Best Practices for All-Electric Homes and Apartments

NESEA Building Energy Conference

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Robb Aldrich, raldrich@swinter.com

Outline

- Why are we talking about all-electric homes?

- Space Heating: air-source heat pumps

<break?>

- Water Heating: resistance, heat pumps, solar

Why are we talking about all-electric homes?

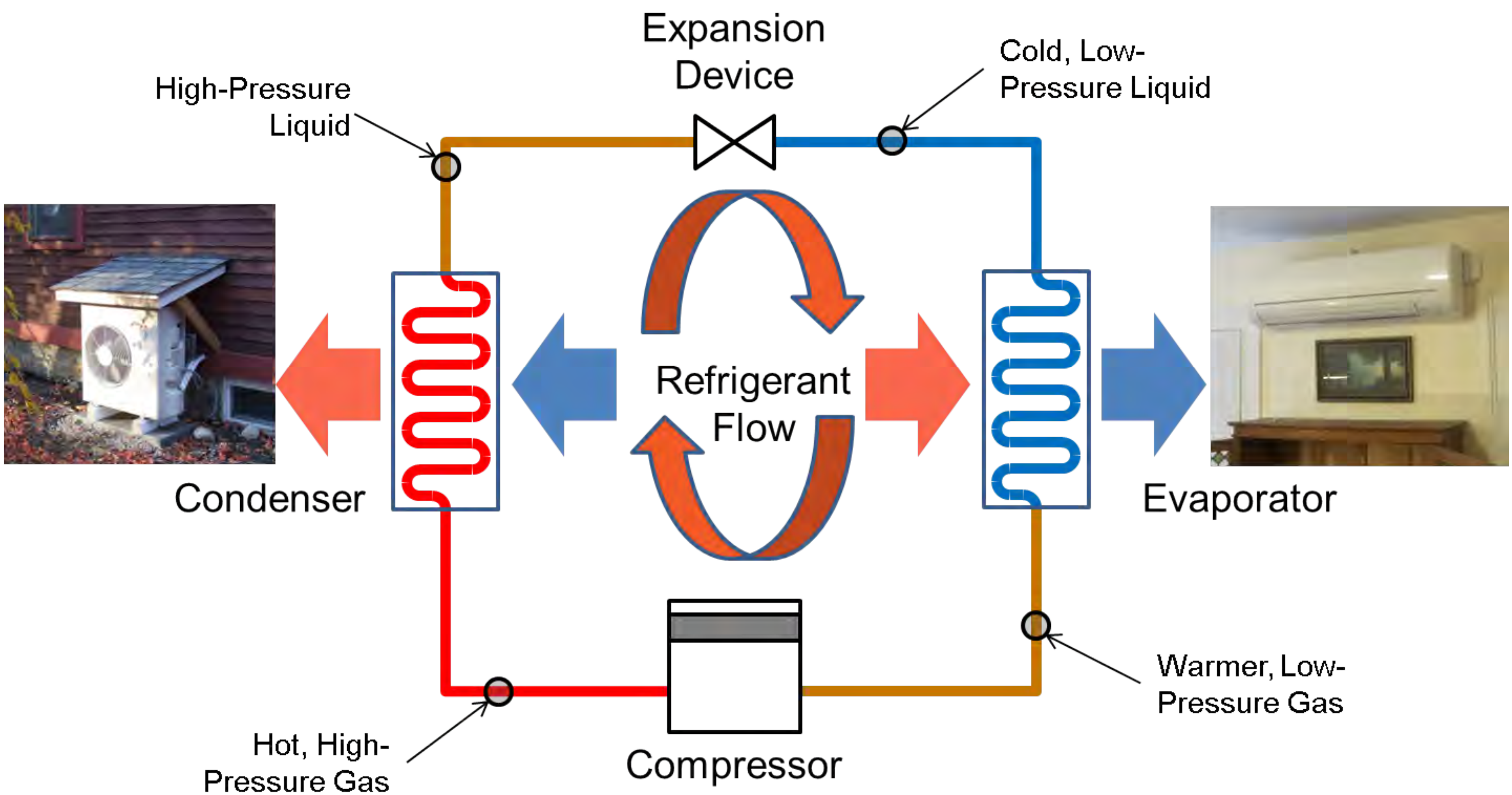
What is an Air Source Heat Pump?

Quick answer: An air conditioner that can run in the reverse.

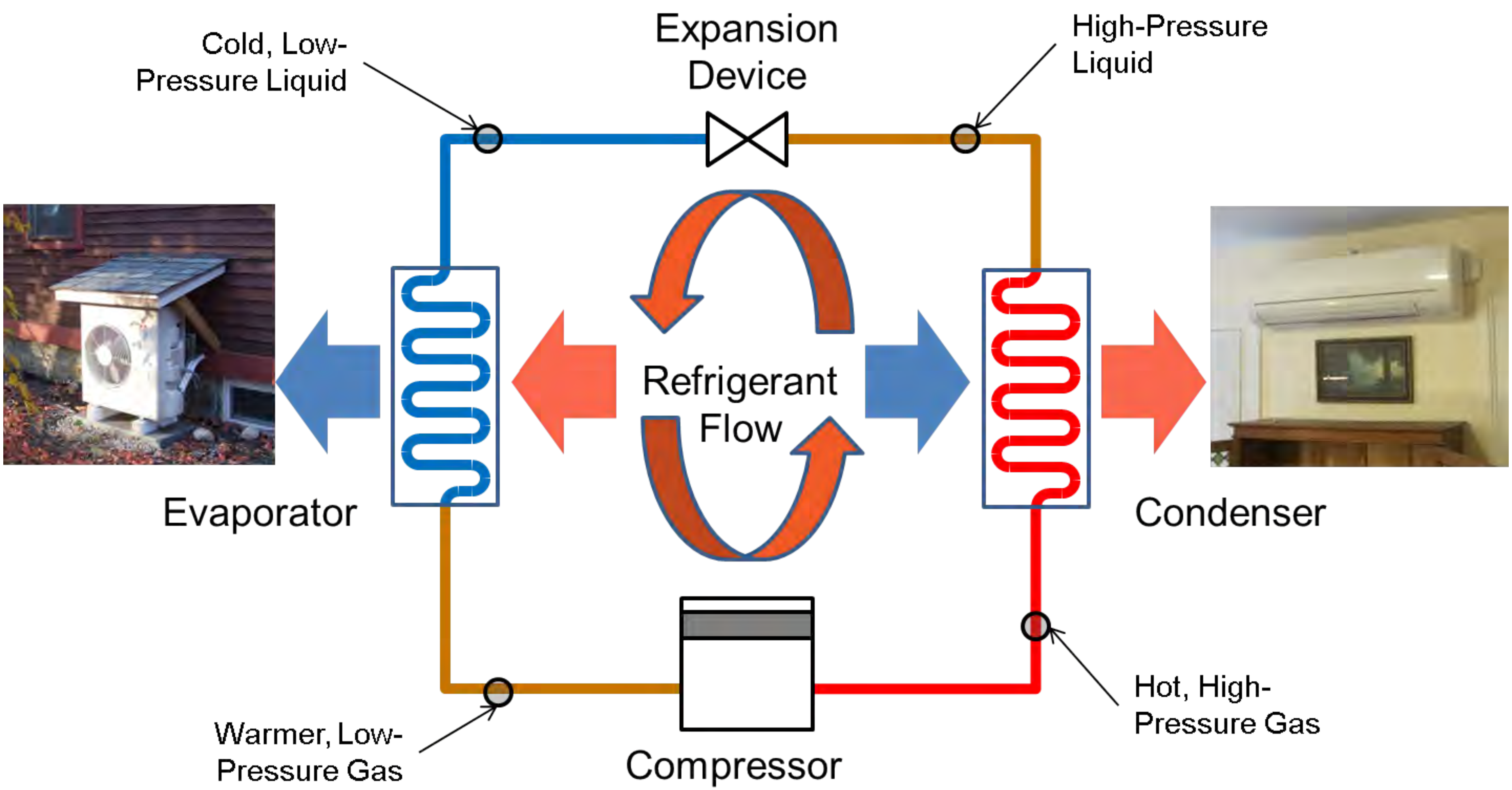
An AC moves heat from indoors to outdoors in the summer.

