aeroseal®

Transitioning to Electrification-Ready: The 3% Solution and Heat Pump Optimization

Duct Distribution Efficiency

Real Savings from Sealing Ducts - McKinsey

	Factory-Designed Efficiency	Delivered Efficiency with Unsealed Ducts			
		2% or Less (SEALED)	10% Leakage	20% Leakage	30% Leakage
A/C and Heat Pumps	24 SEER	23.3	20.3	16.6	12.9
	22 SEER	21.3	18.6	15.2	11.9
	20 SEER	19.4	16.9	13.9	10.8
	18 SEER	17.5	15.2	12.5	9.7
	16 SEER	15.5	13.5	11.1	8.6
	14 SEER	13.6	11.9	9.7	7.6
Furnaces	95% AFUE	93	85	76	67
	90% AFUE	88	81	72	63
	80% AFUE	78	72	64	56

McKinsey: Energy Efficiency Potential

Greater Impact for Heat Pumps

- Remove Furnace, Add Heat Pump

Duct efficiency goes down significantly

Duct Efficiency Results – Supply Losses

	N. Bend	Portland	Medford	Boise	Spokane	Missoula
Loss Component	Annual Duct Efficiency (%)					
Supply – furnace						
20% leak	77.2	78.2	75.9	76.3	76.3	75.8
10% leak	88.7	88.3	88.0	88.2	88.2	88.0
R-1.5 ducts	86.7	86.3	85.9	86.3	86.2	85.8
R-4 ducts	94.8	94.6	94.4	94.5	94.5	94.4
R-8 ducts	97.3	97.2	97.2	97.2	97.2	97.1
Supply – heat pump						
20% leak	72.0	67.9	64.1	59.6	58.9	57.7
10% leak	86.4	84.5	82.5	78.7	78.3	77.0
R-1.5 ducts	83.6	81.5	79.4	75.0	74.6	73.1
R-4 ducts	93.3	92.2	91.4	89.6	88.9	87.9
R-8 ducts	96.6	96.0	95.9	94.6	94.6	94.0

ILLINOIS APPLIED RESEARCH INSTITUTE
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

INDOOR CLIMATE RESEARCH AND TRAINING

Impact of Duct Leakage

Heat pump

- 1200 CFM for 36,000 BTU

Gas furnace

- 1200 CFM for 72,000 BTU

Leaks increase HVAC load for house

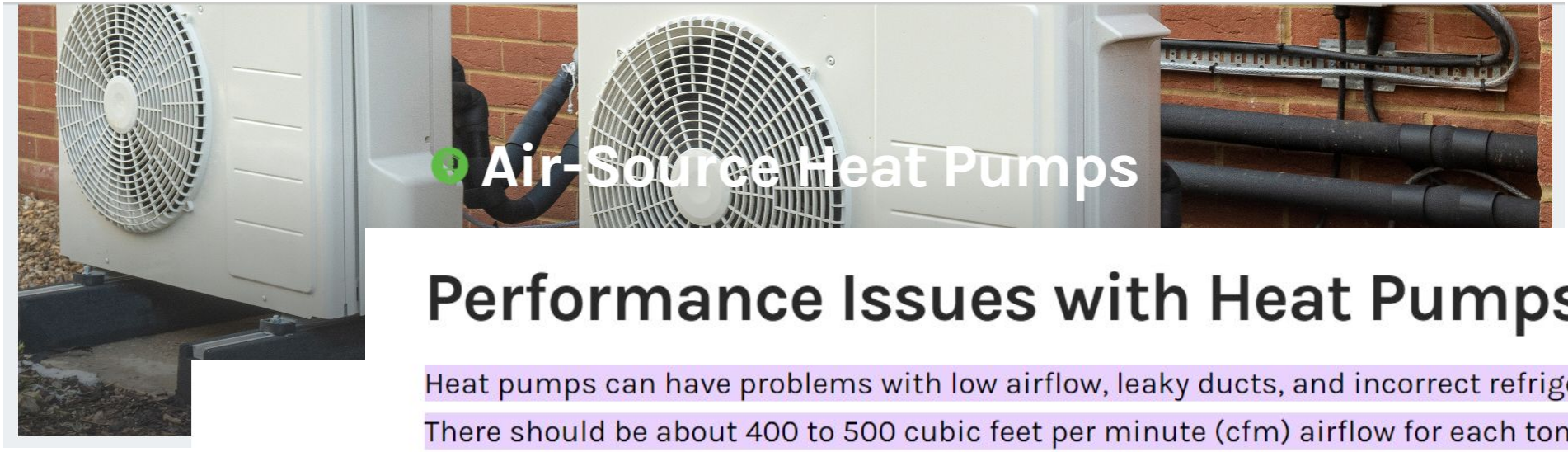
Increase load will increase resistance heat

Heat Pump Performance

ENERGY.GOV | Newsroom | Careers | Energy.gov Offices | National Labs | Search Energy.gov

ENERGY SAVER | ABOUT US | RESOURCES | HOME COMFORT | WATER | EFFICIENT DESIGN | RENEWABLES & ELECTRICITY | TRANSPORTATION

