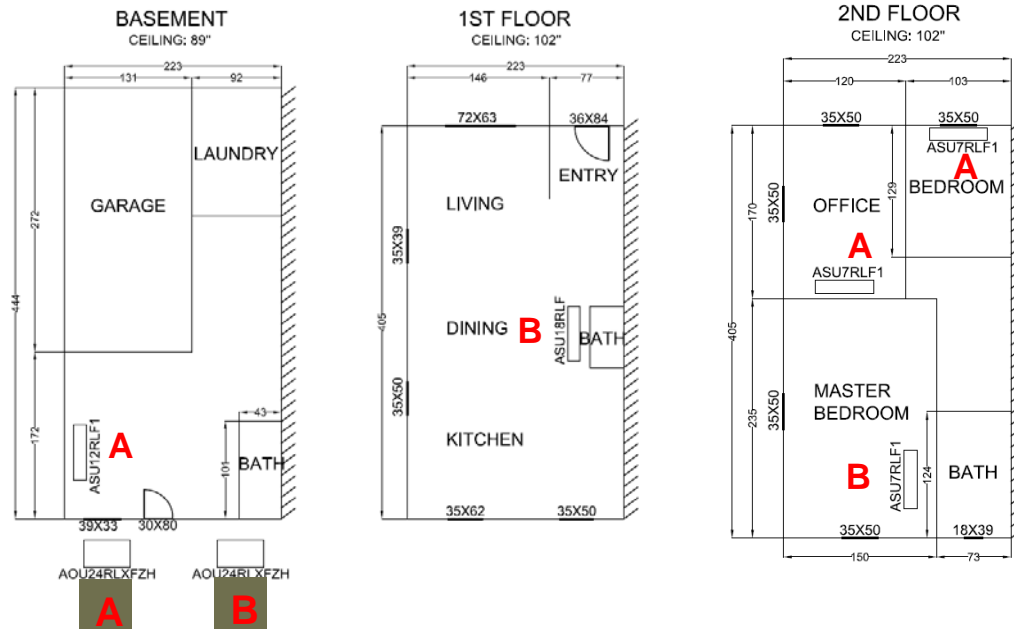
## Costs

Item	Cost
Total job (5 zones)	16,000

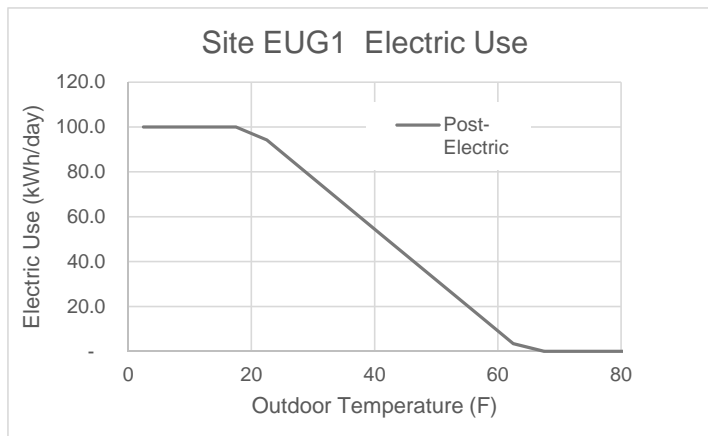
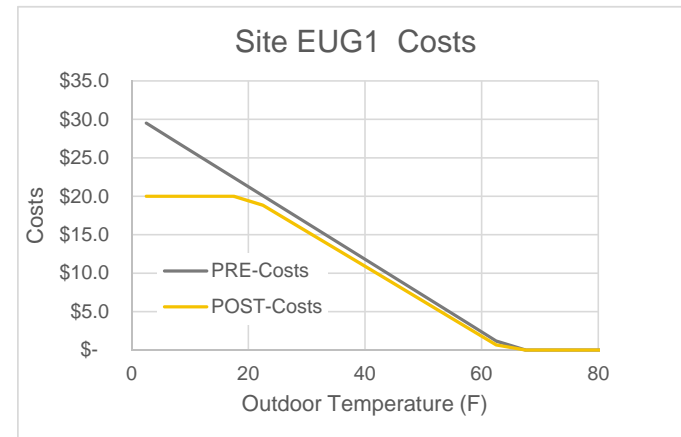
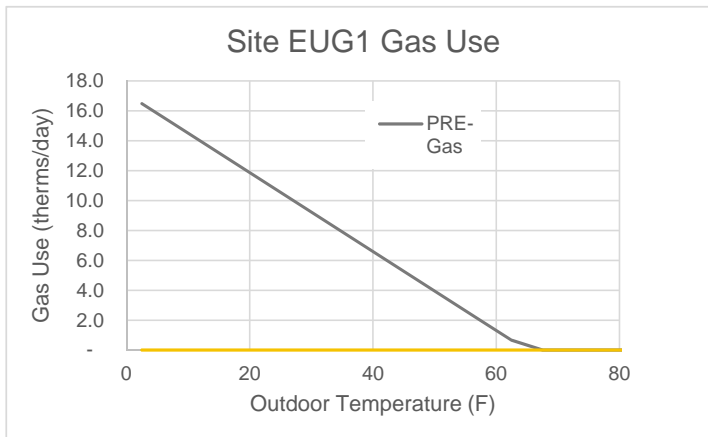


