Heat Pumps

A Crash Course

Keith O’Hara

Eco Performance Builders

- Home Performance all electric retrofits
- General, HVAC, and Insulation contractor
- Design/Build/Commission

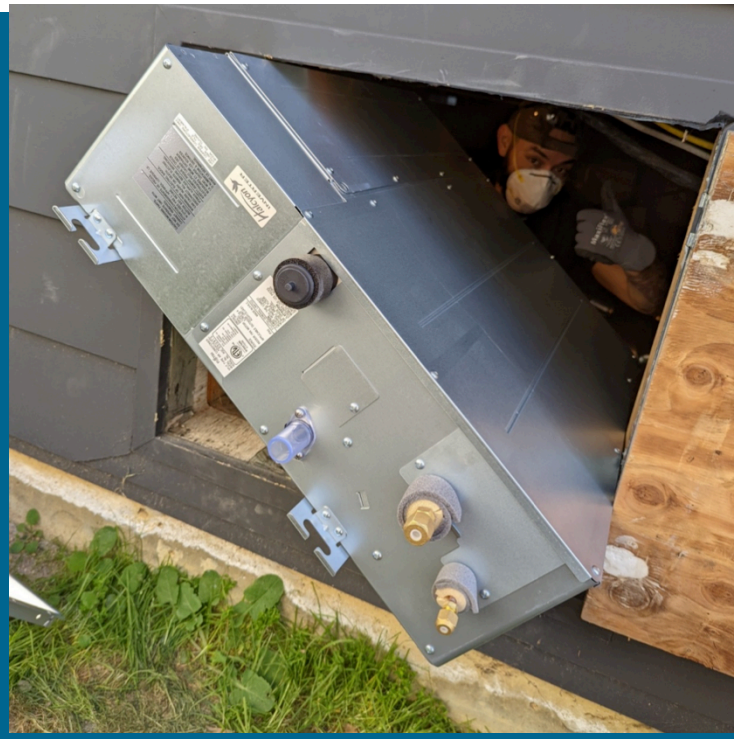
All Electric High Performance Retrofits

Goals:

- Great indoor air quality
- Comfort
- Efficiency
- All electric

Barriers:

- Our housing stock
- Is leaky
- Is poorly insulated
- Has terrible duct systems
- Some has knob and tube wiring
- A lot have asbestos ducts
- Need the air handler relocated
- Has small crawlspaces
- Has small attics



Barriers continued:

- Space for equipment and return
- Space for outdoor units
- Heat pump water heater location & noise issues
- The HVAC industry is largely unaware of how poorly their equipment performs