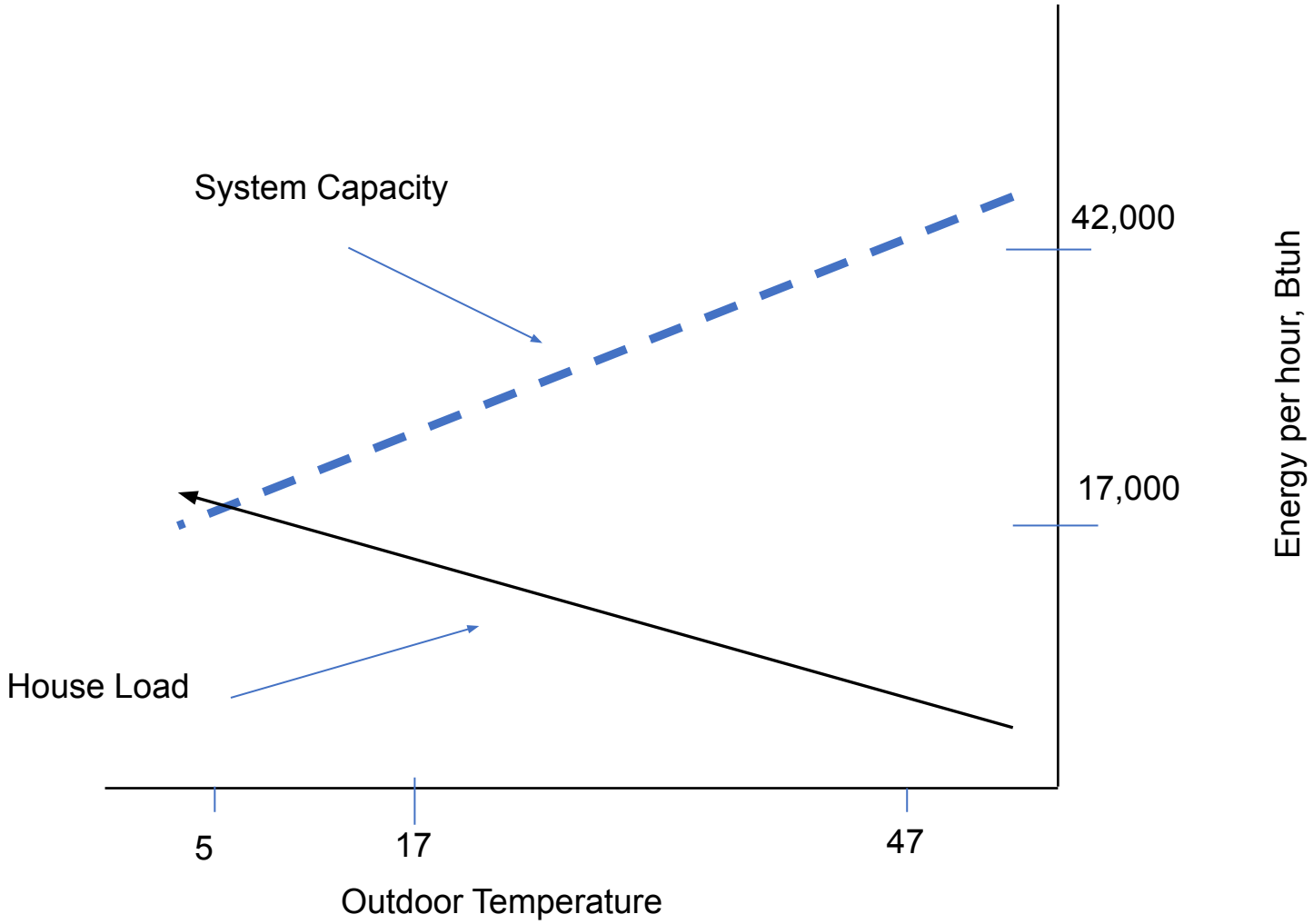
HOME COMFORT



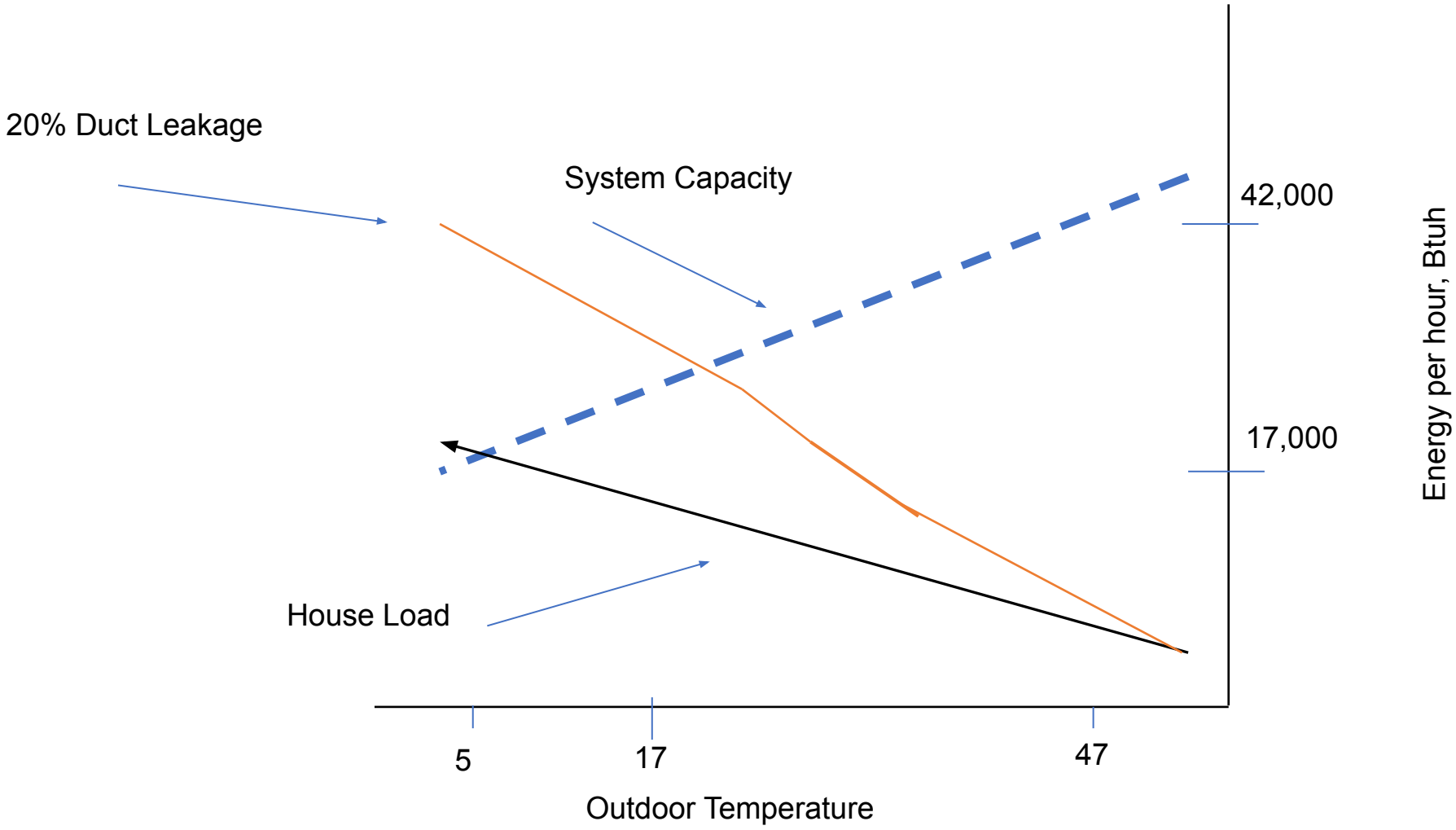
Performance Issues with Heat Pumps

Heat pumps can have problems with low airflow, leaky ducts, and incorrect refrigerant charge. There should be about 400 to 500 cubic feet per minute (cfm) airflow for each ton of the heat pump's air-conditioning capacity. Efficiency and performance deteriorate if airflow is much less than 350 cfm per ton. Technicians can increase the airflow by cleaning the evaporator coil or increasing the fan speed, but often some modification of the ductwork is needed. See minimizing energy losses in ducts and insulating ducts.