# SITE EUG1

Floor	Room	Design						Manual J Loads		
		Indoor Model	Cooling	Heating	Outdoor Model	Cooling	Heating	Cooling	Heating	
Basement	Basement front	ASU12RLP1	12,000	13,500	AOU24RLXFZH, connected to a 12k unit in basement and two 7k units on the 2nd floor			6,460	12,026	
	Total		12,000	13,500						
1st floor	Living room	ASU18RLP1	18,000	20,000	AOU24RLXFZH, connected to a 18k unit on the 1st floor and a 7k unit on the 2nd floor			10,463	10,084	
	Total		18,000	20,000		22000	26000			
2nd floor	Office	ASU7RLP1	7,000	8,100	AOU24RLXFZH, connected to a 18k unit on the 1st floor and a 7k unit on the 2nd floor			11,798	15,816	
	Bedroom	ASU7RLP1	7,000	8,100						
	Master Bedroom	ASU7RLP1	7,000	8,100						
	Total		21,000	24,300		22,000	26,000			
Total	btuh		51,000	57,800			44,000	52,000	28,721	37,926
	ton		4.3	4.8			3.7	4.3	2.4	3.2



# SITE EUG1



	PRE	POST	Savings
<b>Costs</b>	\$2,384	\$2,164	\$220
<b>Gas (therms/yr)</b>	1,332		1,332
<b>Electric (kWh/yr)</b>		10,819	
<b>Implied COP</b>			2.9

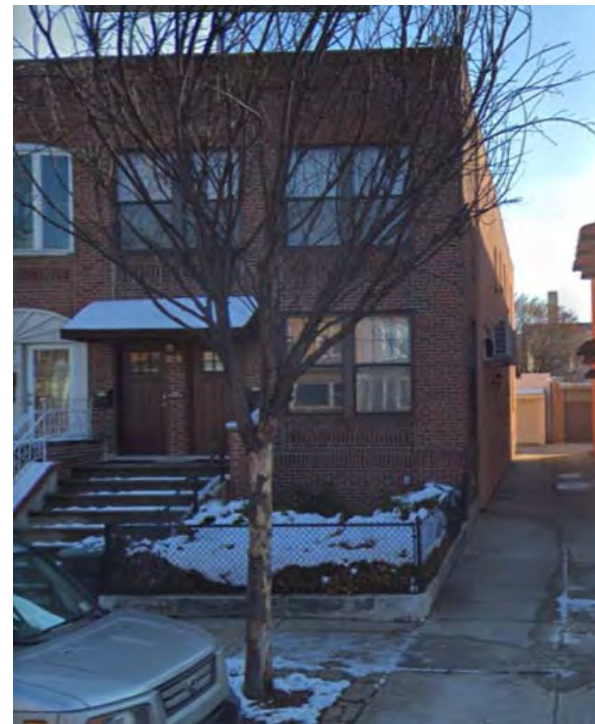
# SITE EUG2

## Envelope Improvements

Envelope Improvement	Details
Back/Side Wall insulation	add EIFs to back and side walls
Front Wall insulation	Add 2" XPS to front wall of first floor