Panel capacity and space

Design

We need a layout

Window type and size

Wall, attic and floor R-values

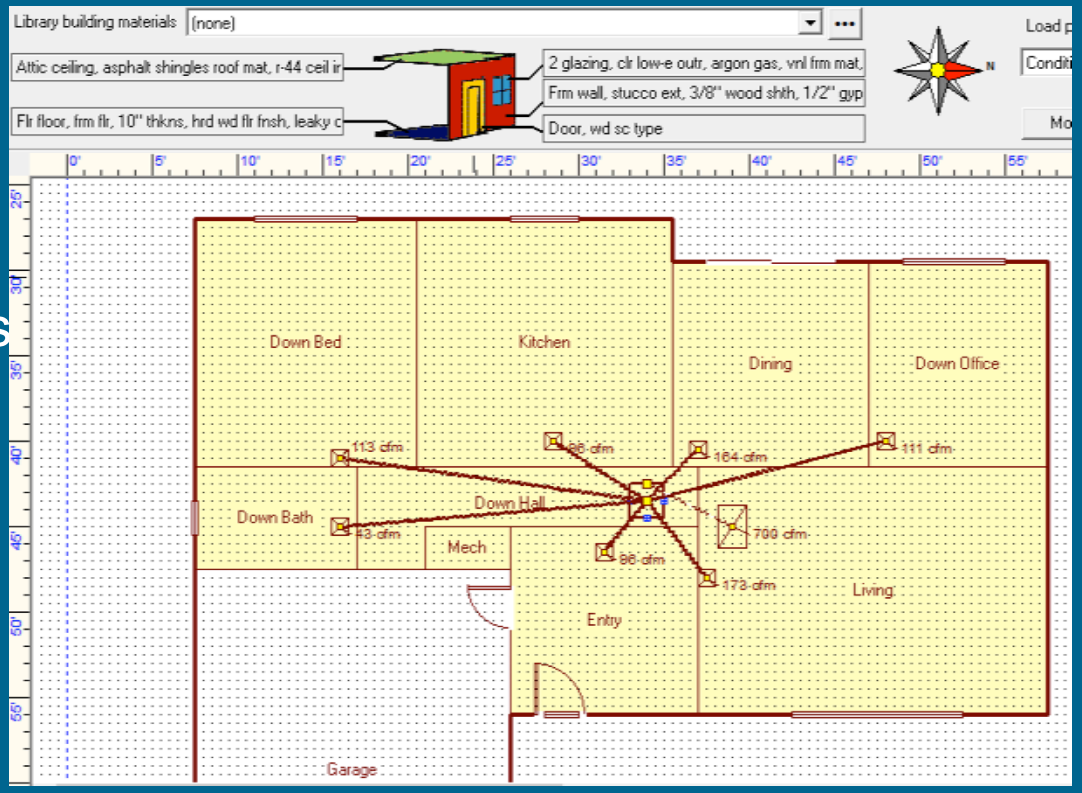
Orientation

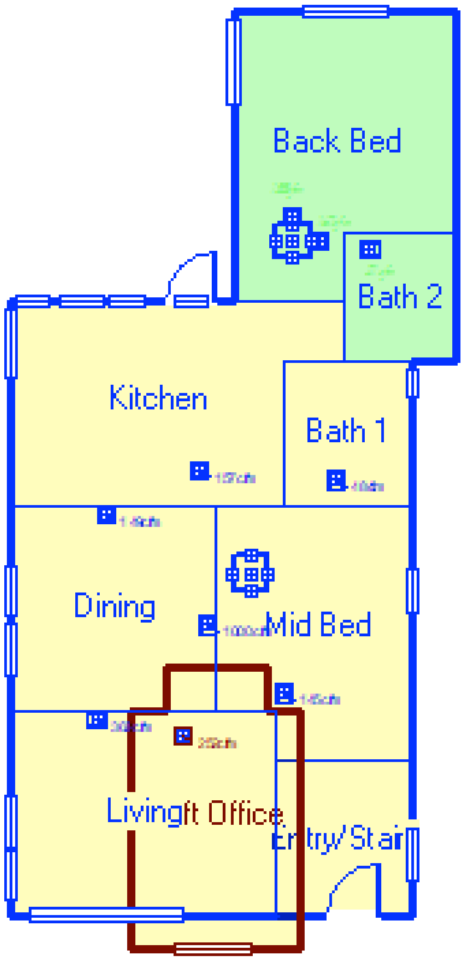
Shading

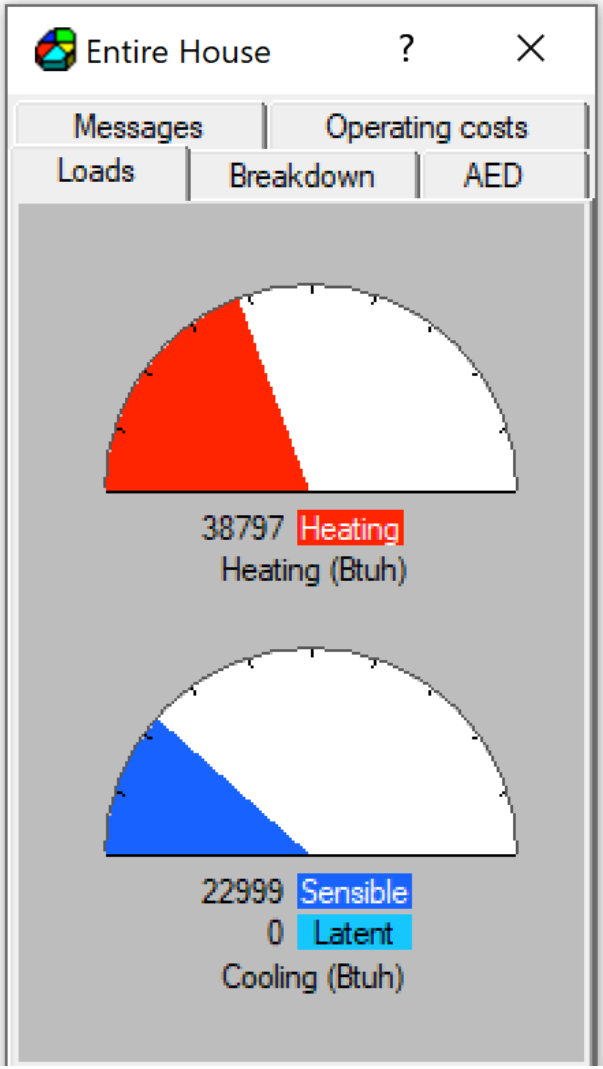
Climate zone

Blower door

Smaller is better




Back Bed
Bath 2
Kitchen
Bath 1
Dining
Mid Bed
Livingft Office
Entry/Stair


Entire House
?
Messages
Operating costs
Loads
Breakdown
AED
38797 Heating
Heating (Btuh)
22999 Sensible
0 Latent
Cooling (Btuh)

MODEL: ARU18RLF

AFR	554

			Indoor temperature							
		°FDB	60		65		70		75	
Outdoor temperature	°FDB	°FWB	TC	IP	TC	IP	TC	IP	TC	IP
	-5	-7	19.3	2.42	18.9	2.47	18.4	2.52	17.5	2.63
