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



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 (MtCO2e)

GHG Emissions Reductions

Relative to 2005

	2030	2050
Buildings	-52%	-82%
Transportation	-58%	-82%
Waste	-64%	-68%
Total	-54%	-80%

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

Greatest absolute number of buildings: 1-4 family homes

Greatest share of GHG emissions: Commercial and multifamily buildings



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

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 buildingbased 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 * Full implementation of TWG ECMs includes 100% overlap with One City: Built to Last initiatives Electricity ** Assumes a 50% reduction from ASHRAE 2013 standards for new construction and substantial Other Fuels renovations in public buildings beginning in 2017, and a 70% reduction from ASHRAE 2013 standards implemented in 2022 for both public and private buildings. One City Built to Last Overlap ***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.



Sample Deep Retrofit Path Results

Multifamily, Post-War, > Seven Stories







Proposed Energy Performance Mandate

To accelerate the transition away from fossil fuels by 2030 or 2035 large and midsized 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 reduction16% reduction in fossil fuel use17,000 direct jobs created

Cleaner air Lower energy costs Improved housing quality



New Efficiency: New York

2025 statewide energy efficiency target



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



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.



INVE Retrofit ACCELERATOR

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 info@nycretrofit.org 212-656-9202





Mayor's Office of Sustainability

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

INTE Retrofit ACCELERATOR





Program Resources

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



High Performance Retrofit Track Participants







AvalonBay Communities

NYC HEALTH+ HOSPITALS











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

NYC Retrofit ACCELERATOR



Thank You

Aaron Ordower 212-676-3294 aordower@cityhall.nyc.gov

nyc.gov/retrofitaccelerator nyc.gov/twg nyc.gov/80x50



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 30th, 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

Scott.smith@nyserda.ny.gov

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


SITES

- 1-4 family buildings
- Owner-occupied with rental units
- Tight urban lots
- Most masonry attached; some wood frame SFD
- Most gas, some oil
- Boilers and window AC
- Old buildings, minimal insulation



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 d^{SZ1}: 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.



STATUS

- 17 sites enrolled and active
- 14 installed
- 13 sites collecting data

Site number:	1	3	5	7	8	9	10	11	12
Community Board	B2	B14	B14	B8	B8	B8	B8	B7	B7
Existing fuel type	Gas	Oil	Gas	Gas	Gas	Gas	Oil	Gas	Gas
Construction type	Brick/Masonry	Wood frame	Frame/stucco	Stone/Masonry	Brick/Masonry	Stone/Masonry	Stone/Masonry	Brick/Masonry	Brick/Masonry
SF conditioned space	2400	4650	3370	2240	2980	4224	4512	2392	2442
Site approved	3/16/2017	3/16/2017	3/16/2017	3/16/2017	3/16/2017	3/16/2017	3/16/2017	3/16/2017	3/16/2017
Site agreement signed	3/23/2017	3/20/2017	3/17/2017	3/22/2017	3/20/2017	3/23/2017	3/20/2017	3/20/2017	3/21/2017
Audit scheduled for	11/29/2017	3/28/2017	3/28/2017	4/27/2017	4/27/2017	4/27/2017	~	5/3/2017	4/19/2017
Audit completed		3/28/2017	3/28/2017	4/27/2017	4/27/2017	4/27/2017	✓	5/2/2017	4/19/2017
Audit report/measures		5/7/2017	5/7/2017	✓	✓	✓	~	✓	✓
WegoHome enabled	✓	✓	4/20/2017	✓	5/4/2017	*	√	5/3/2017	✓
Utility data downloaded	6/22/2017	4/6/2017	4/26/2017	5/3/2017	5/4/2017	4/26/2017	4/26/2017		4/26/2017
Load calcs completed		5/16/2017	5/16/2017	6/2/2017			4/24/2017	5/26/2017	5/26/2017
Equipment selected		5/19/2017	5/22/2017	6/2/2017		1/10/2017	4/24/2017	5/26/2017	5/26/2017
Design report submitted		6/21/2017	6/21/2017	7/7/2017		2/2/2018	2/2/2018	7/7/2017	7/7/2017
Design approved		6/28/2017	6/28/2017	7/28/2017		2/8/2018	2/8/2018	submitted 7/7/17	7/28/2017
Proposal presented to		•							
owner		8/7/2017	~	10/6/2017					8/19/17 AM possible
Proposal				unlikely - maybe					
agreed/contracted		10/4/2017	10/4/2017	spring					9/12/2017
Work scheduled		11/16/2017	week of 11/27						10/2/2017
Work completed		11/20/2017	2/4/2018						10/7/2017
Installation report									
submitted		~							~
M&V equipment									
installed		12/18/2017							12/18/2017
Commissioning and									
education completed									
M&V mid-point						-			
collection									
M&V equipment									
removed									
WegoHome password									
changed									
Site number:	1	3	5	7	8	9	10	11	12
Priority:				1	wait	wait	6		
Information for load									
calculations	1	3	5	7	8	9	10	11	12
Data collection form or									
Audit report with		1	1	~	~	~	1	1	1
enclosure areas and				-	-				
construction									
Floor plan diagrams		~		~	~	~	√	1	~
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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