## Costs

Item	Cost
Heat pump equipment (11 zones)	14,000
Heat pump labor	10,000
Total heat pump	24,000
Cost per ton	3,429
Cost per zone	2,181
Envelope materials + labor	10,000
<b>Total job</b>	<b>34,000</b>

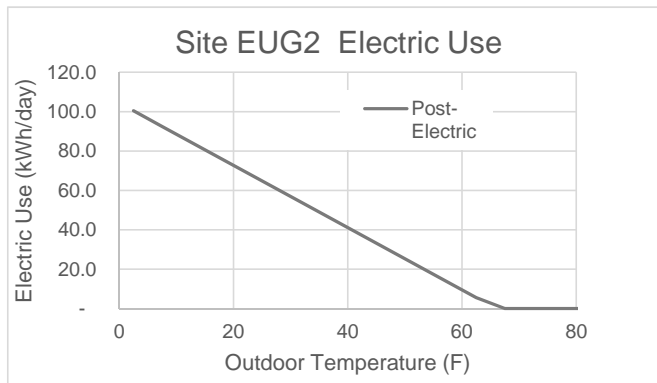
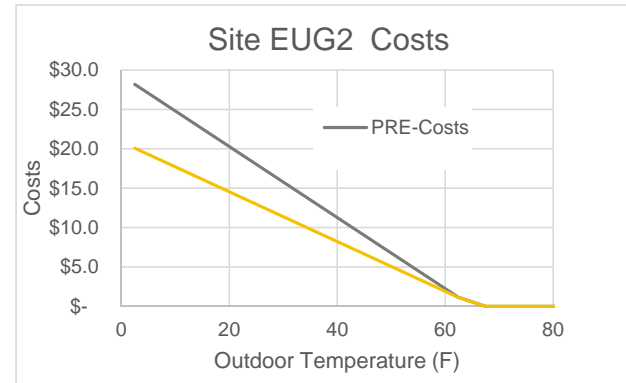
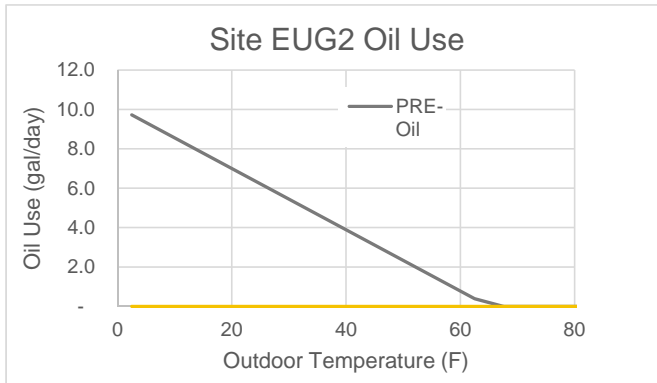