	5	3	20.7	2.63	20.2	2.68	19.7	2.74	18.8	2.85
	14	12	22.2	2.68	21.6	2.73	21.1	2.79	20.1	2.90
	23	19	23.1	2.79	22.6	2.85	22.0	2.91	20.9	3.03
	32	28	23.3	3.02	22.8	3.08	22.2	3.14	21.1	3.19
	41	37	25.5	2.67	24.9	2.73	24.3	2.78	23.1	2.90
	47	43	26.9	2.50	26.2	2.55	25.6	2.60	24.3	2.70
	50	47	29.7	2.23	29.0	2.28	28.3	2.32	26.9	2.42
	59	50	30.8	2.24	30.1	2.29	29.3	2.34	27.9	2.43

AFR: Airflow Rate (CFM)
TC: Total Capacity (kBtu/h)
IP: Input Power (kW)

Installation and Commissioning Goals

Make targets for the install team

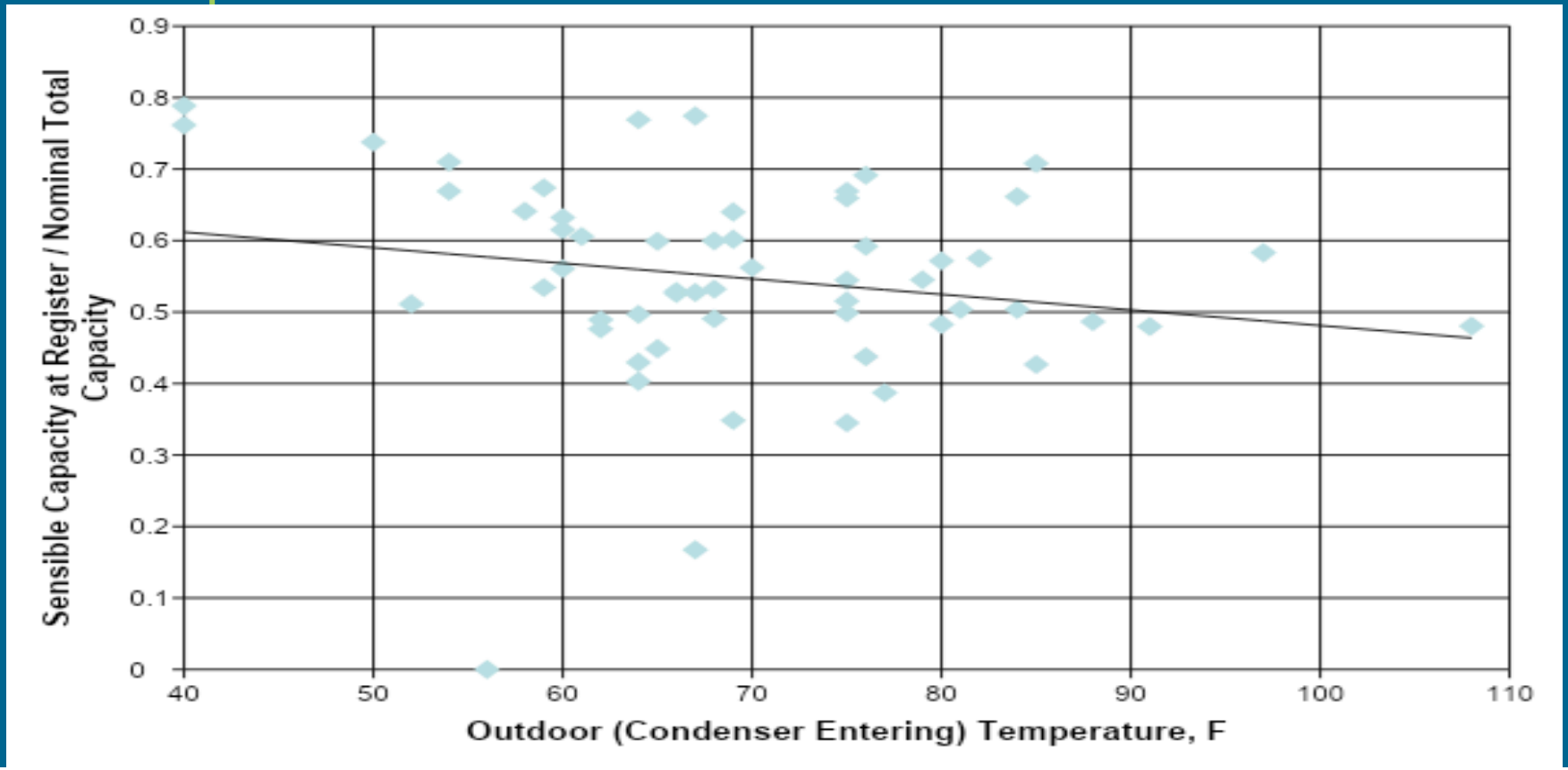
- Zero Duct Leakage
- 10% per room airflow targets
- 5% overall airflow targets
- 5 pascal pressure in rooms
- 3 degrees