A heat pump moves heat from outdoors to indoors in the winter

Air Conditioner



Heat Pump


Expansion Device
Cold, Low-Pressure Liquid
High-Pressure Liquid
Refrigerant Flow
Evaporator
Condenser
Hot, High-Pressure Gas
Warmer, Low-Pressure Gas
Compressor

Old Heat Pumps

- Used very often further south.
- Old HP's didn't work well below ~30°F
- BAD reputation in colder climates

New ASHPs in the past ~10 years that can work well up north!

Terminology

Air-Source

Takes heat from (and rejects heat to) outdoor air.

Inverter, inverter-driven

Variable-speed compressor.

Terminology

Ductless Heat Pump (DHP)

Pretty self-explanatory

Terminology

Mini-Split

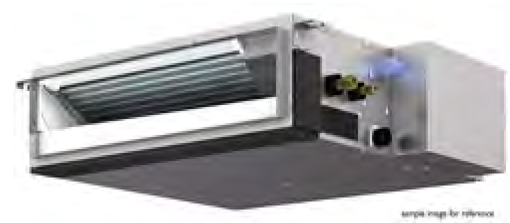
Split and mini (<1.5 tons or so)
Ducted (compact) or Ductless
Usually 1:1

OR

Terminology

Multi-Split (multi-port, multi-zone, <u>not</u> VRF)

One outdoor unit
2+ indoor units
Ducted, Ductless, or mix
1.5 – 4 tons typ.



Images from Mitsubishi

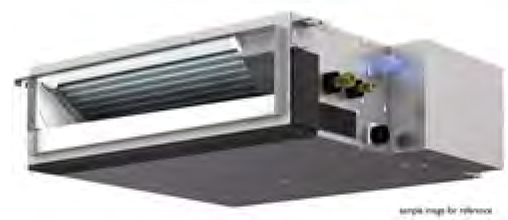
Terminology

VRF (variable refrigerant flow)

Modular outdoor units, ~6-12 tons typ.

Many indoor units, many types

Exp. valves at indoor fan coils



Images from Mitsubishi

Terminology

Central, Split

- Typ. 2 - 5 tons
- One central, ducted air handler
- More conventional residential H/C system
- "Fully ducted"

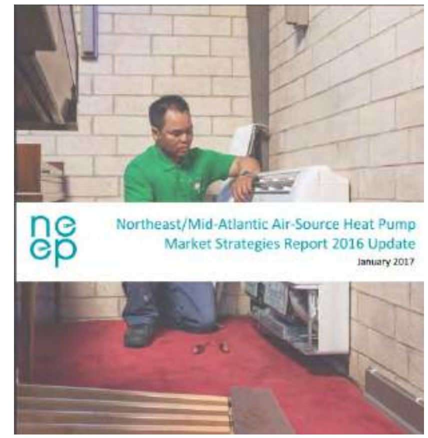
Image from Carrier

NEEP Strategy Report

NEEP Market Strategy Report

Residential market in Northeast:
- ~300,000 units/year and growing (2015)

Installed cost of ductless mini-splits
- $3,000 - $5,000 on average



http://www.neep.org/sites/default/files/NEEP_ASHP_2016MTStrategy_Report_FINAL.pdf

One big need identified in the market study:

What ASHPs are appropriate for cold climates?

Standard Info

- **HSPF** (heating season performance factor) – not a great indicator of cold weather performance

- **Manufacturer info** – Inconsistent presentation of performance data

NEEP's Cold Climate Spec.

Three key requirements:

- **Variable-speed** compressor
- At maximum capacity (heat output) **COP @ 5°F >1.75**

$$\boxed{COP = \frac{\text{Energy Out (heat)}}{\text{Energy In (elec)}}}$$

- **Provide performance data** in the specified format

Manufacturers fill this out

Outdoor Dry Bulb (°F)	Indoor Dry Bulb (°F)		Capacity Level		
			Minimum	Rated	Maximum
47°F	70°F	Btu/h			
		kW			
		COP			
17°F	70°F	Btu/h			
		kW			
		COP			
5°F*	70°F	Btu/h			
		kW			
		COP			

Optional: SECTION FOUR	Outdoor Dry Bulb (°F)*	Indoor Dry Bulb (°F)		Capacity Level		
				Minimum	Rated	Maximum
		70°F	Btu/h			
			kW			
			COP			

NEEP's Cold-Climate ASHP Spec.

http://www.neep.org/initiatives/high-efficiency-products/emerging-technologies/ashp/cold-climate-air-source-heat-pump

Download Spreadsheet

Cold Climate Air-Source Heat Pump Listing : ...