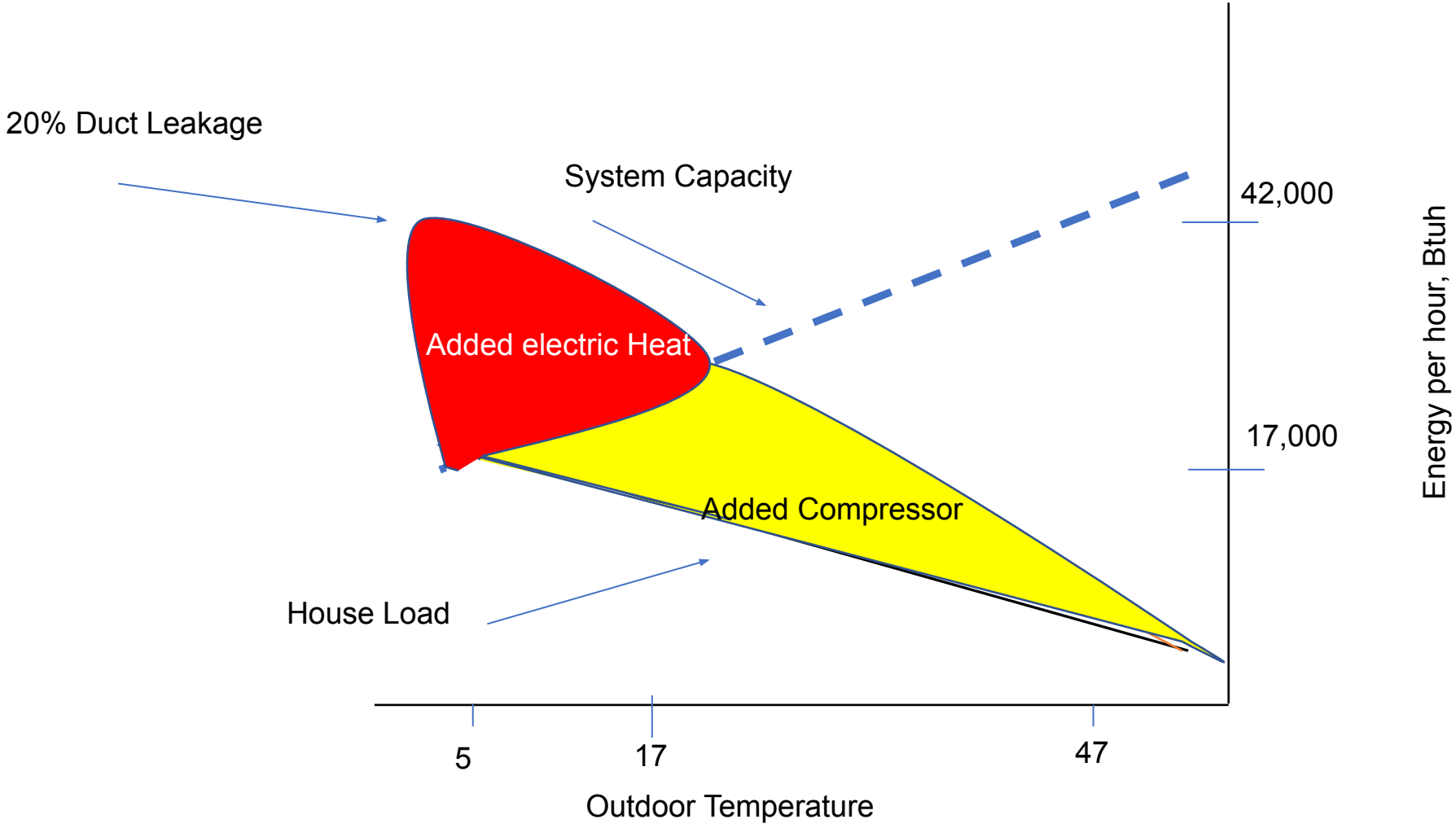
Heat Pump Performance



Impact of Ducts

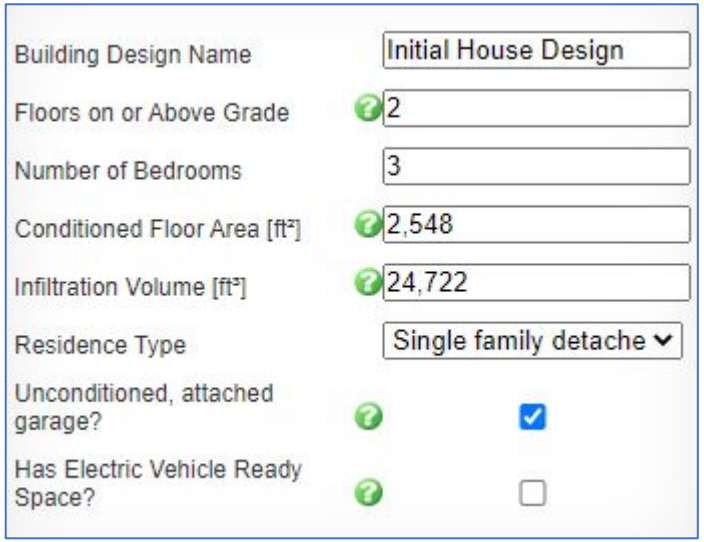


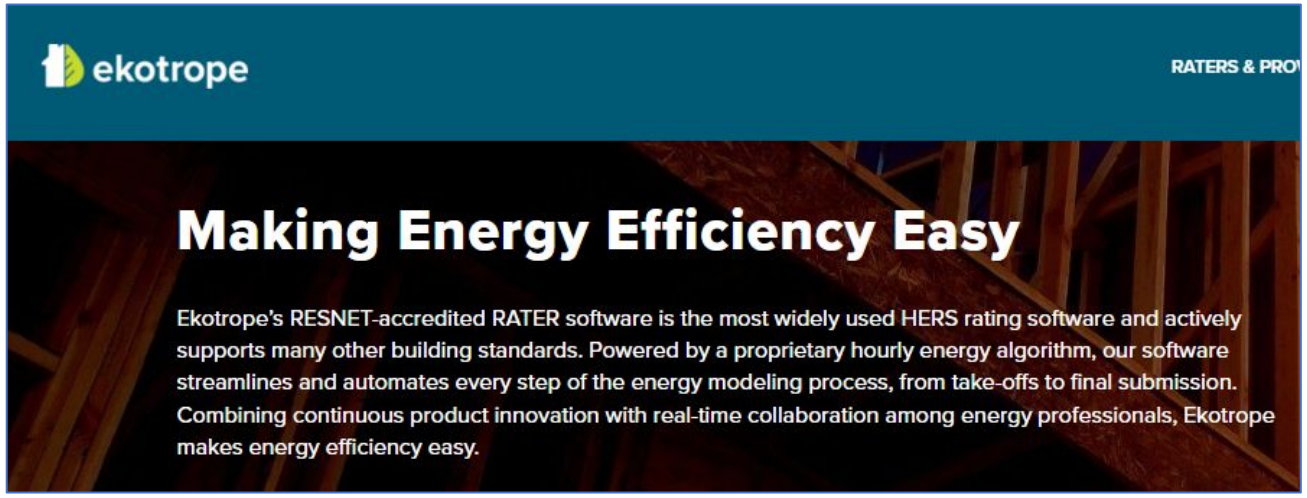
Impact of Ducts



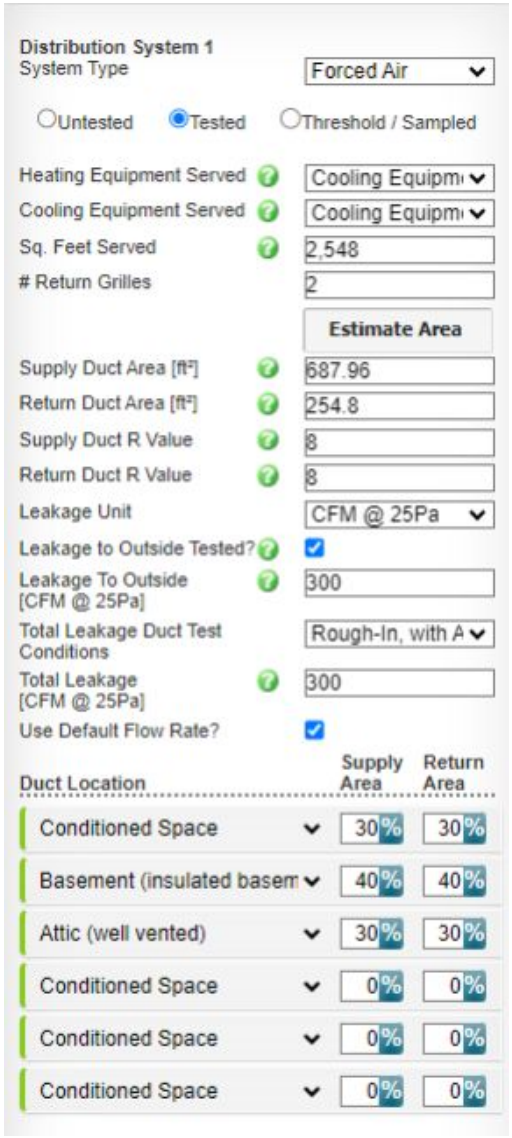
Ekotrope – Duct Design

- 3rd party rating software designed to assist in HERS ratings as well as support other building standards. High amount of precision in determining how a house performs as well as how changes might impact energy usage.
- Software allows user to easily drag and drop new equipment in and see resultant HERS





Ekotrope – Duct Design



0.1 " W.C.

RESStock Data Base

- Over 3,000 seals across NY
- Average of 200 CFM sealed

Ekotrope – Initial Design

Energy Bill Breakdown [$]	
Heating Costs	$448
Cooling Costs	$139
Water Heating Costs	$131
Lights and Appliances Costs	$782
Onsite Power Production	-$0
Service Charges	$0
Total Energy Bill	$1,501

Building Design Name	Initial House Design
Floors on or Above Grade	2
Number of Bedrooms	3
Conditioned Floor Area [ft²]	2,548
Infiltration Volume [ft³]	24,722
Residence Type	Single family detache
Unconditioned, attached garage?	☑
Has Electric Vehicle Ready Space?	☐

Total Area [ft²]	
Conditioned Space	2,548.0
Conditioned Volume [ft³]	24,722.0
Shell Area	5,768.0
Above Grade Shell Area	5,768.0
Slab Floors	0.0
Foundation Walls	0.0
Framed Floors	1,200.0
Rim/Band Joists	102.0
Above Grade Walls	2,725.0
Windows	302.0
Doors	56.0
Ceilings	1,741.0
Skylights	0.0
Ducts	942.8

Ratios	
Window to Wall Ratio	0.111
Window to Floor Ratio	0.119
Average Ceiling Height	9.703
Ceiling to Floor/Slab Ratio	1.451

Window Areas by Orientation	
North Window Area	108.0
North # of Windows	2
Northeast Window Area	0.0
Northeast # of Windows	0
East Window Area	15.0
East # of Windows	1
Southeast Window Area	0.0
Southeast # of Windows	0
South Window Area	145.0
South # of Windows	1
Southwest Window Area	0.0
Southwest # of Windows	0
West Window Area	34.0
West # of Windows	1
Northwest Window Area	0.0
Northwest # of Windows	0
TOTAL Window Area	302.0
TOTAL # of Windows	5