# SITE EUG2

Floor	Room	Pre-installed Design						Manual J Loads	
		Indoor Model	Cooling	Heating	Outdoor Model	Cooling	Heating	Cooling	Heating
Basement	Basement back	ASU9RLP1	9,000	10,200	AOU18RLXFZH				
	Total		<b>21,000</b>	<b>23,700</b>				<b>10,986</b>	<b>22,722</b>
1st floor	Living room	ASU9RLP1	9,000	10,200	AOU24RLXFZH	<b>18,000</b>	<b>23,500</b>		
	Dining/kitchen	ASU9RLP1	9,000	10,200					
	1st floor MBR	ASU7RLP1	7,000	8,100					
	1st floor small room	ASU7RLP1	7,000	8,100					
	Total		<b>32,000</b>	<b>36,600</b>		<b>22,000</b>	<b>26,000</b>	<b>18,281</b>	<b>18,270</b>
2nd floor	Apt 1 BR1	ASU7RLP1	7,000	8,100	AOU24RLXFZH				
	Apt 1 BR2	ASU7RLP1	7,000	8,100					
	Apt 1 kitchen/dining	ASU9RLP1	9,000	10,200					
	Total		<b>23,000</b>	<b>26,400</b>		<b>22,000</b>	<b>26,000</b>	<b>17,221</b>	<b>15,507</b>
2nd floor	Apt 2 kitchen/dining	ASU9RLP1	9,000	10,200	AOU24RLXFZH				
	Apt 2 BR1	ASU7RLP1	7,000	8,100					
	Apt 2 BR2	ASU7RLP1	7,000	8,100					
	Total		<b>23,000</b>	<b>26,400</b>		<b>22,000</b>	<b>26,000</b>	<b>16,478</b>	<b>12,957</b>
Total	btuh		<b>99,000</b>	<b>113,100</b>		<b>96,000</b>	<b>115,000</b>	<b>62,966</b>	<b>69,456</b>
	ton		<b>8.3</b>	<b>9.4</b>		<b>8.0</b>	<b>9.6</b>	<b>5.2</b>	<b>5.8</b>



# SITE EUG2



	PRE	POST	Savings
<b>Costs</b>	\$2,278	\$1,675	\$603
<b>Oil (gal/yr)</b>	786		786
<b>Electric (kWh/yr)</b>		8,374	
<b>Implied COP</b>			3.2

# SAVINGS SUMMARY

Site #	Site 3	Site 5	Site 10	Site 12	Site 19	Site EUG1	Site EUG2
Old heating fuel	Oil	Gas	Oil	Gas	Oil	Gas	Oil
\$ Savings	\$1594	(\$514)	\$4297	\$246	\$1117	\$220	\$603
Site Energy Savings (MMBTU)	131.0	278.3	243.1	39.3	167.0	96.3	80.3
Emission Savings (Metric ton)	(1.9)	(0.8)	8.5	(0.4)	2.2	(1.0)	0.8

# COSTS SUMMARY

Site #	Site 3	Site 5	Site 10	Site 12	Site 19	Site EUG1	Site EUG2
Equipment cost	11,156	-	10,783	12,687	8,405	-	14,000
Labor cost	13,500	-	25,000	15,500	9,000	-	10,000
Total heat pump	24,656	-	35,783	28,178	17,405	-	24,000
Number of zones	7	10	10	8	5	5	11
Cost per ton	4,086	-	4,647	4,271	4,144	-	3,429
Cost per zone	3,522	-	3,578	3,523	3,481	-	2,182
Envelope measure cost	12,992	-	10,736	18,943	21,135	-	10,000
Total cost	37,648	57,690	46,519	47,130	38,540	16,000	34,000

# HEAT PUMP COSTS SUMMARY

Site #	Average Contractor 1 (6 sites)	Average Contractor 2 (6 sites)	Average Contractor 3 (1 site)
Number of zones	7	6	4
Cost per ton	\$4,813	\$3,492	\$3,361
Cost per zone	\$3,805	\$2,634	\$3,361
Total heat pump system cost	\$26,627	\$15,683	\$13,444

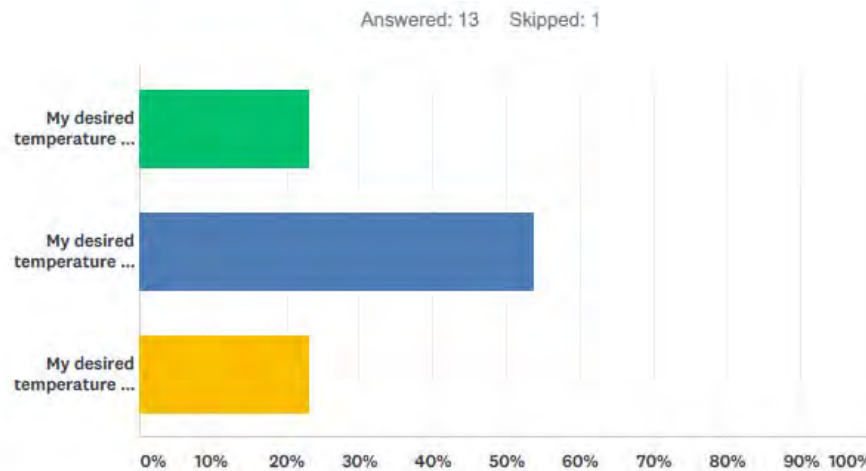
# SURVEY RESULT

Q1- HOW IMPORTANT WERE THE FOLLOWING IN YOUR DECISION TO INSTALL AN AIR-SOURCE HEAT PUMP SYSTEM?