ltem	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
Total job	37,648



		Outdoor unit		Indo	or units		
Floor	Room	Model	Cooling	Heating	Model	Cooling	Heating
1st	Living Room				MSZ-FH12NA	12,000	13,600
151	Dining Bedroom	MXZ-3C24NAHZ	22,000	25,000	MSZ-FH09NA	12,000	13,600
	Total				Indoor unit total	24,000	27,200
Attic	Front Room				MSZ-FH12NA	12,000	13,600
2nd	Back Bedroom	MXZ-3C24NAHZ	22,000	2,000 25,000	MSZ-FH06NA	6,000	8,700
	Total				Indoor unit total	18,000	22,300
2nd	Front Bedroom				MSZ-FH12NA	9,000	10,900
Attic	Office		20.400	20,000	MSZ-FH12NA	12,000	13,600
2nd	Side Bedroom	MXZ-3C30NAHZ	28,400	28,600	MSZ-FH09NA	9,000	10,900
	Total				Indoor unit total	30,000	35,400
		Total Cap Outdoor	72,400	78,600			
		RHVAC load calc	82,230	99,462			







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

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
Total job (10 zones)	57,690



		Outd	Outdoor unit		Indoor units		
Floor	Room	Model	Cooling	Heating	Model	Cooling	Heating
1st	Living Room		1		MSZ-FH15NA	15,000	18,000
2nd	Front Bedroom 1	MXZ-3C24NAHZ2			MSZ-FH06NA	6,000	8,700
	Total	A	22,000	25,000	Indoor unit total	21,000	26,700
1et	Dining Room				MSZ-FH06NA	6,000	8,700
Ist	Kitchen	MXZ-3C24NAHZ2			SLZ-KA09NAR1.TH	9,000	10,900
2nd	Back Bedroom 2	В			MSZ-FH06NA	6,000	8,700
	Total		22,000	25,000	Indoor unit total	21,000	28,300
2nd	Back Bedroom 1				MSZ-FH06NA	6,000	8,700
Attic	Back Bedroom-1	MXZ-3C24NAHZ2)	MSZ-FH06NA	6,000	8,700
Actic	Back Bedroom 2	c		1	MSZ-FH06NA	6,000	8,700
	Total		22,000	25,000	Indoor unit total	18,000	26,100
Attic	Front Room				MSZ-FH09NA	9,000	10,900
2nd	Front Bedroom 2	MXZ-3C24NAHZ2			MSZ-FH06NA	6,000	8,700
	Total	D	22000	25000	Indoor unit total	15,000	19,600
			Total	capacity	Calculated load	ds	
	B					•	
	B				C Fiort Bed]
	1st 2nd 1st 2nd 2nd Attic Attic	1st Living Room 2nd Front Bedroom 1 Total Dining Room 1st Dining Room Xitchen Back Bedroom 2 Total Total 2nd Back Bedroom 1 Back Bedroom 1 Back Bedroom 1 Attic Front Room 2nd Front Room 2nd Front Bedroom 2 Total Total	Floor Room Model 1st Living Room MXZ-3C24NAHZ2 2nd Front Bedroom 1 MXZ-3C24NAHZ2 