Mechanical Equipment

Mechanical Equipment 1

Name	Heating Equipment
Type	FURNACE,AFUE:95,60
	Edit Add Copy
Serial Number	
% Heating Load Served	100
Location	Unconditioned Basen

Remove Copy

Mechanical Equipment 2

Name	Cooling Equipment
Type	ACC,36K,13SEER
	Edit Add Copy
Serial Number	
% Cooling Load Served	100
Location	Unconditioned Basen

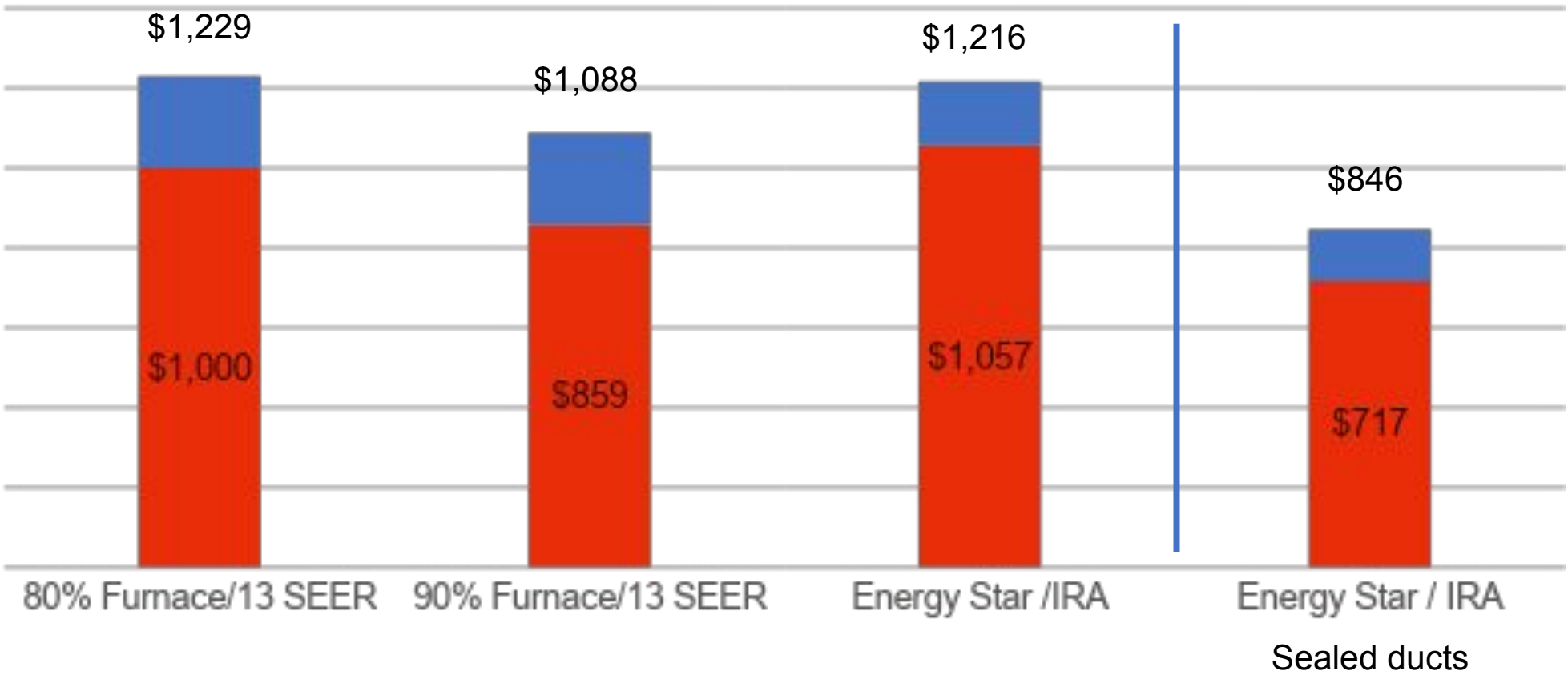
Remove Copy

Mechanical Equipment 3

Name	Water Heater
Type	TANKLESS,AFUE:95,H
	Edit Add Copy
Serial Number	
% Hot Water Load Served	100
Location	Unconditioned Basen