Air leakage targets

Noise

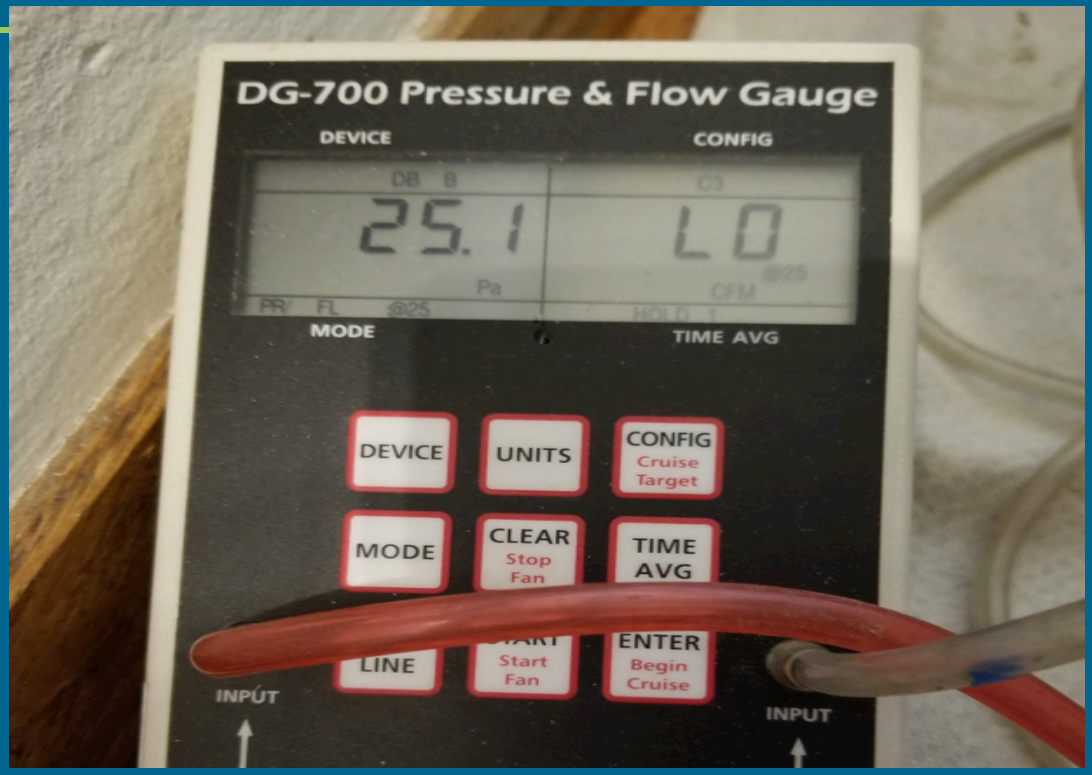
Delivered performance

State of the Industry
CEC Study on Delivered Performance



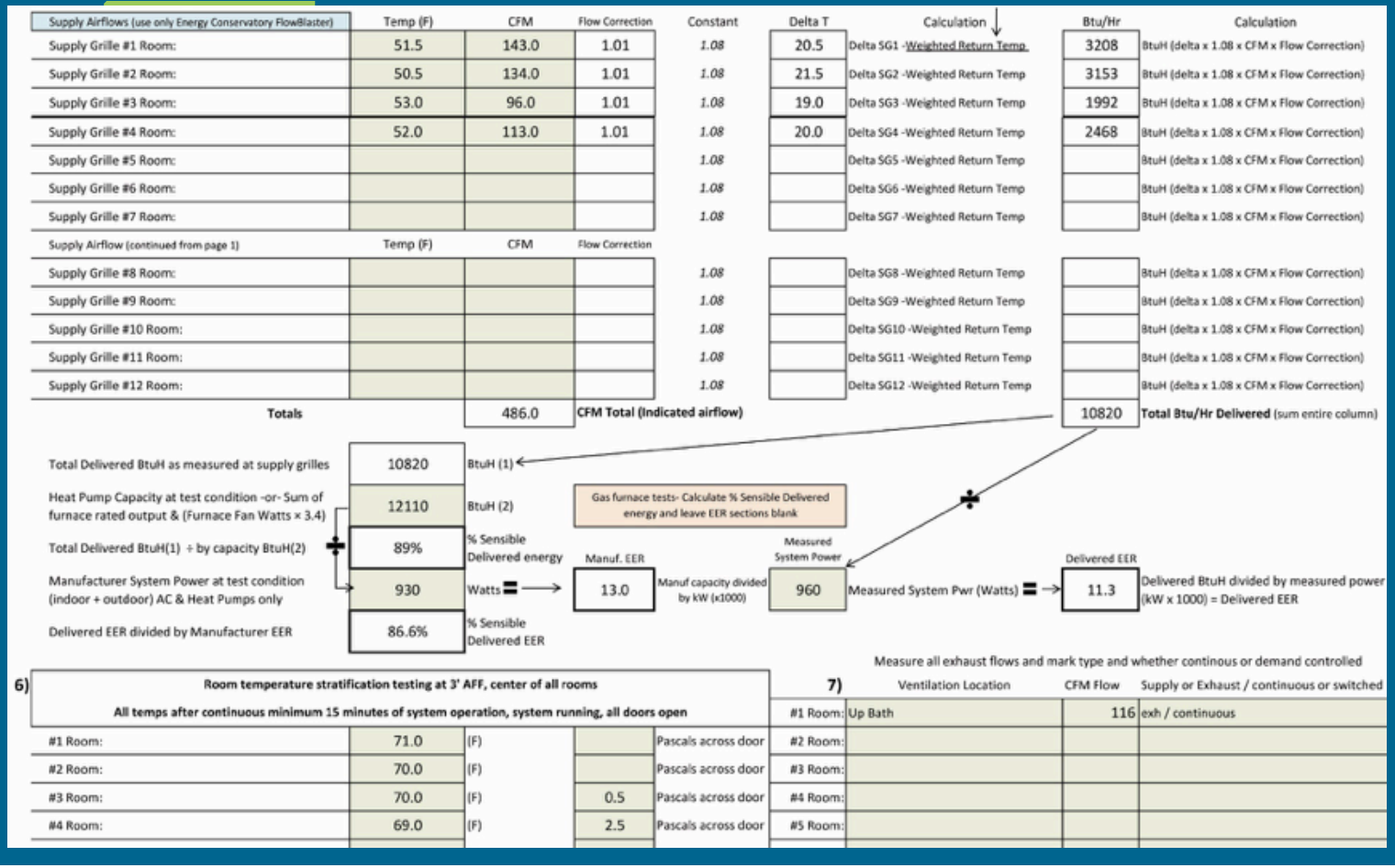
Not Intuitive Quality

Performance Factors



Snap Shot Commissioning

Commissioning



Supply Airflows (use only Energy Conservatory FlowBlaster)	Temp (F)	CFM	Flow Correction	Constant	Delta T	Calculation	Btu/Hr	Calculation
Supply Grille #1 Room:	51.5	143.0	1.01	1.08	20.5	Delta SG1 -Weighted Return Temp	3208	BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #2 Room:	50.5	134.0	1.01	1.08	21.5	Delta SG2 -Weighted Return Temp	3153	BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #3 Room:	53.0	96.0	1.01	1.08	19.0	Delta SG3 -Weighted Return Temp	1992	BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #4 Room:	52.0	113.0	1.01	1.08	20.0	Delta SG4 -Weighted Return Temp	2468	BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #5 Room:				1.08		Delta SG5 -Weighted Return Temp		BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #6 Room:				1.08		Delta SG6 -Weighted Return Temp		BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #7 Room:				1.08		Delta SG7 -Weighted Return Temp		BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Airflow (continued from page 1)	Temp (F)	CFM	Flow Correction					
Supply Grille #8 Room:				1.08		Delta SG8 -Weighted Return Temp		BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #9 Room:				1.08		Delta SG9 -Weighted Return Temp		BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #10 Room:				1.08		Delta SG10 -Weighted Return Temp		BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #11 Room:				1.08		Delta SG11 -Weighted Return Temp		BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #12 Room:				1.08		Delta SG12 -Weighted Return Temp		BtuH (delta x 1.08 x CFM x Flow Correction)
Totals		486.0	**CFM Total (Indicated airflow)**				10820	**Total Btu/Hr Delivered** (sum entire column)

Total Delivered BtuH as measured at supply grilles	10820	BtuH (1)
Heat Pump Capacity at test condition -or- Sum of furnace rated output & (Furnace Fan Watts x 3.4)	12110	BtuH (2)
Total Delivered BtuH(1) ÷ by capacity BtuH(2)	89%	% Sensible Delivered energy
Manufacturer System Power at test condition (indoor + outdoor) AC & Heat Pumps only	930	Watts
Delivered EER divided by Manufacturer EER	86.6%	% Sensible Delivered EER

Gas furnace tests- Calculate % Sensible Delivered energy and leave EER sections blank

Manuf. EER: 13.0 — Manuf capacity divided by kW (x1000)

Measured System Power: 960 — Measured System Pwr (Watts) =

Delivered EER: 11.3 — Delivered BtuH divided by measured power (kW x 1000) = Delivered EER

6) Room temperature stratification testing at 3' AFF, center of all rooms

All temps after continuous minimum 15 minutes of system operation, system running, all doors open

#1 Room:	71.0	(F)		Pascals across door
#2 Room:	70.0	(F)		Pascals across door
#3 Room:	70.0	(F)	0.5	Pascals across door
#4 Room:	69.0	(F)	2.5	Pascals across door

7) Measure all exhaust flows and mark type and whether continous or demand controlled

	Ventilation Location	CFM Flow	Supply or Exhaust / continuous or switched
#1 Room:	Up Bath	116	exh / continuous
#2 Room:			
#3 Room:			
#4 Room:			
#5 Room:			