1st Dining Room MXZ-3C24NAHZ2 2nd Back Bedroom 2 B 2nd Back Bedroom 1 MXZ-3C24NAHZ2 Attic Back Bedroom 1 MXZ-3C24NAHZ2 Attic Back Bedroom 1 MXZ-3C24NAHZ2 Attic Front Room C 2nd Front Room MXZ-3C24NAHZ2 Attic Front Room MXZ-3C24NAHZ2 D MXZ-3C24NAHZ2 C Attic Front Bedroom 2 C Total MXZ-3C24NAHZ2 D	Floar Room Model Cooling 1st Living Room MXZ-3C24NAHZ2 22,000 1st Dining Room MXZ-3C24NAHZ2 22,000 1st Dining Room MXZ-3C24NAHZ2 22,000 1st Back Bedroom 2 B 22,000 2nd Back Bedroom 1 MXZ-3C24NAHZ2 B 2nd Back Bedroom 1 MXZ-3C24NAHZ2 C 2nd Back Bedroom 1 MXZ-3C24NAHZ2 C Attic Back Bedroom 2 C C Total C Z2,000 C Attic Front Room MXZ-3C24NAHZ2 D 2nd Front Bedroom 2 C Z2,000 Attic Front Bedroom 2 C Z2,000 Attic Front Bedroom 2 MXZ-3C24NAHZ2 D 2nd Front Bedroom 2 MXZ-3C24NAHZ2 D D Z2000 Total D Z2000	Floor Room Model Cooling Heating 1st Living Room MXZ-3C24NAH22	Floor Room Model Cooling Heating Model 1st Uving Room MXZ-3C24NAHZ2 MSZ-FH15NA MSZ-FH06NA 2nd Front Bedroom 1 MXZ-3C24NAHZ2 MSZ-FH06NA MSZ-FH06NA 1st Dining Room MXZ-3C24NAHZ2 SLZ-KA09NAR1T.H MSZ-FH06NA 1st Back Bedroom 2 B MSZ-FH06NA MSZ-FH06NA 2nd Back Bedroom 2 B MSZ-FH06NA 7otal NXZ-3C24NAHZ2 MSZ-FH06NA MSZ-FH06NA 2nd Back Bedroom 1 MXZ-3C24NAHZ2 MSZ-FH06NA Attic Back Bedroom 2 C MSZ-FH06NA Total C MSZ-FH06NA MSZ-FH06NA Attic Front Room MSZ-FH06NA MSZ-FH06NA 2nd Front Room MSZ-FH06NA MSZ-FH06NA 2nd Front Room MSZ-FH06NA MSZ-FH06NA 2nd Front Room MSZ-FH06NA MSZ-FH06NA B C MSZ-FH06NA Coloui Itotal 2nd	Floor Room Model Cooling Heating Model Cooling 1st Living Room MSZ-FH16NA 15.000 MSZ-FH16NA 15.000 2nd Front Bedroom 1 A 22.000 25.000 Indoor unit total 21.000 1st Dining Room MXZ-3C24NAH22 SLZ-KA09NAR1.TH 9.000 2nd Back Bedroom 2 B MSZ-FH06NA 6.000 2nd Back Bedroom 1 MXZ-3C24NAH22 MSZ-FH06NA 6.000 2nd Back Bedroom 1 MXZ-3C24NAH22 MSZ-FH06NA 6.000 2nd Back Bedroom 1 MXZ-3C24NAH22 MSZ-FH06NA 6.000 Attic Back Bedroom 1 MXZ-3C24NAH22 MSZ-FH06NA 6.000 Attic Front Room Z MSZ-FH06NA 6.000 Attic Front Room MXZ-3C24NAH22 MSZ-FH06NA 6.000 2nd Front Room MXZ-3C24NAH22 MSZ-FH06NA 6.000 2nd Fort Room MSZ-FH06NA 6.000 Gooling </th





Attic.