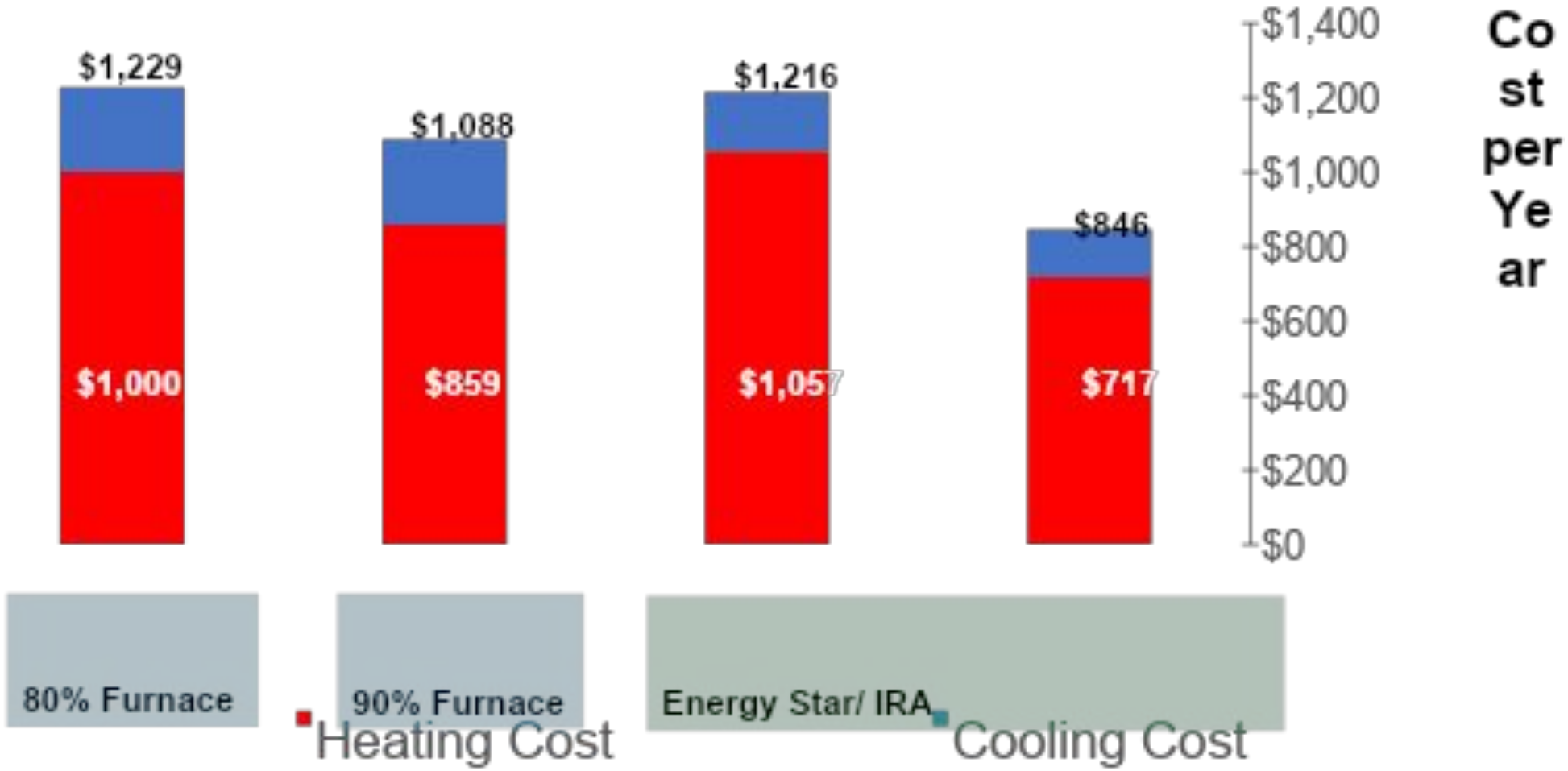
Remove Copy

Heating Options - NY



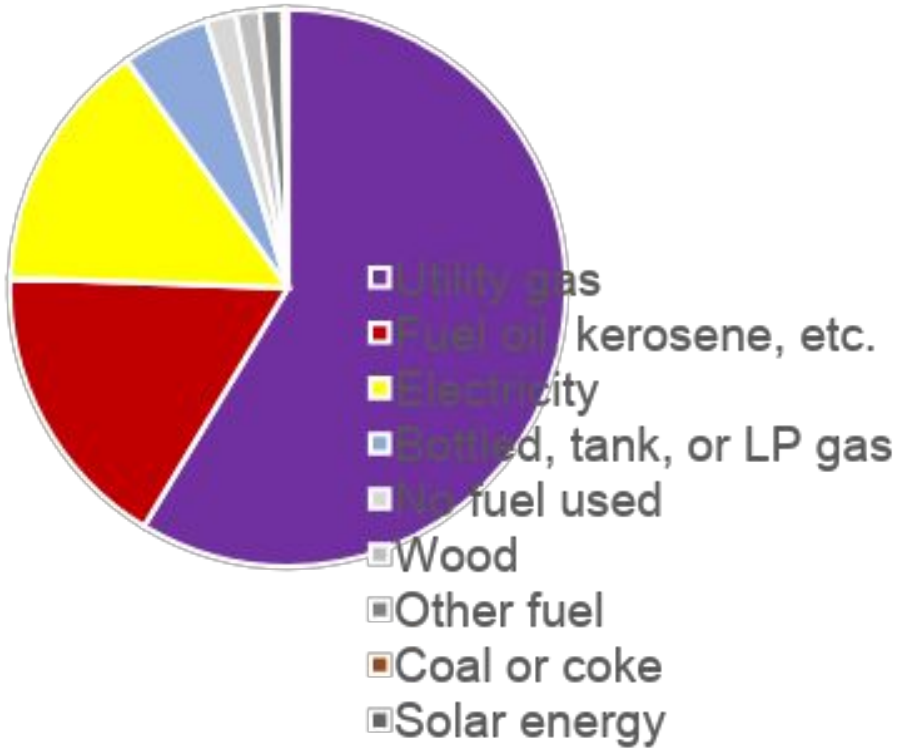
Electric: 22.27 cents Natural Gas $1.97 Therm 3 ton/60k furnace

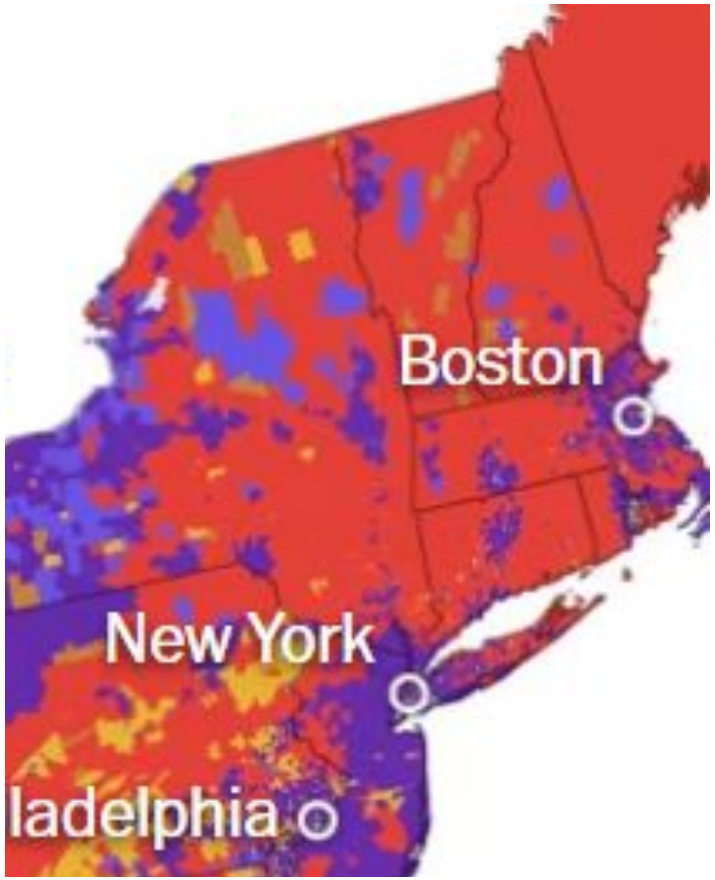
Heating Options - NYS



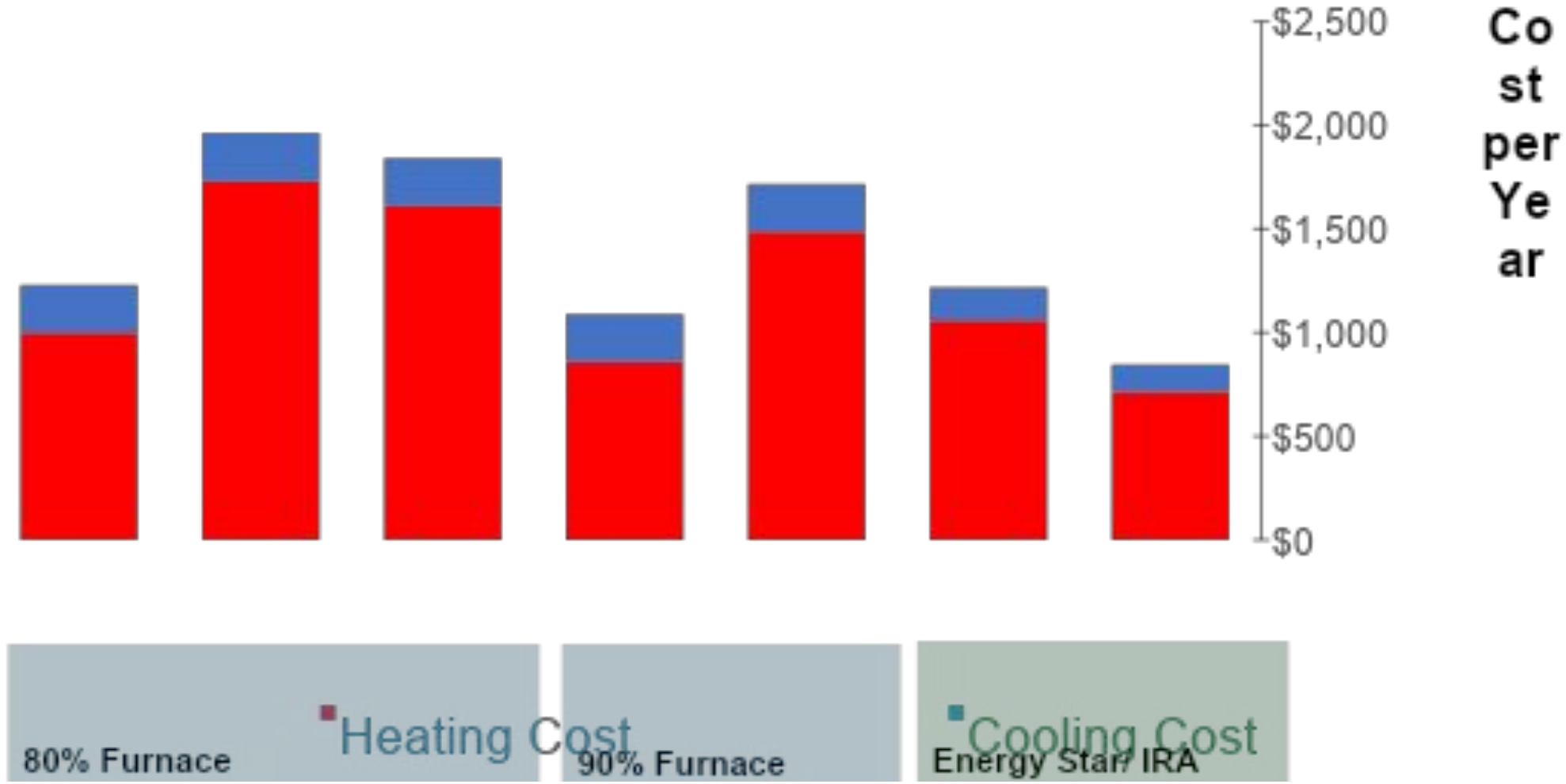
Electric: 22.27 cents Natural Gas $1.97 Therm 3 ton/60k furnace