Delivered Performance

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	47	43	26.9	2.50	26.2	2.55	25.6	2.60	24.3	2.70
	50	47	29.7	2.23	29.0	2.28	28.3	2.32	26.9	2.42
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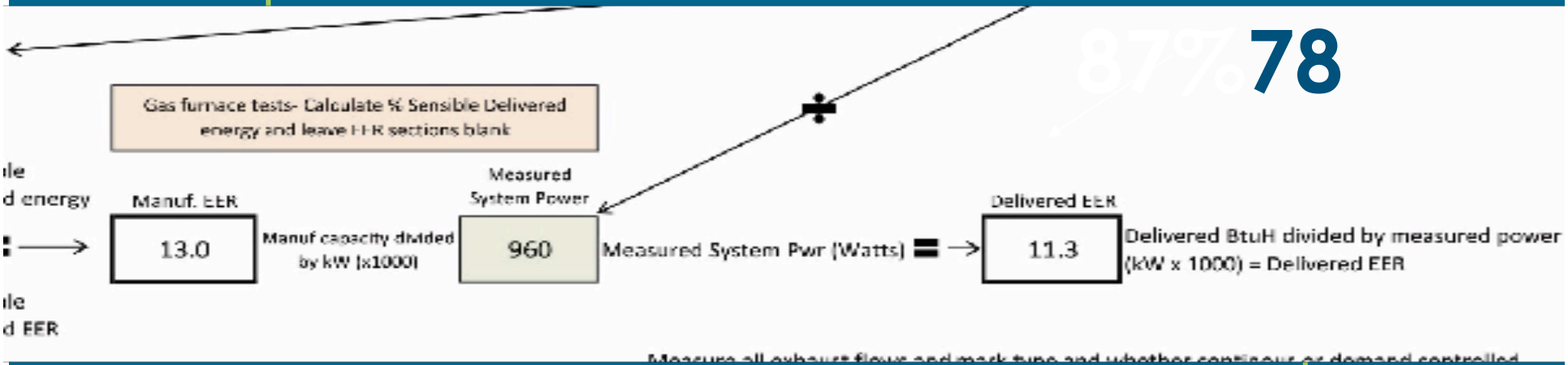
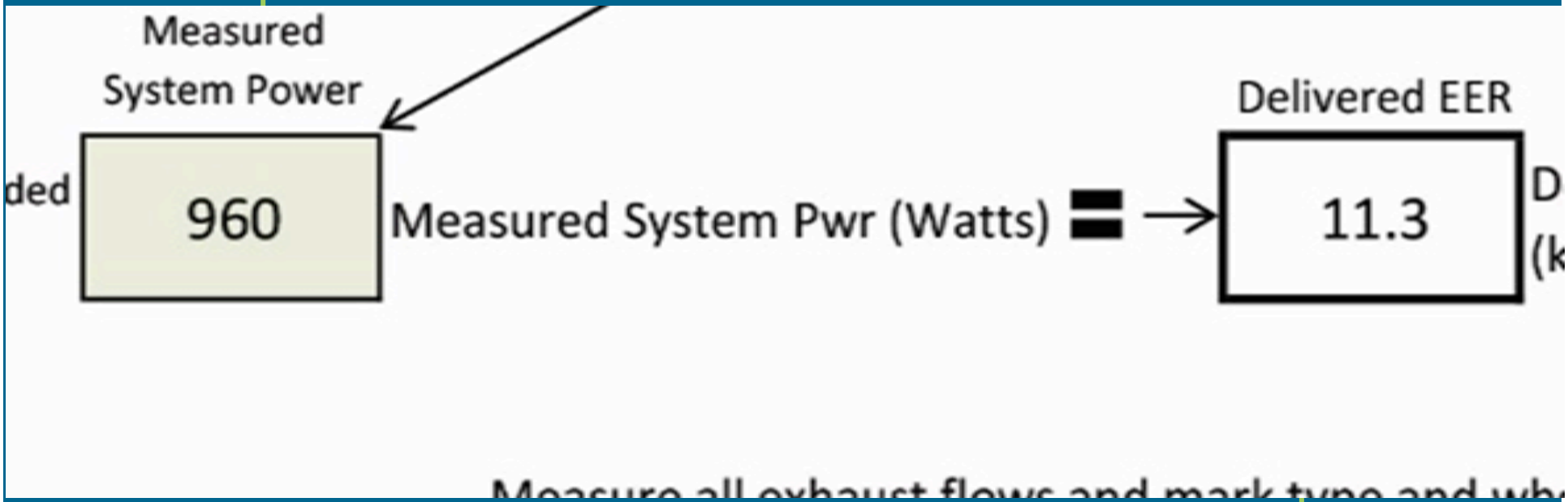
Commissioning