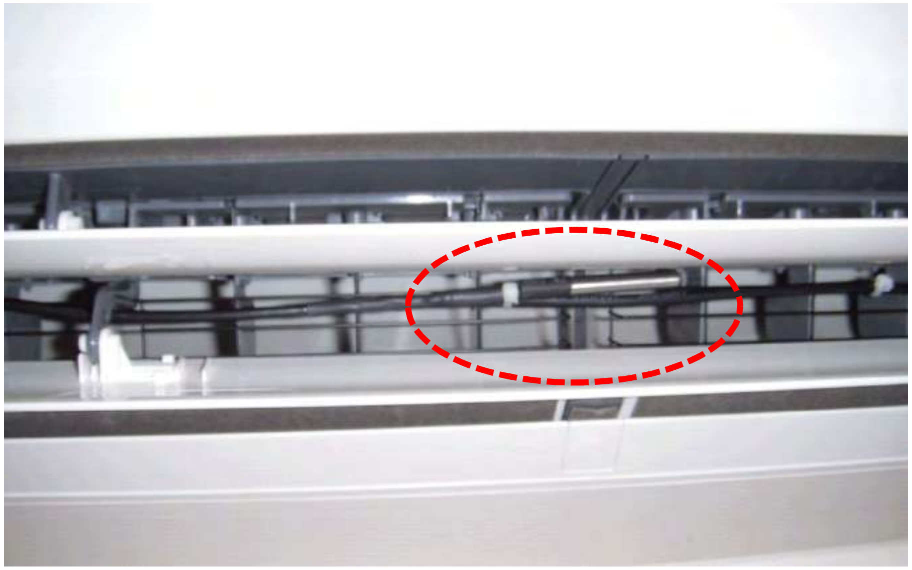
LG		7180060	LMU18CHV	Non-Ducted Indoor Units	9.7	22
LG		7180062	LMU24CHV	Non-Ducted Indoor Units	10.6	21.7
LG		7184507	LMU24CHV	Mixed	10.2	19.6
LG		8111355	LMU30CHV	Non-Ducted Indoor Units	10	22
LG		7180063	LMU36CHV	Non-Ducted Indoor Units	10	22
LG		8111358	LMU480HV	Non-Ducted Indoor Units	10	19.5
Mitsubishi		7451974	MXZ-2C20NAHZ	Non-Ducted Indoor Units	9.8	17
Mitsubishi		7451969	MXZ-3C24NAHZ	Non-Ducted Indoor Units	10	19
Mitsubishi		7451794	MXZ-3C30NAHZ	Non-Ducted Indoor Units	11	18
Mitsubishi		7434482	MXZ-4C36NAHZ	Non-Ducted Indoor Units	11.3	19.1
Mitsubishi		7434477	MXZ-5C42NAHZ	Non-Ducted Indoor Units	11	19
Mitsubishi		4908219	MUZ-FE09NA	MSZ-FE09NA	10	26
Mitsubishi		4934170	MUZ-FE12NA	MSZ-FE12NA	10.5	23
Mitsubishi		4217888	MUZ-FE18NA	MSZ-FE18NA	10.3	20.2
Mitsubishi		7002062	MUZ-FH09NA	MSZ-FH09NA	13.5	30.5
Mitsubishi		7002063	MUZ-FH12NA	MSZ-FH12NA	12.5	26.1
Mitsubishi		7002444	MUZ-FH15NA	MSZ-FH15NA	12	22

How do ASHPs actually perform in buildings?

