# LEAN

(Low income Energy Affordability Network)

- LEAN = 25 Massachusetts agencies that deliver the energy efficiency and fuel assistance programs to low income households.
- Ma CEC provided funding to LEAN for installation of renewable thermal technologies in low income households 2013-2015.
- Mostly used to install "cold climate" ASHPs in state supported public housing.
- LEAN installed 437 ASHPs at 12 different sites.
- Most were mini splits in one bedroom apartments serving the elderly. Some family units also served with larger equipment.
- Displaced electric baseboard or electric storage heat.
- Cost information on 12 projects, and some savings data on 8 projects.

### LEAN ASHP Costs

type	BTU size	condensers	\$ range	average	cost per room served
mini split	9000	48	3858-3858	3858	3858
mini split	12000	313	4305 - 5785	5009	2505
mini split	15000	48	4548-7405	6027	2257
mini split	18000	24	4548 - 8139	6697	2392
multi zone	24000	1	8500 est	8500	2833
multi zone	36000	1	18125 est	18125	4531
city multi	92000	2	216,890	216,890	6379

### LEAN ASHP Savings

Туре	# Units	Estimated Year 1 Savings	Realized Year 1 Savings	Possible reasons for differences
city multi	1	50%	41%	Bathroom heaters used extensively after change out. Stairwell wall heaters maximized.
min splits	24	50%	35%	Possibly oversized.
min splits	4	40%	na	Extreme variation in savings - 15% to 40%.
min splits	20	40%	na	Extreme variation in savings - 2% to 47%.
min splits	44	50%	54%	Hallways/stairwells not heated.
min splits	6	50%	na	Rehabbed in 2014 utilizing advanced energy efficiency measures. After mods, energy usage has been remarkably low compared to similar sized all electrical buildings. LEAN has not yet identified respective contributions of savings from various EE measures.
min splits	12	50%	37%	Large hallways on 2 floors remain heated with electric baseboard. Demand usage reduced by 50%.
min splits	68	50%	50%?	Upon complete installation in March, saw an immediate 53% reduction year over year @ normalized degree day levels.

# LEAN

Elliott Jacobsen, Action, Inc. & John Wells, ABCD, Inc., LEAN Co-Chairs

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## Residential ASHPs: Performance Monitoring and Modeling

#### NEEP Workshop October 2015

Robb Aldrich Steven Winter Associates, Inc. raldrich@swinter.com

Steven Winter Associates, Inc. NEW YORK, NY | WASHINGTON, DC | NORWALK, CT



# Monitoring

- DOE funding through Building America Program
- Partnership with Efficiency Vermont
- 10 DHPs in homes around New England
- Monitored winter 2013-14
- Report online: <u>http://apps1.eere.energy.gov/buildings/publications/pdfs/building\_a</u> <u>merica/inverter-driven-heat-pumps-cold.pdf</u>



# Air Temperatures







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# Flow Testing



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# Flow vs. Fan Current



# Air Flow Measurement



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# **SCOP** Summary

_				SILE			
Month	1	2	4	5	8	9	10
Nov 2013	1.6	-	-	-	-	-	-
Dec 2013	1.6	-	2.3	-	-	-	-
Jan 2014	1.4	2.0	2.4	-	-	-	-
Feb 2014	1.6	1.9	2.2	1.8	-	-	-
Mar 2014	1.8	2.0	2.3	1.7	2.2	1.0	1.8
Apr 2014	2.2	1.9	3.0	-	2.5	1.3	2.4
Overall	1.6	2.0	2.3	1.7	2.3	1.1	2.1

Cito





Western MA HDD65: 6,929 Design Temp: 2°F SCOP: 1.6

Near Burlington, VT HDD65: 7,956 Design Temp:-4°F SCOP: 2.3

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### Heat Output-FE18



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# Possible Reasons for low COPs

- Low fan speed (not just low flow)
- Higher return air temperatures



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# High Return Temp?



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Used published studies to create calibrated energy models. Studies included:

- Heating electricity consumption
- Building specifications (all SF homes) Two studies, 5 home types, ~30 homes

Modeling tools used:

- Energy Plus & BEopt
- EQUEST
- REM/Rate
- TREAT

2014



### Predicted ASHP Elec. Use Energy Plus / BEOPT 25-40% Low EQUEST REM/Rate TREAT



### Predicted ASHP Elec. Use Energy Plus / BEOPT 25-40% Low EQUEST 25-40% Low REM/Rate TREAT





### Predicted ASHP Elec. Use Energy Plus / BEOPT 25-40% Low EQUEST 25-40% Low REM/Rate 30-40% High TREAT



### Predicted ASHP Elec. Use Energy Plus / BEOPT 25-40% Low EQUEST 25-40% Low REM/Rate 30-40% High TREAT Pretty Accurate



## Heat Output – FE12

Site 2





# Site 2: CT Passive House

Modeled ASHP Electricity:

PHPP:613 kWh/yBEopt (Energy Plus):738 kWh/yREM/Rate:1,053 kWh/y

Measured ASHP Electricity: 1,446 kWh/y

(values are for heating season only)

## Questions?

Thanks to:

- U.S. DOE Building America Program
- Efficiency Vermont
- NYSERDA
- NEEP

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