Northeast Heating by Fuel Type



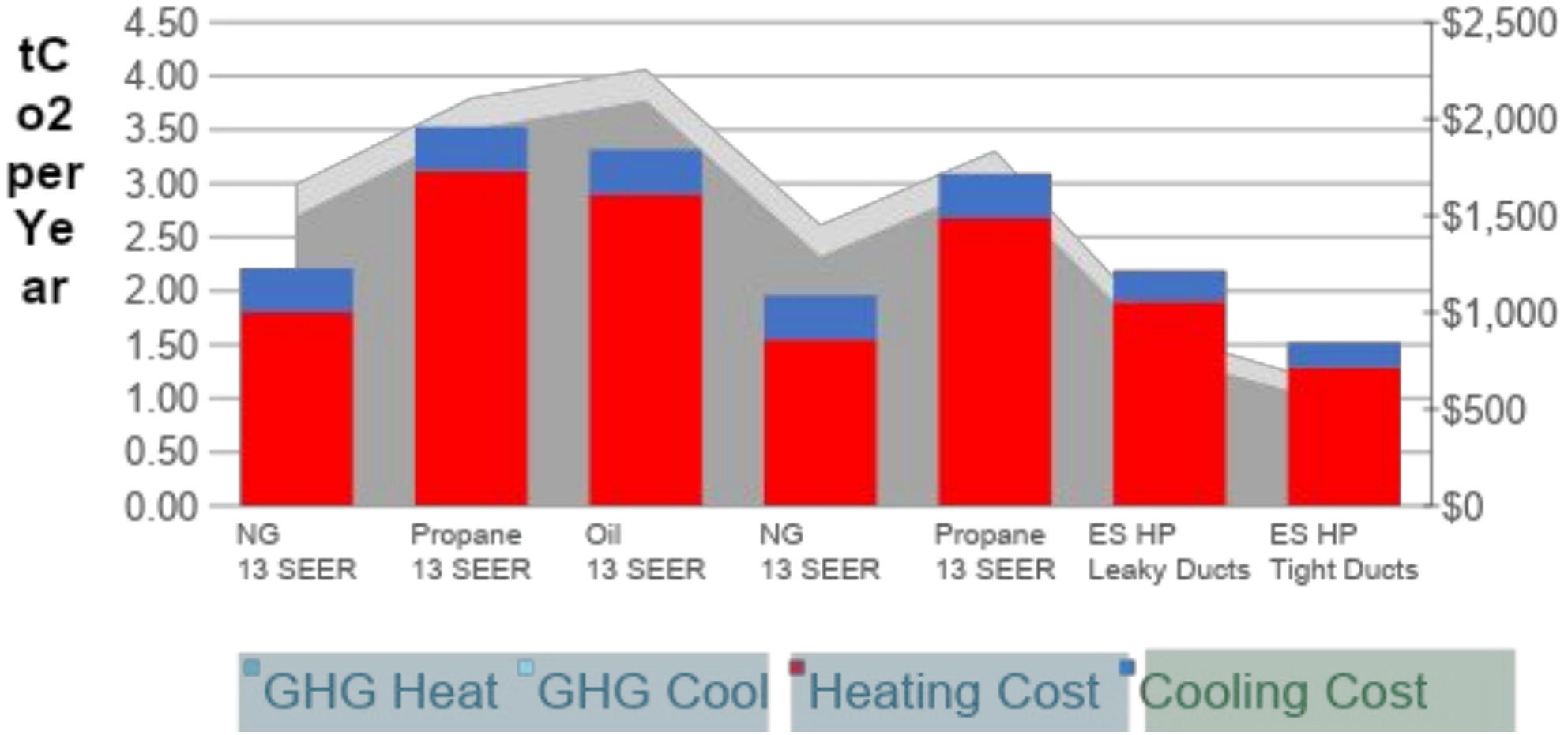


Heating Options - NYS



Electric: 22.27 cents Natural Gas $1.97 Therm 3 ton/60k furnace

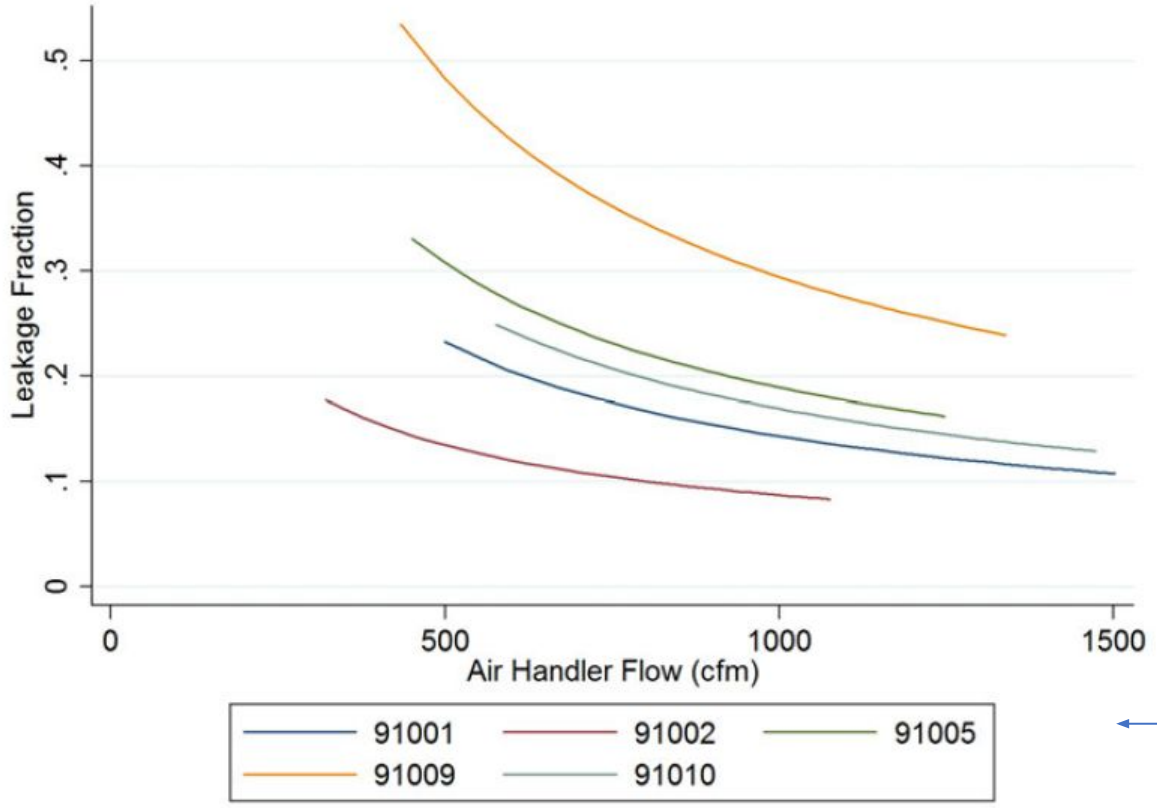
GHG by Heating Type - NYS



Electric: 22.27 cents Natural Gas $1.97 Therm 3 ton/60k furnace

Variable Speed Ducted – Cold Climate

Lower system flows lead to larger percentage losses*



Five sample houses

Figure 5. Leakage Fraction vs. System Airflow – All Sites

Variable Speed Ducted

Design Heat Load with & without Duct Loss

Table 4. Heat Pump Balance Point Inputs and Result (Bend, OR design temp = 4° F)

Site ID	Peak total UA† (BTU/hr °F)	DHL base‡ (BTU/hr)	DHL w/DE†† (Btu/hr)	HP Balance Point (°F)	Heat Pump Size (tons)
91001	896	63,638	97,122	41	3
91002	283	19,260	26,814	12	2
91004	1126	72,632	72,632	36	3
91005	580	40,996	69,719	26	3
91009	502	37,452	72,367	20	4
91010	632	42593	66,391	17	4