	NOT AT ALL IMPORTANT	SOMEWHAT IMPORTANT	VERY IMPORTANT	TOTAL
Lower operating costs (save on energy bills)	0.00% 0	18.18% 2	81.82% 9	11
Ability to both heat and cool	0.00% 0	0.00% 0	100.00% 11	11
Quieter than existing heating/cooling system(s)	27.27% 3	45.45% 5	27.27% 3	11
Reduced greenhouse gas emissions	27.27% 3	18.18% 2	54.55% 6	11
Reduced peak load and need for more electric generating plants	36.36% 4	36.36% 4	27.27% 3	11
Reduce or remove chance of carbon monoxide poisoning	45.45% 5	18.18% 2	36.36% 4	11
Lower maintenance costs	18.18% 2	36.36% 4	45.45% 5	11
Lower life cycle cost due to longer equipment lifetime	36.36% 4	27.27% 3	36.36% 4	11
Dehumidification during summer	0.00% 0	36.36% 4	63.64% 7	11
Consistent room temperature	0.00% 0	45.45% 5	54.55% 6	11
Reduced installation costs compared to alternate HVAC system	36.36% 4	36.36% 4	27.27% 3	11
Ability to control temperature separately in each room	9.09% 1	36.36% 4	54.55% 6	11
Modern, trendy technology	63.64% 7	36.36% 4	0.00% 0	11
Recommended by someone I trust	18.18% 2	27.27% 3	54.55% 6	11
Financial incentives (e.g. rebate)	9.09% 1	45.45% 5	45.45% 5	11

# SURVEY RESULT

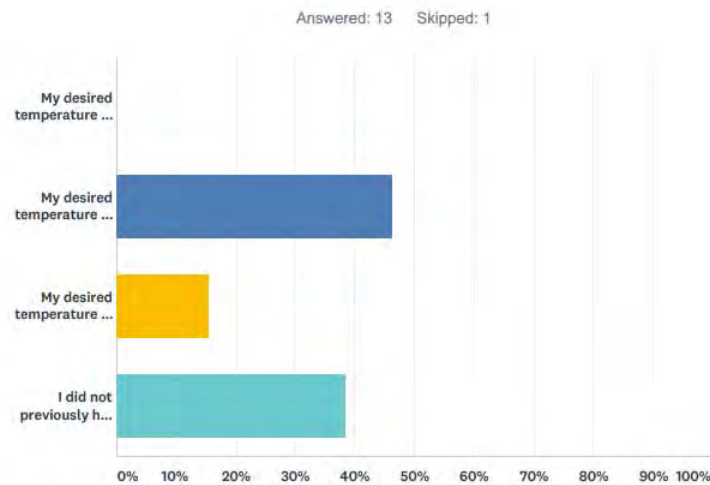
Q2- HOW DID YOUR HOME HEATING SYSTEM PERFORM OVER THE MOST RECENT WINTER, PRIOR TO THE HEAT PUMP UPGRADE?



ANSWER CHOICES	RESPONSES	
My desired temperature was maintained in all rooms of my home.	23.08%	3
My desired temperature was maintained in some rooms, but not in others (i.e., it was warm enough in some rooms but too cold in others).	53.85%	7
My desired temperature was not reached in any area of my home (i.e., it was too cold in every room).	23.08%	3
TOTAL		13

# SURVEY RESULT

Q3- HOW DID YOUR HOME COOLING SYSTEM PERFORM OVER THE MOST RECENT SUMMER, PRIOR TO THE HEAT PUMP UPGRADE?