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

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
Total job	46,519



				E	quipment s	Selection		
			Outo	loor unit		Inc	loor units	
SITE 10	Floor	Room	Model	Cooling	Heating	Model	Cooling	Heating
SILIU		Living Room (C1)				MSZ-FH12NA	12,000	10,900
		Bedroom (C2)				MSZ-FH06NA	6,000	8,700
	1st floor	Kitchen (C3)	MXZ-4C36NAHZ			MSZ-FH06NA	6,000	8,700
		Back Bedroom (C4)	с			MSZ-FH09NA	9,000	10,900
		Total		36,000	45,000	total	33,000	39,200
	2nd floor	Dining/Kitchen (B1)				MSZ-FH15NA	15,000	12,900
		Back Bedroom (B2)	MXZ-3C30NAHZ			MSZ-FH12NA	9,000	7,900
	3rd Floor	Bedroom (B3)	-			MSZ-FH09NA	9,000	7,900
		Total	В	28,400	28,600		33,000	28,700
	3rd Floor	Front Bedoom (A1)				MSZ-FH12NA	12,000	13,600
	ALL (1	Front Bedroom (A2)	MXZ-3C30NAHZ			MSZ-FH12NA	12,000	13,600
00 - 20 5 500 4 6 4 G 20 5 6.00 7	4th floor	Bedroom (A3)	A			MSZ-FH09NA	9,000	10,900
100 24. 4 500 22 05 1G 24 1600 23	Harras	Total BTUH		28,400 92,800	28,600 102,200		33,000 99,000	38,100 106,000
		Tons		92,800	8.5		8.3	8.8
		04 0.00 95	20.00 BATH BATH CCL CCL CCL SIM BEDROOM SCL SCL A	93,273	ads 110,633			





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

40

-PRE-Costs

POST-Costs

60

80

Envelope Improvements

Envelope Improvement	Details
Exterior wall	Upgrade 1,160 sqft, from interior, to Gyp Bd, 2x4 16" OC, 3.5" cellulose,
insulation	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
Total job	47,130



			Outdoor unit			Indoor units			
SITE 12									
· · ·		Floor	Room	Model	Cooling	Heating	Model	Cooling	Heating
			Living Room				MSZ-FH12NA	12,000	13,600
		Ground	Main Bedroom	MXZ-5C30NAHZ			MSZ-FH09NA	9,000	10,900
		floor	Baby Bedroom	WINZ-SCSUNARZ			MSZ-FH06NA	6,000	8,700
			total		28,400	28,600	Indoor unit total	27,000	33,200
		2nd	Kitchen-Dining				MSZ-FH15NA	15,000	18,000
		3rd	Front Room 2	MXZ-3C24NAHZ2			MSZ-FH09NA	9,000	10,900
					22,000	25,000	Indoor unit total	24,000	28,900
			Front Room 1				MSZ-FH06NA	6,000	8,700
Cooling	Heating	3rd	Office	MXZ-4C30NAHZ			MSZ-FH06NA	6,000	8,700
Capacity 78,800	82,200	510	Back Room+Bathroom				MSZ-FH12NA	12,000	13,600
Calculated 75,623	74,167		total		28,400	28,600	Indoor unit total	24,000	31,000



SITE 12 - OWNER







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

SITE 12 - OWNER



SITE 12 - TENANT





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

SITE 12 - TENANT



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

Cost
8,405
9,000
17,405
4,144
3,481
21,135
38,540



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







Floor







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

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



			Design						I J Loads	
Floor	Room	Indoor Model	Cooling	Heating	Outdoor Model	Cooling	Heating	Cooling	Heating	
Basement	Basement front	ASU12RLP1	12,000	13,500	AOU24RLXFZH,					
Basement	Total		12,000	13,500	connected to a 12k unit			6,460	12,026	
1st floor	Living room	ASU18RLP1	18,000	20,000	in basement and two 7k					
IST HOOF	Total		18,000	20,000	units on the 2nd floor	22000	26000	10,463	10,084	
	Office	ASU7RLP1	7,000	8,100	0 AOU24RLXFZH,					
2nd floor	Bedroom	ASU7RLP1	7,000	8,100	connected to a 18k unit					
2nd noor	Master Bedroom	ASU7RLP1	7,000	8,100	on the 1st floor and a 7k					
	Total		21,000	24,300	unit on the 2nd floor	22,000	26,000	11,798	15,816	
Tatal	btuh		51,000	57,800	800	44,000	52,000	28,721	37,926	
Total	ton		4.3	4.8		3.7	4.3	2.4	3.2	