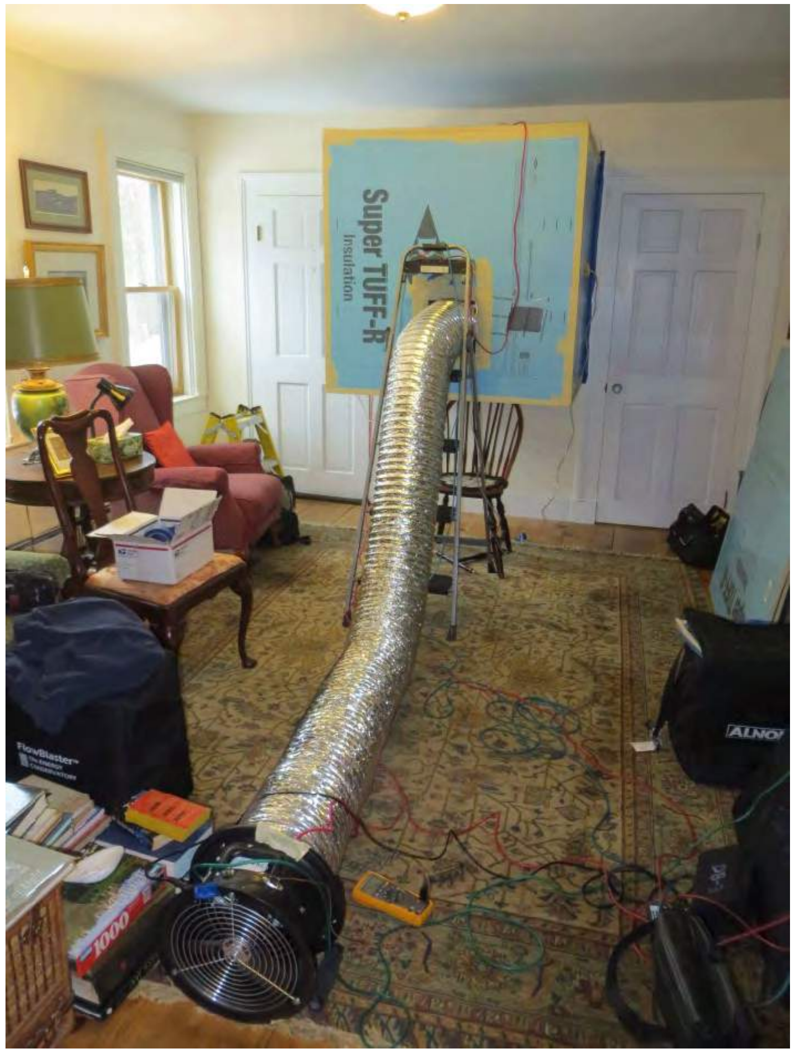
Field Evaluations

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

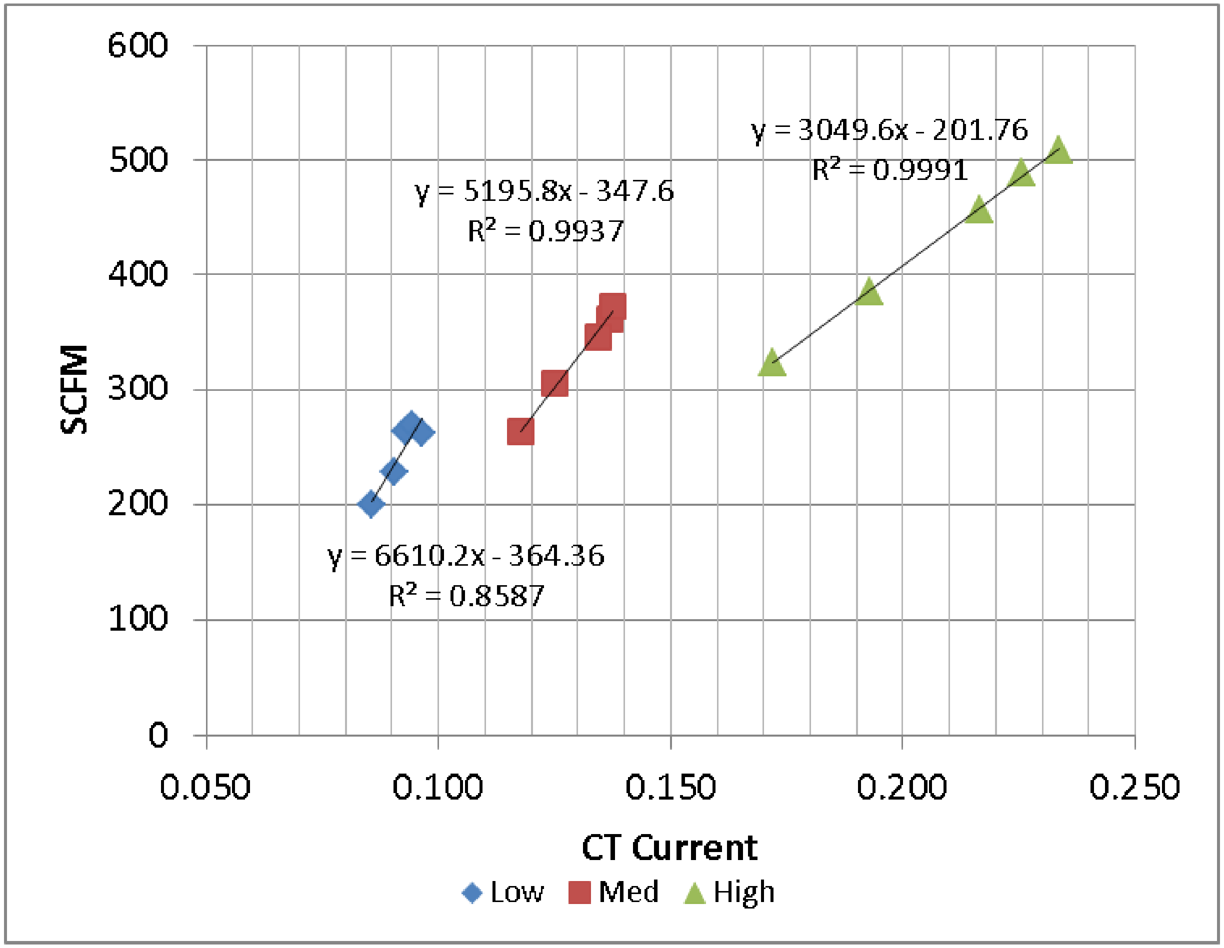
Air Temperatures



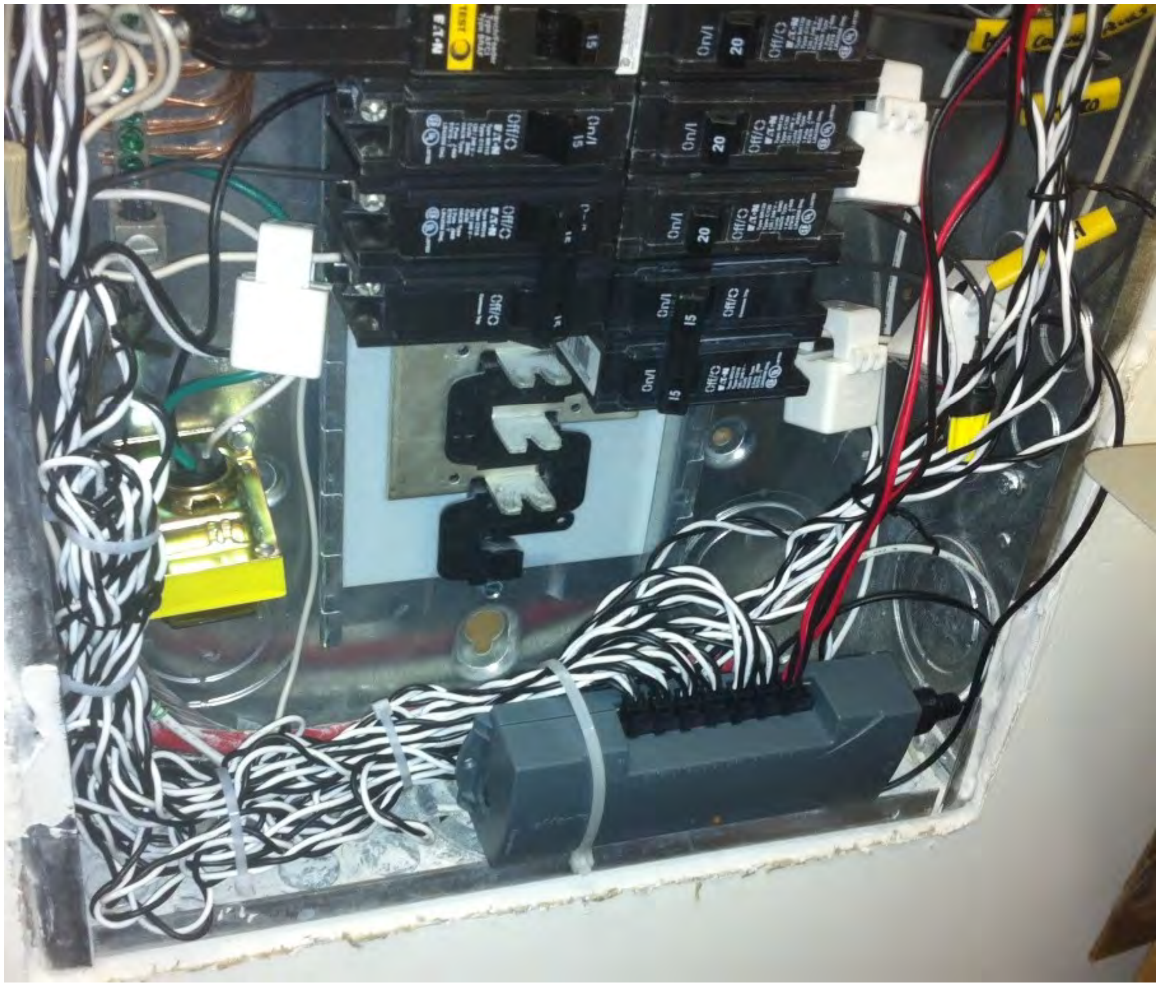
Flow Testing



Flow vs. Fan Current



Powerwise / Site Sage



Measured COP

$$\text{COP}=\frac{\text{Energy Out (Flow, Temperature diff.)}}{\text{Energy In (Elec. Panel)}}$$

Seasonal COP Summary

	Site						
	1	2	4	5	8	9	10
Overall	**1.6**	**2.0**	**2.3**	**1.7**	**2.3**	**1.1**	**2.1**