†Shell plus infiltration heat loss at heating design temperature
‡Design Heating Load without duct losses at the design temperature
††Design Heating Load with duct losses included

Distribution Efficiency

ulated Average Distribution System Efficiency

Site ID	System Airflow (CFM)	Supply Buffer Zone Temp (°F)	Supply Leakage Fraction	Return Leakage Fraction	Distribution Efficiency
91001	675	56.8	0.08	0.11	0.65
91002	550	55.2	0.13	0	0.82
91004	722	n/a	0	0	1.0
91005	766	55.9	0.07	0.17	0.61
91009	748	65.3	0.18	0.19	0.49
91010	1159	57.7	0.13	0.02	0.68

Duct Characteristics

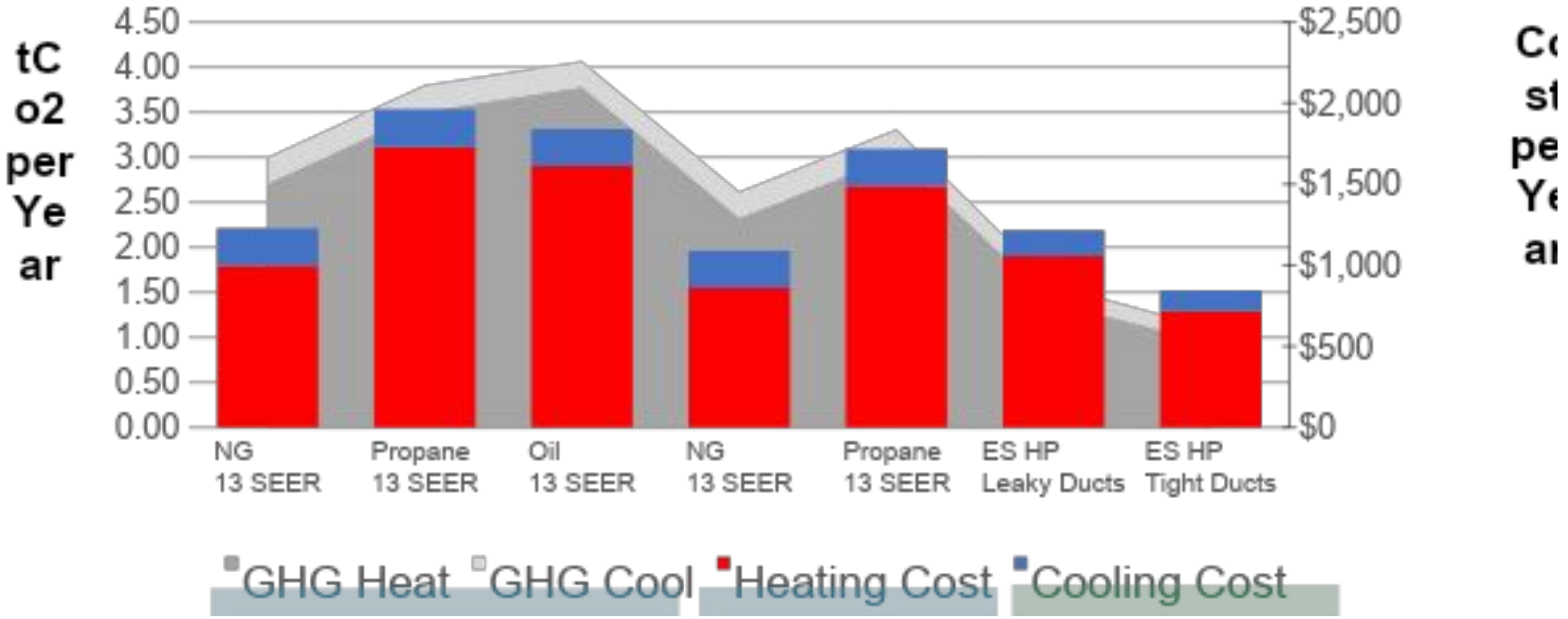
Airflow and Leakage

Site ID	Both sides duct leak to out at 50 Pa* (SCFM)	Supply duct leak to out at 50 Pa* (SCFM)	Reference‡ Air Handler Flow (CFM, SCFM)*	Reference‡ supply static pressure (Pa)	Reference‡ return static pressure (Pa)
91001	231	151	943, 1061	18	-84.5
91002	276	275	688, 774	16	-21
91004	n/a	n/a	889, 1000	21.5	-48
91005	273	131	924, 1040	26	-72.5
91009	329	208	1340, 1395	50	-139
91010	148	131	1271, 1430	116	-158

* Leakage and air handler flow results corrected to standard air (68°F and 1 atmosphere). The elevation of houses in the Bend area (about 3,000 ft above sea level) means the density is about 89% of the density of standard air. The air handler flow values show both the local CFM and the standard CFM (SCFM).

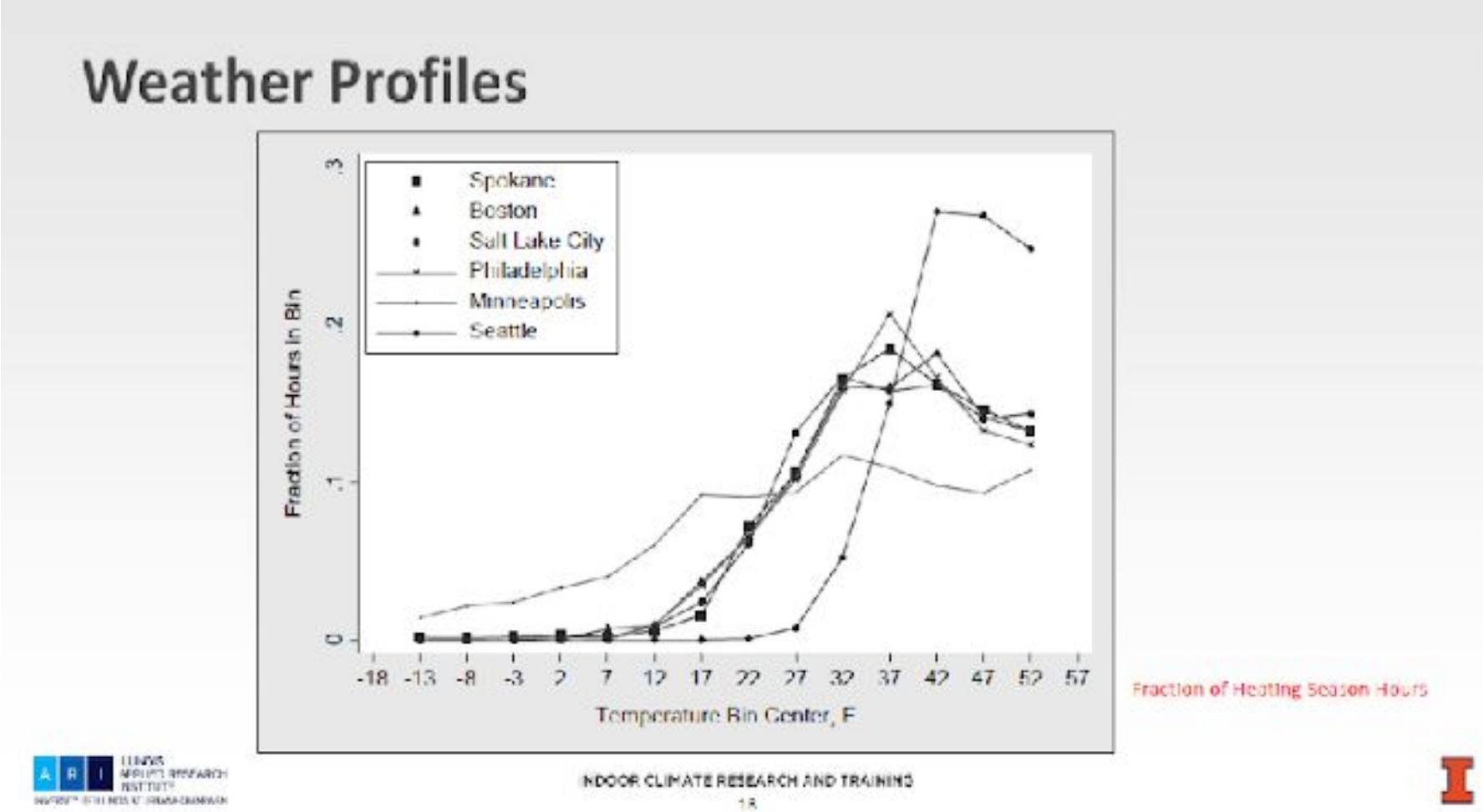
‡ "Reference" airflow corresponds to the supply and return static pressure measurements shown in the table. Typically this airflow represents the highest flow that could be attained using the User Interface (thermostat); this measurement was taken to make sure the air handler was not working against an extreme external static pressure (above 200 Pa) at its highest flow. No adverse static pressure conditions were found. All of these systems were set up by the installer in COMFORT mode (so maximum flows typically average 325-350 CFM/nominal ton of capacity).