1ST FLOOR













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

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

Cost
14,000
10,000
24,000
3,429
2,181
10,000
34,000



			I	Pre-installed	Design			Manual	J Loads		
Floor	Room	Indoor Model	Cooling	Heating	Outdoor Model	Cooling	Heating	Cooling	Heating		
Basement	Basement back	ASU9RLP1	9,000	10,200							
	Total		21,000	23,700	AOU18RLXFZH			10,986	22,722		
	Living room	ASU9RLP1	9,000	10,200		18,000	23,500				
	Dining/kitchen	ASU9RLP1	9,000	10,200	AOU24RLXFZH						
1st floor	1st floor MBR	ASU7RLP1	7,000	8,100							
	1st floor small room	ASU7RLP1	7,000	8,100		AUUZ4KLXFZH					
	Total		32,000	36,600		22,000	26,000	18,281	18,270		
	Apt 1 BR1	ASU7RLP1	7,000	8,100							
2 1 (1	Apt 1 BR2	ASU7RLP1	7,000	8,100							
2nd floor	Apt 1 kitchen/dining	ASU9RLP1	9,000	10,200	AOU24RLXFZH						
	Total		23,000	26,400		22,000	26,000	17,221	15,50		
	Apt 2 kitchen/dining	ASU9RLP1	9,000	10,200							
o 1 (1	Apt 2 BR1	ASU7RLP1	7,000	8,100							
2nd floor	Apt 2 BR2	ASU7RLP1	7,000	8,100	AOU24RLXFZH						
	Total		23,000	26,400		22,000	26000	16,478	12,95		
-	btuh		99,000	113,100		96,000	115,000	62,966	69,45		
Total	ton		8.3	9.4		8.0	9.6	5.2	5.		





	PRE	POST	Savings
Costs	\$2,278	\$1,675	\$603
Oil (gal/yr)	786		786
Electric (kWh/yr)		8,374	
Implied COP			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	VERY IMPORTANT	TOTAL	
Lower operating costs (save on energy bills)	0.00%	18.18%	81.82%		
	0	2	9	11	
Ability to both heat and cool	0.00%	0.00%	100.00%		
	0	0	11	11	
Queter than existing heating/cooling system(s)	27.27%	45,45%	21.21%		-
	3	5	3	11	
Reduced greenhouse gas emissions	27.27%	18.18%	54.55%		
	3	2	6	11	
Reduced peak load and need for more electric	36.36%	38.38%	27.27%		
generating plants	4	4	3	11	
Reduce or remove chance of carbon monoxide	45.45%	18.18%	36.36%		
poisoning	5	2	4	11	
Lower maintenance costs	18.18%	36.36%	45.45%		
	2	4	5	11	
Lower life cycle cost due to longer equipment lifetime	36.36%	27.27%	36.36%		
	4	3	4	11	
Dehumidification during summer	0.00%	36.36%	63.64%	1	
	0	4	7	11	
Consistent room temperature	0.00%	45.45%	54.55%		
	0	5	6	11	
Reduced installation costs compared to alternate HVAC	36.36%	38.38%	27,27%		
system	4	4	3	11	
Ability to control temperature separately in each room	9.09%	36.36%	54.55%		
	1	4	6	11	
Modern, trendy technology	63.64%	36.36%	0.00%		
	7	4	0	11	
Recommended by someone I trust	18.18%	27.27%	54.55%		
and a strength of the state of	2	3	6	11	
Financial incentives (e.g. rebate)	9.09%	45.45%	45.45%	-	
and the second se	1	5	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	RESPON	SES
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).		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
TOTAL		13

STAKEHOLDER'S MOTIVATION TO ENDORSE CHANGE

Owner or single decision maker

Reduce operating costs

- Maximize return-oninvestment 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
 - <u>https://www.nyserda.ny.gov/-</u> /media/files/programs/ashp/inspection-checklist.pdf
- Clean Heating & Cooling Campaigns to promote standardization of quality and customer service

Jordan Dentz, The Levy Partnership, Inc.

jdentz@levypartnership.com

Julie Liu, Centsible House julie@centsiblehouse.com