Seasonal COP Summary

	Site						
	1	2	4	5	8	9	10
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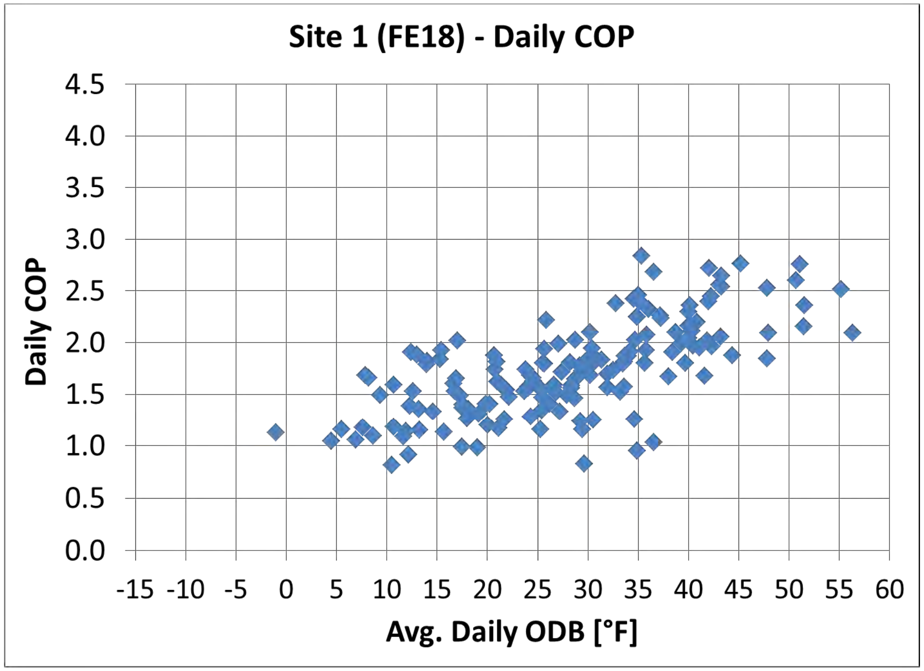
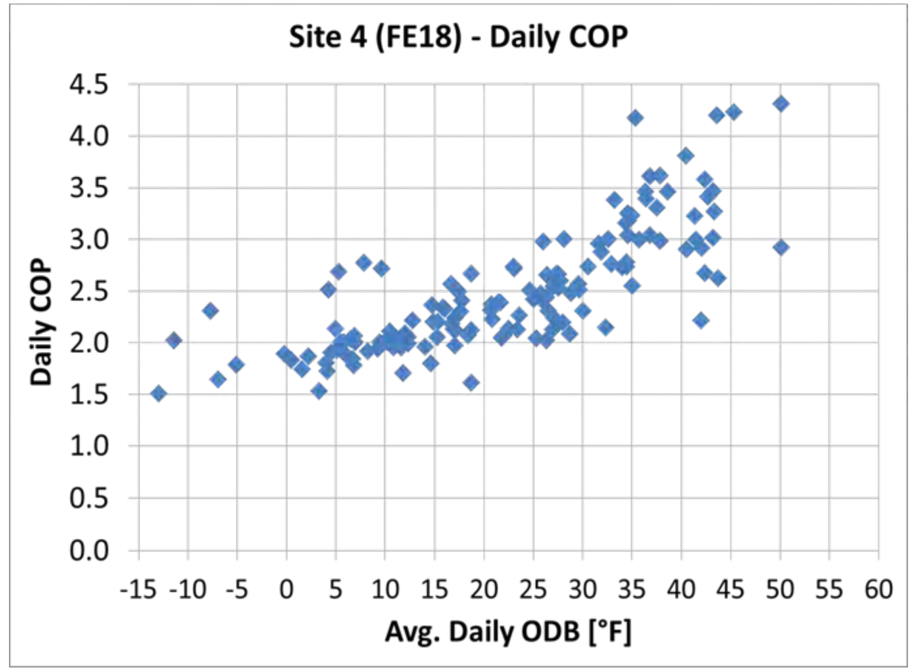
Same HP- Different Results