Skyline November - January



87% 78

Commissioning

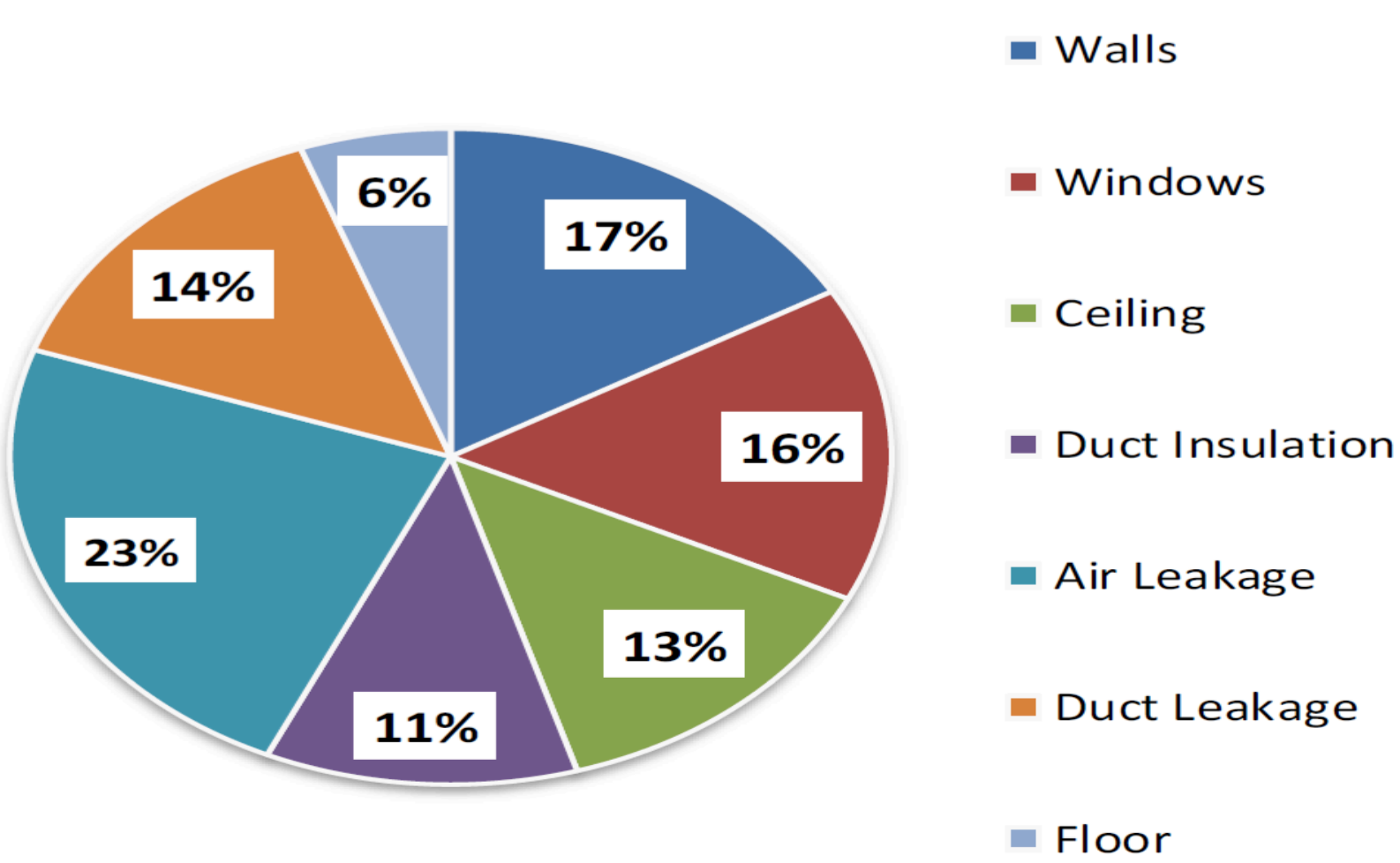


There are a lot of houses

They’re all different

Nano were designed for us to fix them!


A.O. Smith


17%
16%
13%
11%
23%
14%
6%
Walls
Windows
Ceiling
Duct Insulation
Air Leakage
Duct Leakage
Floor

Multi Zones

Ductless Systems

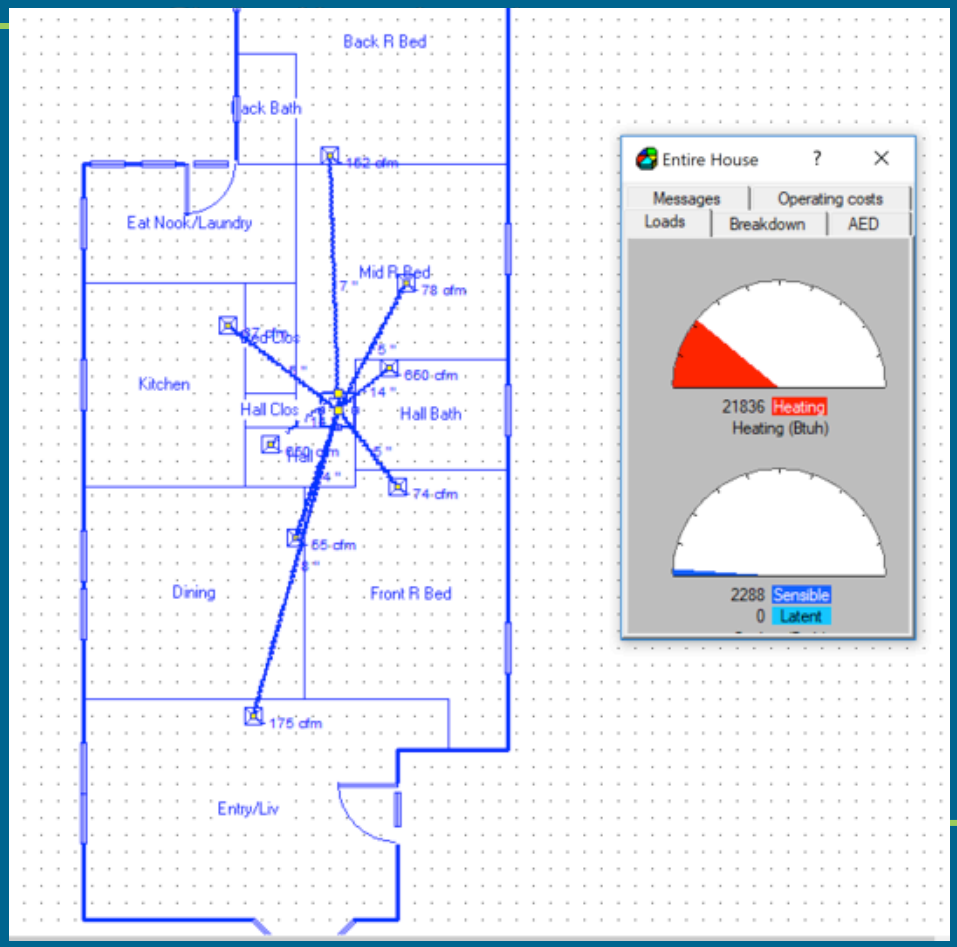
Ducted Mini Splits Work Best in Most Cases