GHG by Heating Type - NYS



Electric: 22.27 cents Natural Gas $1.97 Therm 3 ton/60k furnace

I LOVE HEAT PUMPS



Most heating time is spent in zone where heat pumps can be efficient

IRA Impact

INCOME ELIGIBILITY AND % COSTS COVERED	
LOW-INCOME: <80% Area Median Income (AMI) % costs covered (Including Installation)	100%
MODERATE-INCOME: 80-150% AMI % costs covered (Including Installation)	50%
OVERALL INCENTIVES	
Max Consumer Rebate	$14,000
Max Contractor Rebate	$500
REBATES FOR QUALIFIED ELECTRIFICATION PROJECTS	
Heat Pump HVAC	$8,000
Heat Pump Water Heater	$1,750
Electric Stove/Cooktop	$840
Heat Pump Clothes Dryer	$840
Breaker Box	$4,000
Electric Wiring	$2,500
Weatherization Insulation, Air Sealing, Ventilation	$1,600

Solution: Require bundling heat pumps with weatherization

Homerun in south with lower heating requirements

Solves installed cost

Pays for electrical

Weatherization likely makes operating cost better than just replacing furnace

Appendix

Heat Pump vs. Furnace

- Duct leakage reduces both flow and register temperatures
- Heat Pump is colder than design intent (7f)
- The extra load created by duct losses means heat pumps can not keep up with load. You must switch to emergency/back-up electric heat.

GHG Emissions

Fuel Type Comparison

Ekotrope – Initial Design

Started with a house in Salt Lake City, Utah.

Designed with a 95 AFUE, 60k furnace and a 13 SEER 3 ton AC.

Heating and Cooling costs below

Energy Bill Breakdown [$]	
Heating Costs	$448
Cooling Costs	$139
Water Heating Costs	$131
Lights and Appliances Costs	$782
Onsite Power Production	-$0
Service Charges	$0
Total Energy Bill	$1,501

Building Design Name	Initial House Design
Floors on or Above Grade	2
Number of Bedrooms	3
Conditioned Floor Area [ft²]	2,548
Infiltration Volume [ft³]	24,722
Residence Type	Single family detache
Unconditioned, attached garage?	☑
Has Electric Vehicle Ready Space?	☐

Total Area [ft²]	
Conditioned Space	2,548.0
Conditioned Volume [ft³]	24,722.0
Shell Area	5,768.0
Above Grade Shell Area	5,768.0
Slab Floors	0.0
Foundation Walls	0.0
Framed Floors	1,200.0
Rim/Band Joists	102.0
Above Grade Walls	2,725.0
Windows	302.0
Doors	56.0
Ceilings	1,741.0
Skylights	0.0
Ducts	942.8

Ratios	
Window to Wall Ratio	0.111
Window to Floor Ratio	0.119
Average Ceiling Height	9.703
Ceiling to Floor/Slab Ratio	1.451

Window Areas by Orientation	
North Window Area	108.0
North # of Windows	2
Northeast Window Area	0.0
Northeast # of Windows	0
East Window Area	15.0
East # of Windows	1
Southeast Window Area	0.0
Southeast # of Windows	0
South Window Area	145.0
South # of Windows	1
Southwest Window Area	0.0
Southwest # of Windows	0
West Window Area	34.0
West # of Windows	1
Northwest Window Area	0.0
Northwest # of Windows	0
TOTAL Window Area	302.0
TOTAL # of Windows	5

Mechanical Equipment

Mechanical Equipment 1

Name	Heating Equipment
Type	FURNACE,AFUE:95,60I
	Edit Add Copy
Serial Number	
% Heating Load Served	100
Location	Unconditioned Basen

Remove Copy

Mechanical Equipment 2

Name	Cooling Equipment
Type	ACC,36K,13SEER
	Edit Add Copy
Serial Number	
% Cooling Load Served	100
Location	Unconditioned Basen

Remove Copy

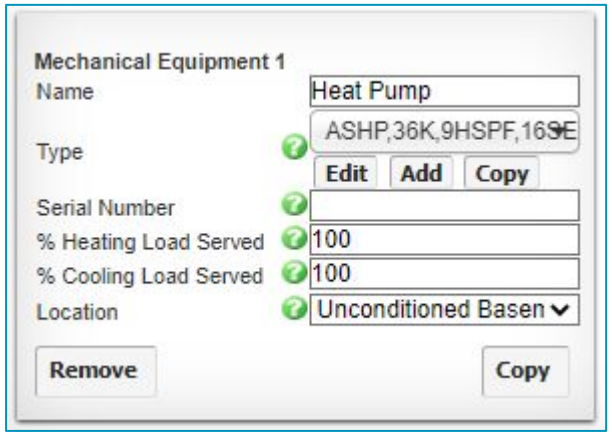
Mechanical Equipment 3

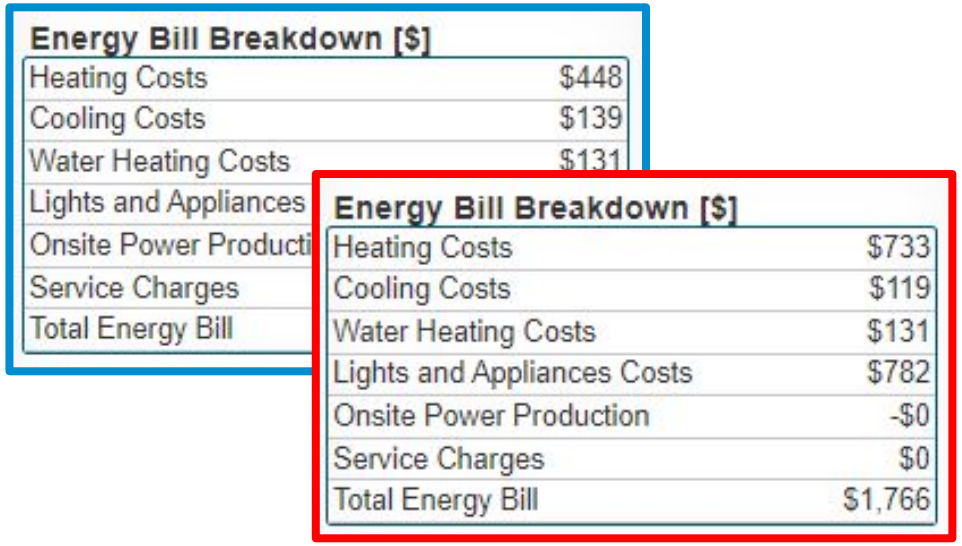
Name	Water Heater
Type	TANKLESS,AFUE:95,H
	Edit Add Copy
Serial Number	
% Hot Water Load Served	100
Location	Unconditioned Basen

Remove Copy

Ekotrope - Delta

- Replaced Furnace and AC with a 3 ton, 9HSPF, 16 SEER Heat Pump with no other changes.
- Heating costs rose from $448 to $733, a 64% increase
- Cooling costs dropped from $139 to $119, a 14% decrease
- Total cost increase of $275 per year





Ekotrope - Delta

- Replaced Furnace and AC with a 3 ton, 8.5HSPF, 15 SEER Heat Pump with no other changes.
- Heating costs rose from $448 to $776, a 73% increase
- Cooling costs dropped from $139 to $126, a 9% decrease
- Total cost increase of $314 per year