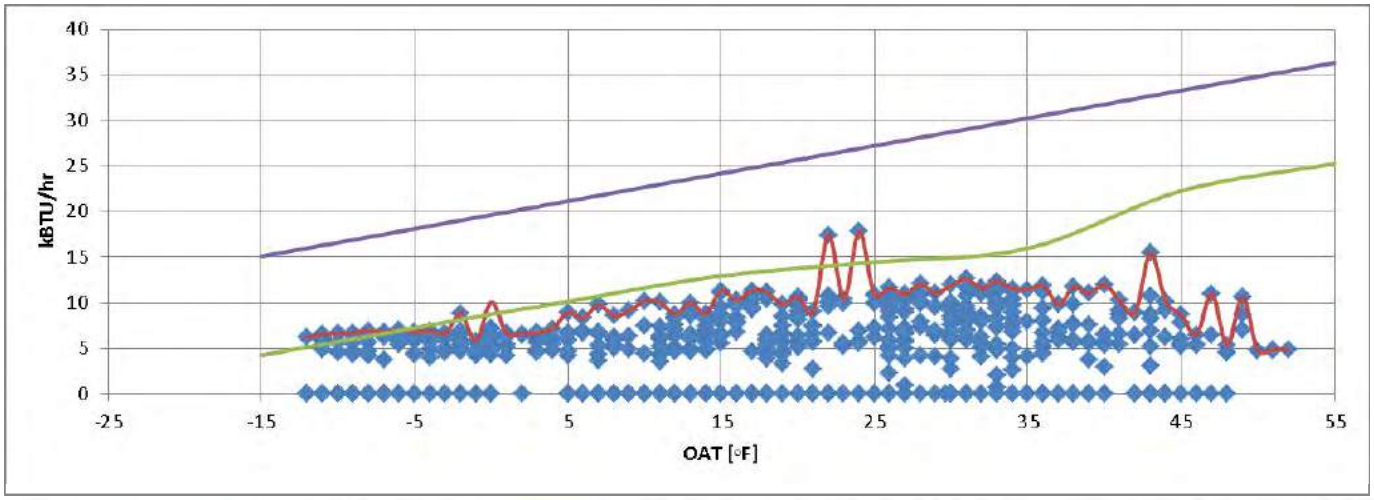


Western MA
HDD65: 6,929
Design Temp: 2°F
SCOP: 1.6

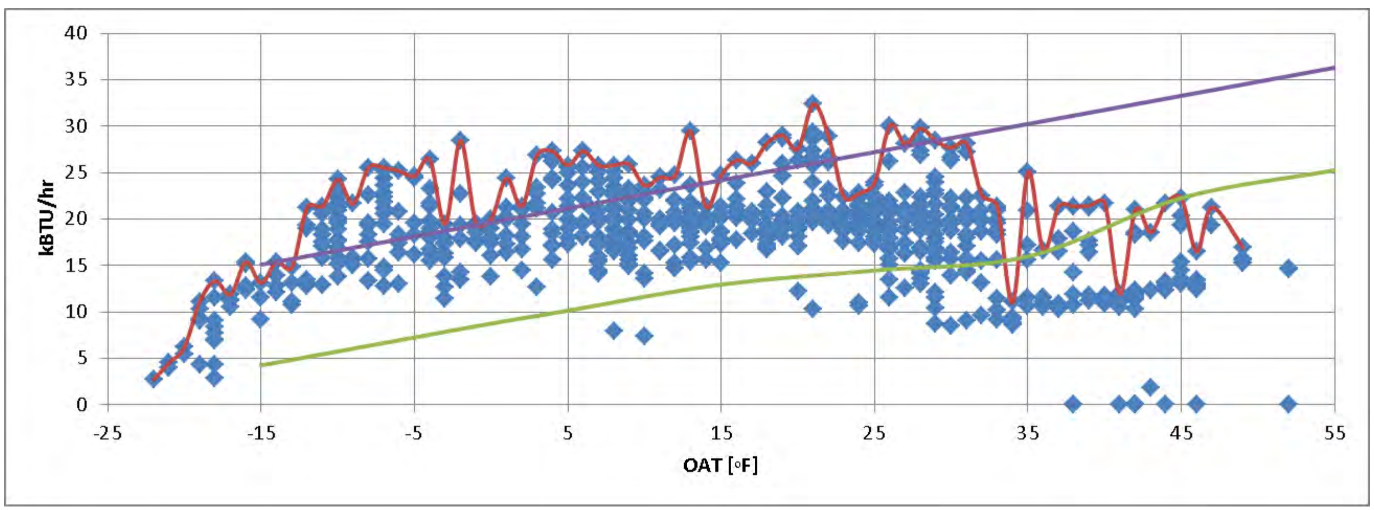
Near Burlington, VT
HDD65: 7,956
Design Temp:-4°F
SCOP: 2.3