ANSWER CHOICES	RESPONSES
My desired temperature was maintained in all rooms of my home.	0.00% 0
My desired temperature was maintained in some rooms, but not in others (i.e., it was cool enough in some rooms but too hot in others).	46.15% 6
My desired temperature was not reached in any area of my home (i.e., it was too hot in every room).	15.38% 2
I did not previously have cooling at this building/unit.	38.46% 5
<b>TOTAL</b>	<b>13</b>

# STAKEHOLDER'S MOTIVATION TO ENDORSE CHANGE

## **Owner or single decision maker**

- **Reduce operating costs**
- **Maximize return-on-investment of planned replacement**
- **Increase properties marketability**

## **Tenants or other stakeholders**

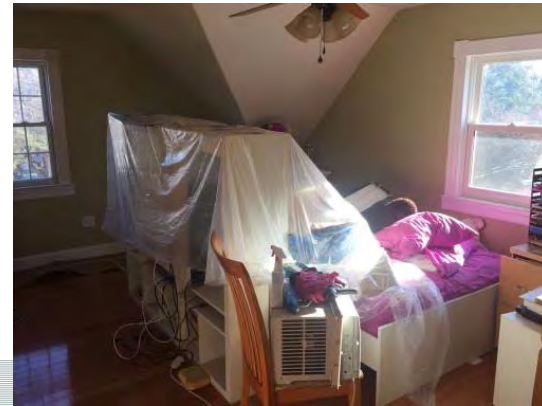
- **Comfort**
- **Health**
- **Do not increase costs**



# LESSONS

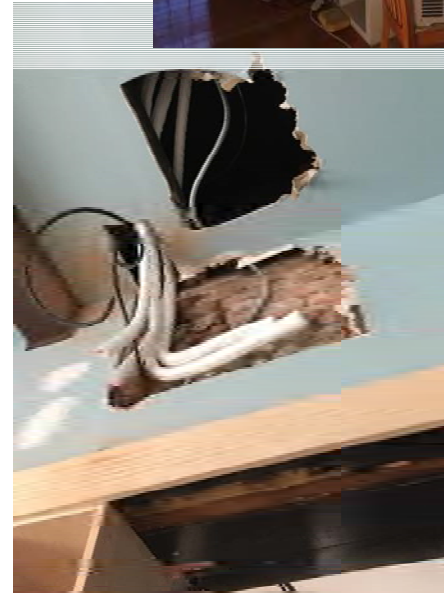
## SALES

- **Let homeowner talk about rooms and spots that cause discomfort.**
- **Pitch air handler locations and envelope measures to address biggest complaints.**
- **Clearly lay out how the work area will be restored to acceptable condition at the agreed budget . Will lines be surface mounted or recessed?**



## PLANNING

- **Agree to equipment selection and placement locations. Mark locations on the walls.**
- **Under-promise and over-deliver on completion date.**
- **Agree on house rules regarding job site cleanliness.**



# LESSONS



## IMPLEMENTATION

- **Respect house rules.**
- **Assemble a multitalented team that is problem solving-focused.**
- **Offer solutions to solve roadblocks, not demands for more money.**
- **Finger-pointing diminishes client's confidence.**

## OPERATIONS

- **Set-up operation modes for all zones.**
- **Provide tutorial for proper heating usage. Treat this no differently than boiler and furnace job sign-off.**
- **Emphasize the importance of maintenance. Call back seasonally to schedule service.**

**Successful implementation and healthy equipment generates loyalty and referrals.**

# LEVERAGE NYSERDA PROGRAMS AND TOOLS

- **Encourage installers to participate in NYSERDA co-marketing programs to lower equipment cost and attend training**
  - [PON 3653 ASHP incentive](#) and [3694 Co-marketing](#)
- **Help homeowners adopt NYSERDA commissioning checklist**
  - <https://www.nyserda.ny.gov/-/media/files/programs/ashp/inspection-checklist.pdf>
- **Clean Heating & Cooling Campaigns to promote standardization of quality and customer service**



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