Duct Location Considerations

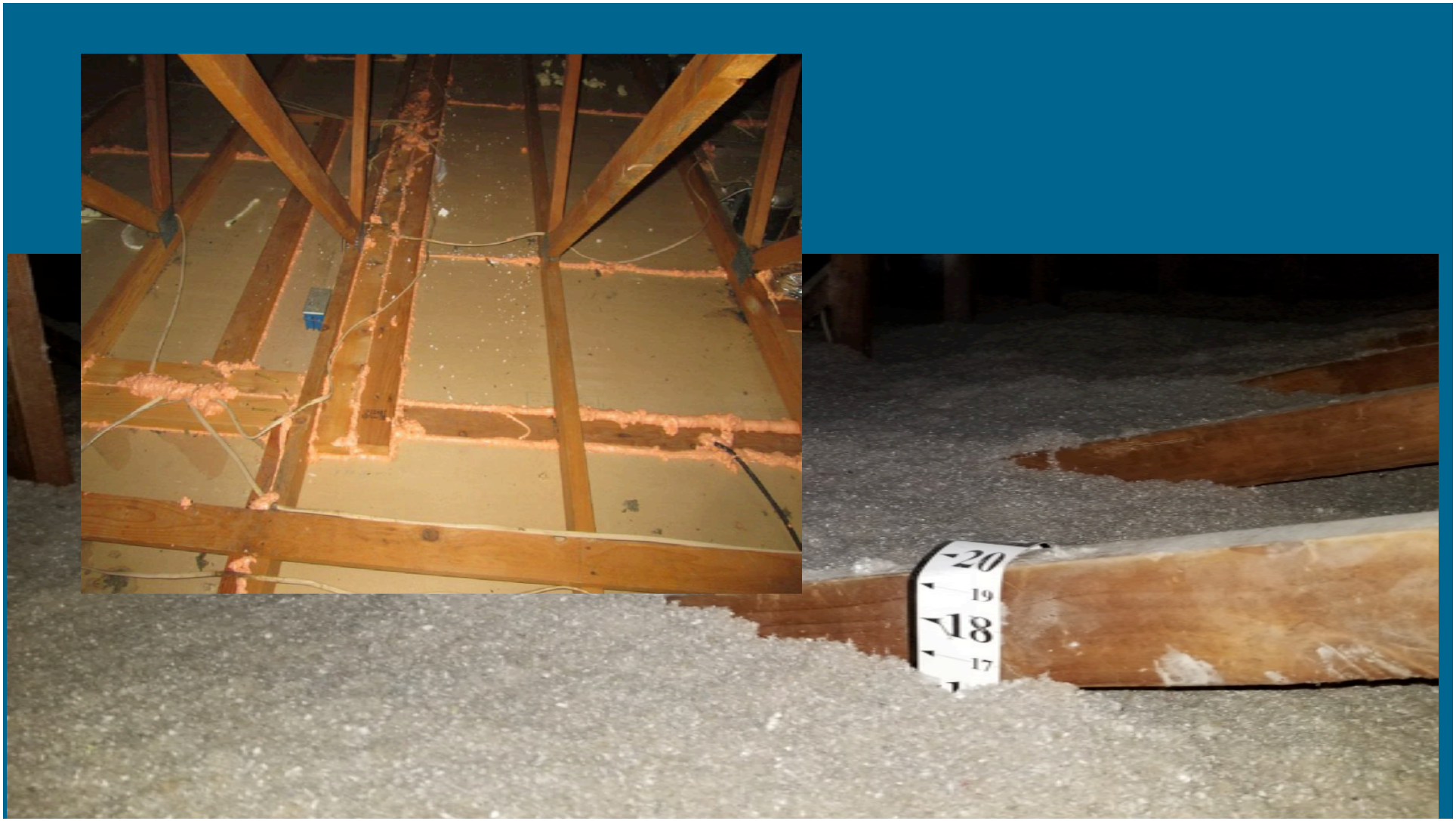
Duct locations

- Attics with buried ducts
- Ducts as short as possible
- Sealed crawlspace
- Ducts always as short as possible

Short Ducts


Back R Bed
Back Bath
162 cfm
Eat Nook/Laundry
Mid R Bed
78 cfm
Kitchen
660 cfm
Hall Clos
Hall Bath
74 cfm
65 cfm
Dining
Front R Bed
175 cfm
Entry/Liv
Entire House
Messages
Operating costs
Loads
Breakdown
AED
21836 Heating
Heating (Btuh)
2288 Sensible
0 Latent

Air Sealing Before and After


20
19
18
17

Simple Filtration

Home Ventilation

Minimum standard

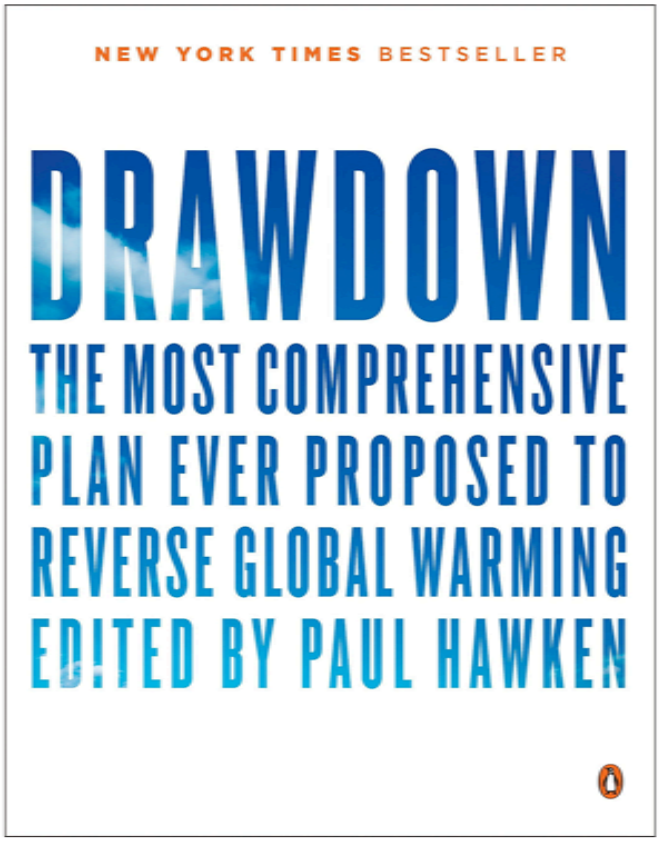
- Continuous running low flow bath fan(s)
- Ducted range hood with good flow and low noise