Heat Output-FE18

Site 1



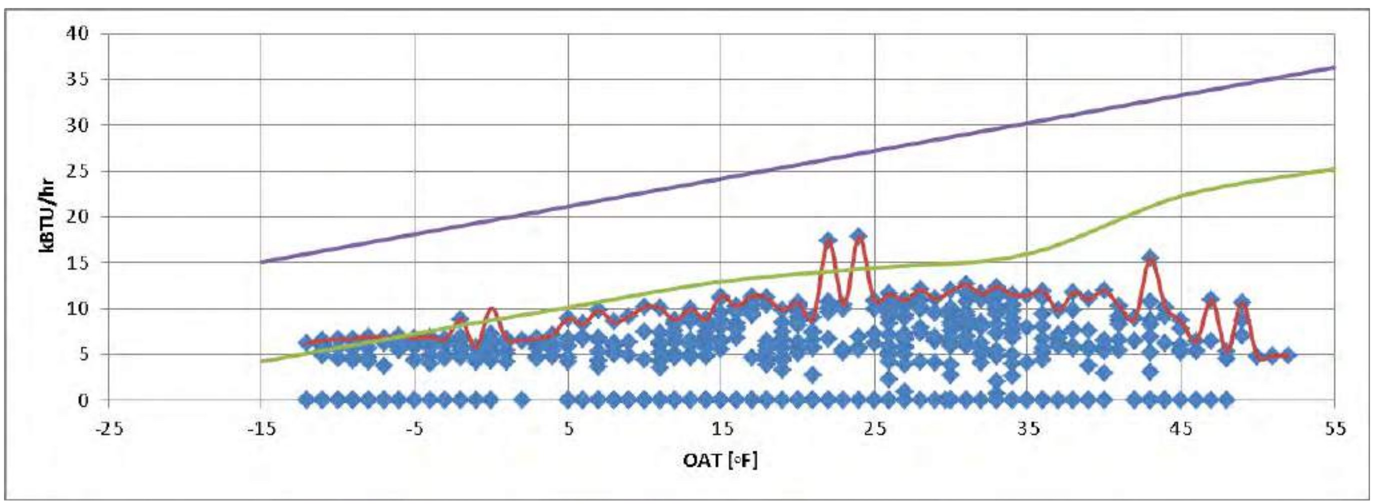
Site 4



Possible Reasons for Lower Performance

- Charge?
- Lower heating load
- Low fan speed

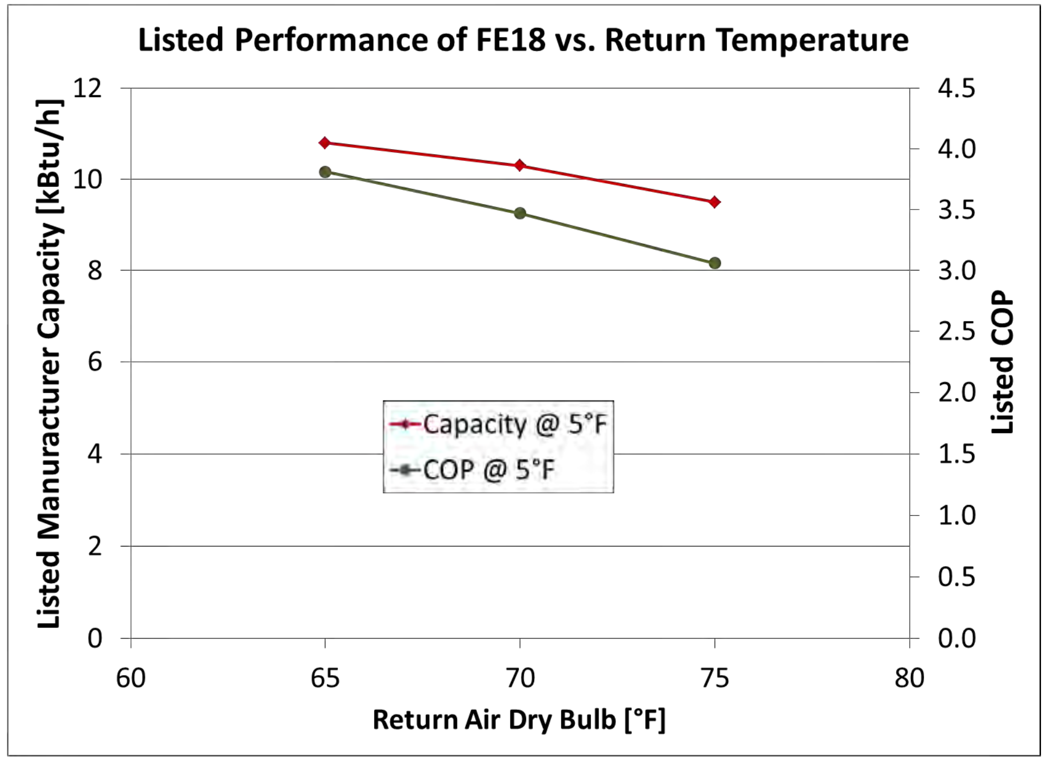
Site 1



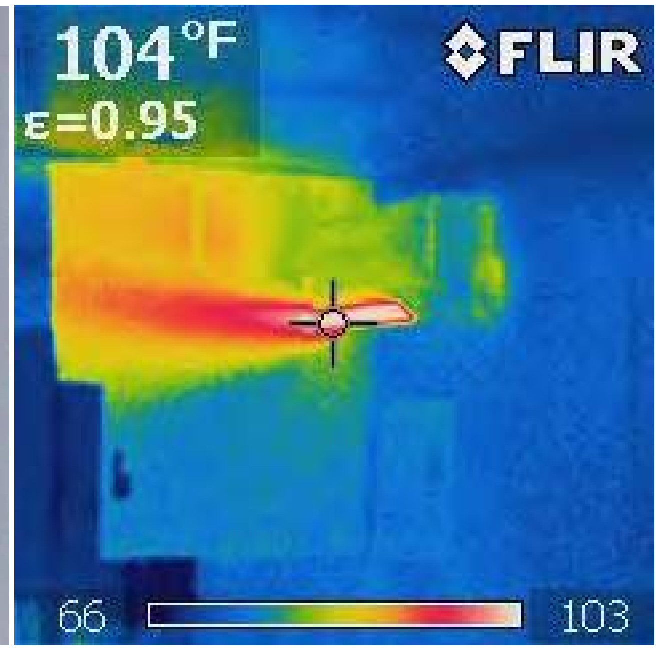
Possible Reasons for Lower Performance

- Charge?
- Lower heating load
- Low fan speed
- Higher return air temperatures

High Return Temp?



High Return Temp?