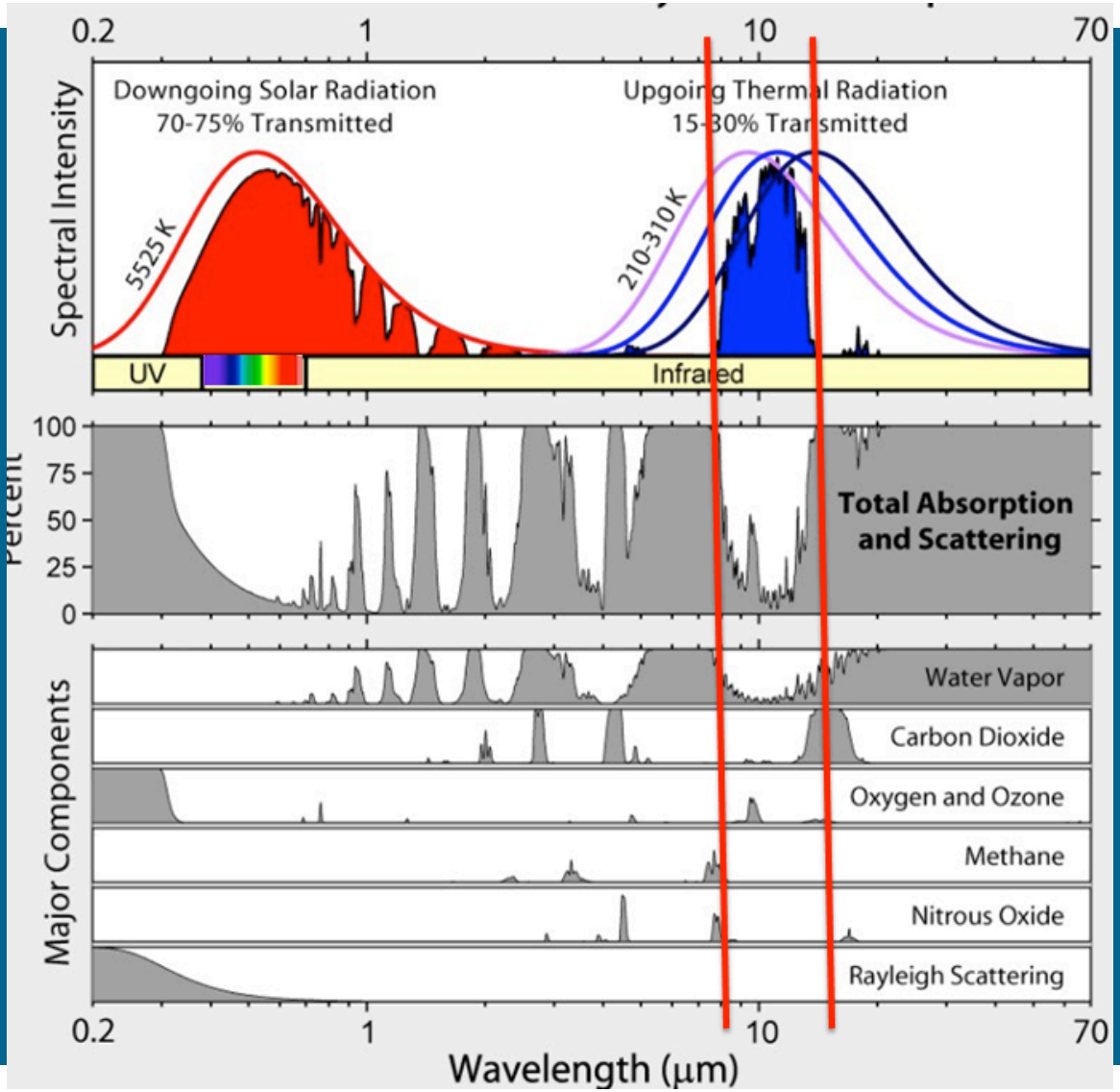
The best solution

- Balanced HRV/ERV ducted to bedrooms and bathrooms

One Compilation of Defeating Global Warming

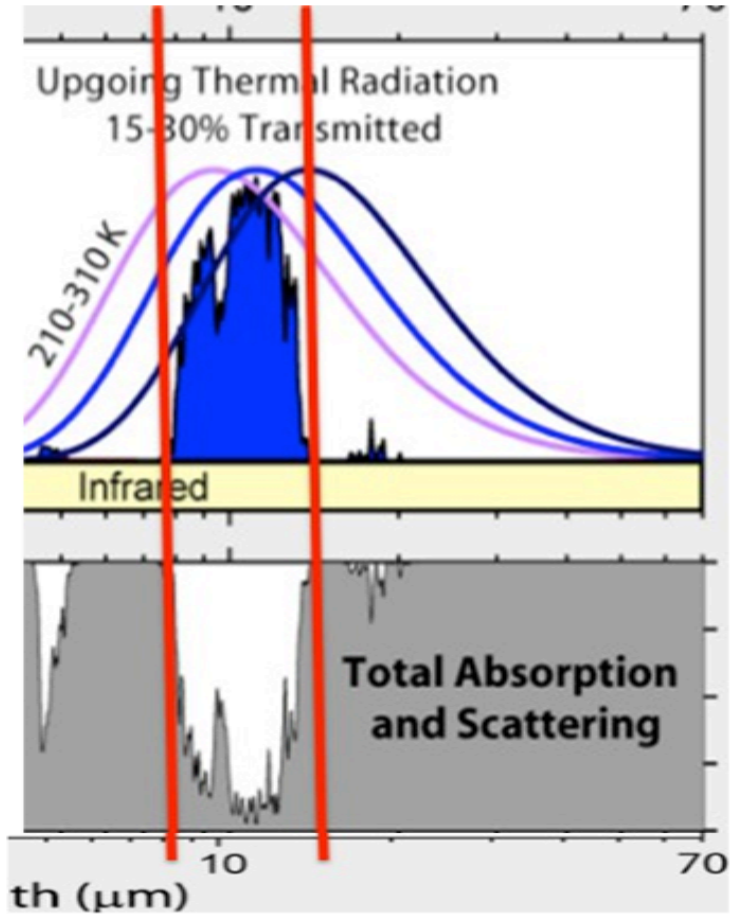
Ranking	Solution	CO2 Equiv. Reduction
1	Refrigerant Capture	89.74 GT
2	On Shore Wind Turbines	84.60
8	Solar Farms	36.90
10	Rooftop Solar	24.60
26	Electric Vehicles	10.80




0.2
1
10
70
Spectral Intensity
Downgoing Solar Radiation
70-75% Transmitted
Upgoing Thermal Radiation
15-30% Transmitted
5525 K
210-310 K
UV
Infrared
100
75
50
25
0
Total Absorption and Scattering
Major Components
Water Vapor
Carbon Dioxide
Oxygen and Ozone
Methane
Nitrous Oxide
Rayleigh Scattering
0.2
1
10
70
Wavelength (μm)

This is Effectively Earth's Outgoing Thermal Radiation Window

8 to 11 Microns



Wavelength (µm)

Refrigerant leaks and how to minimize them

Equivalency Calculator

6lbs leaked r410a

=

Driving a commuter car 16,000 miles

Making Flares

Ultrasonic Leak Detector

Refrigerant Leak Detector

FLARE CONNECTIONS

- Three main issues
  - Flare connections are difficult to install correctly and test
  - Technicians aren’t trained on how to install and/or test them
  - 500 PSI
  - Hot and cold
  - No accountability

Why Is It Compicated??

- Smaller ducts to fit in the space and lose less energy
- Less air = one central return
- Lower watt draw
- Low noise
- Comfort.
- Less energy usage
- Lower equipment cost and easier to purchase
- Less grid impact
- Air sealing and insulation is fantastic load shifting battery
- Panel space / capacity