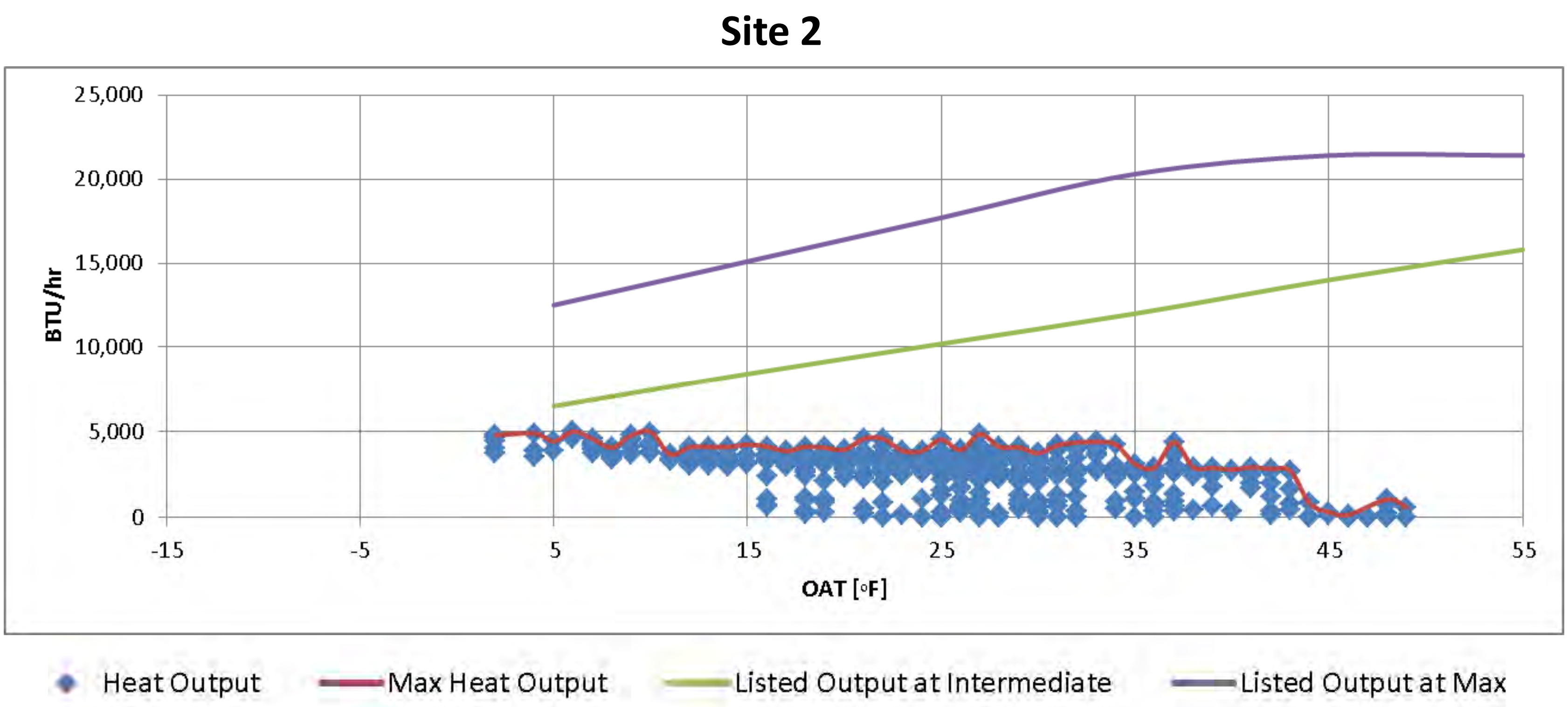


Possible Reasons for Lower Performance

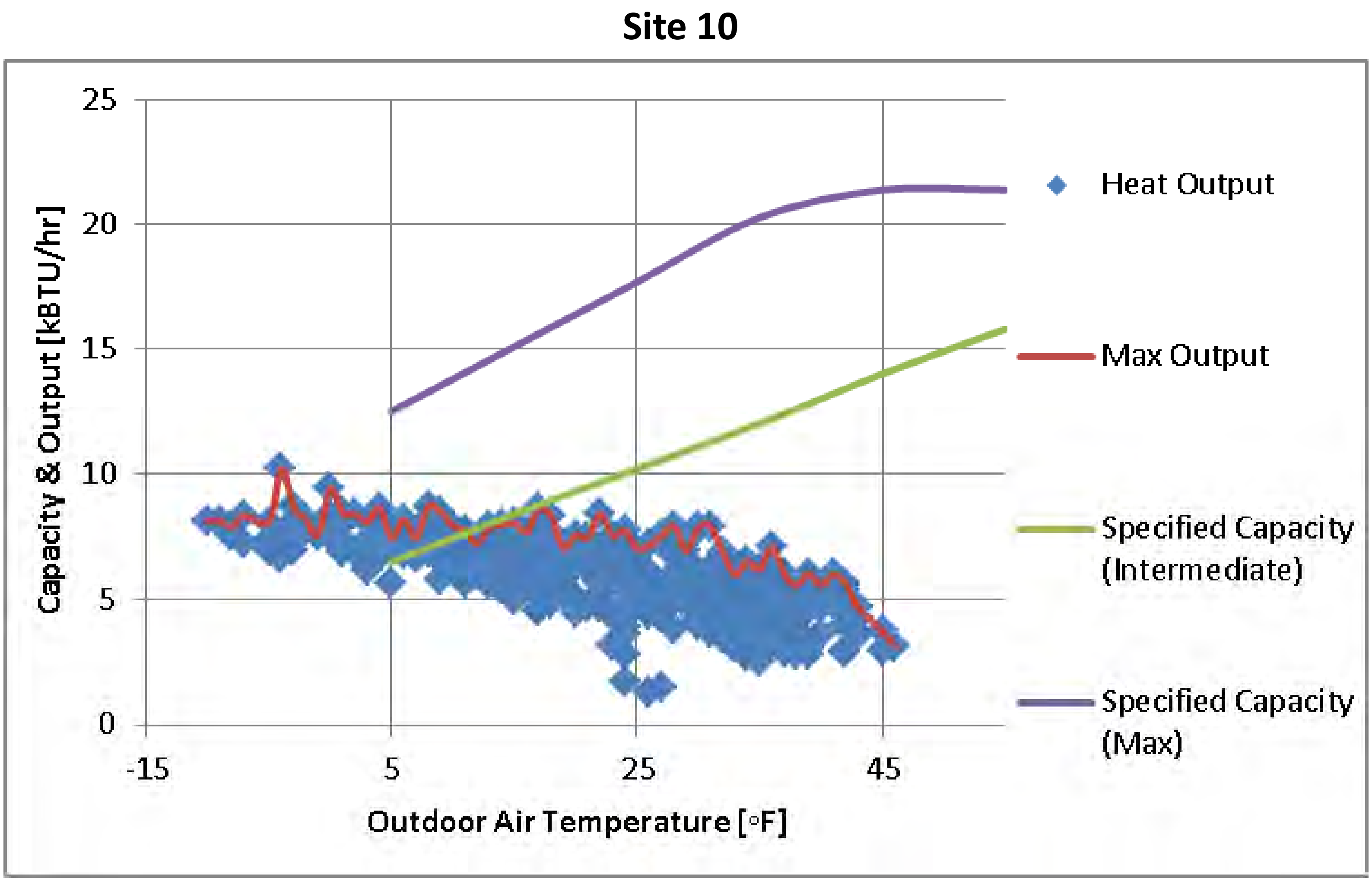
- Charge?
- Lower heating load
- Low fan speed
- Higher return air temperatures
- Setback/control

Site 2 – CT Passive House

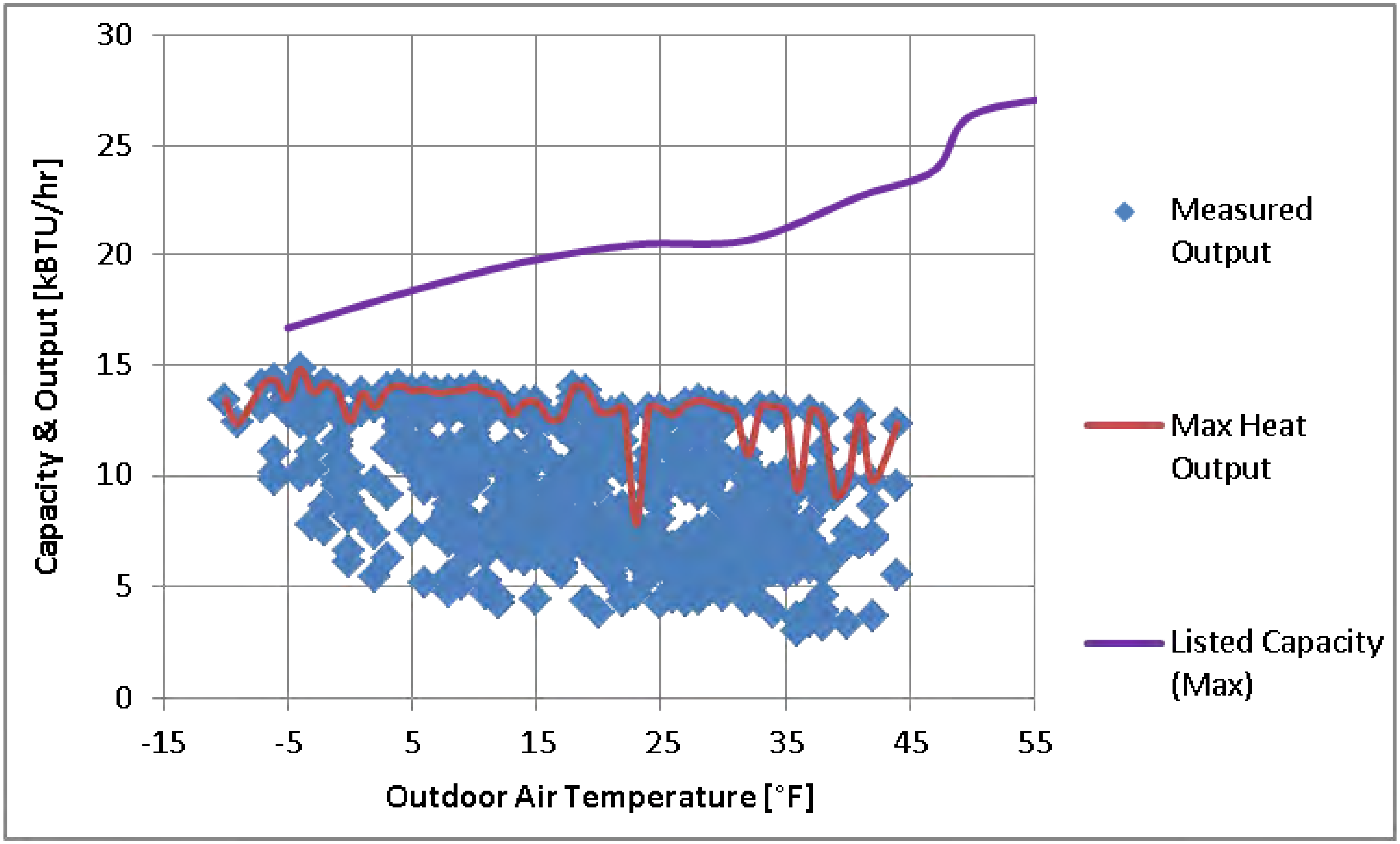
Heat Output – FE12



Heat Output – FE12



Heat Output – Fujitsu 15RLS2



Conclusions

Capacity

In general, ASHPs <u>DO</u> provide rated heat output.

Efficiency

WIDE range in efficiencies; often not as efficient as we'd hoped…

More recent study:

http://ma-eeac.org/wordpress/wp-content/uploads/Ductless-Mini-Split-Heat-Pump-Impact-Evaluation.pdf

Energy Modeling

PHPP:	613 kWh/y
BEopt (Energy Plus):	738 kWh/y
REM/Rate:	1,053 kWh/y

Measured ASHP Electricity: 1,446 kWh/y

(for heating season only)