Heat Pump Workshop

for Space and Water Heating

Saturday, March 9

8:30 a.m. to 1 p.m.

D Street Neighborhood Center

1301 D St., Arcata

8:30 a.m.	Meet local heat pump contractors and enjoy refreshments
9-10:30 a.m.	Heat pump space heaters and Q&A
10:30-11 a.m.	Refreshments and time with local contractors, our expert instructor Dan Perunko, and RCEA staff
11 a.m.-12:15 p.m.	Heat pump water heaters and Q&A
12:15-1 p.m.	More time with local contractors, instructor Dan Perunko, and RCEA staff

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Dan@balancepointhp.com

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To go in-depth on any of these training topics I cover, please visit the PG&E Energy Center to learn more:

https://pge.docebosaas.com/learn/external-ecommerce;view=none;redirectURL=?ctldoc-catalog-0=se-perunko

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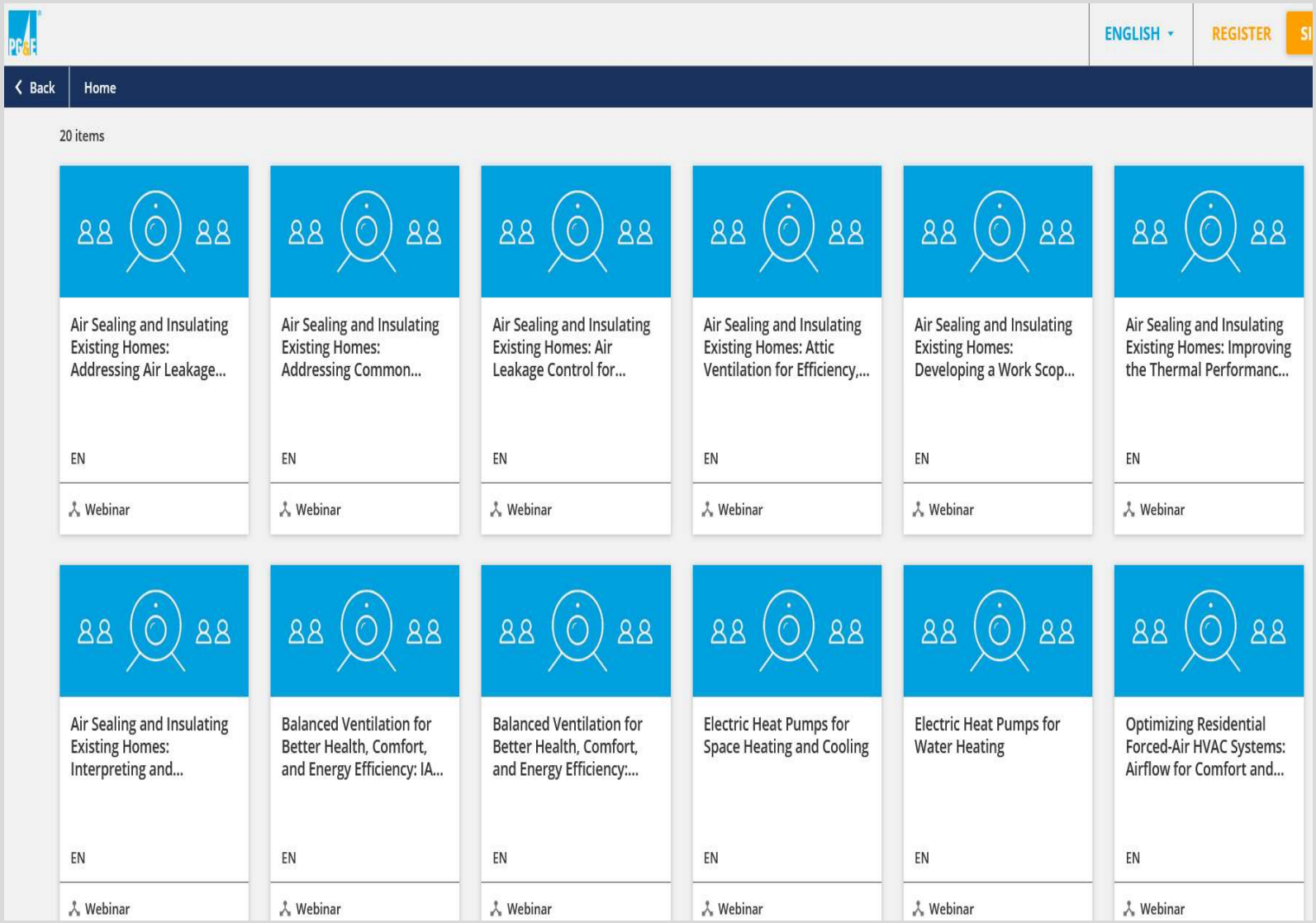
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Introductions - Dan

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Agenda Part 1

1. What is a heat pump?
2. Types of heat pumps
3. Heat pump benefits
4. Refrigerants and the environment
5. Expectations for design and installation
6. Q&A (15 minutes)

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1. What is a Heat Pump?

Heat pumps are based on a minor change to technology we have relied on for decades.

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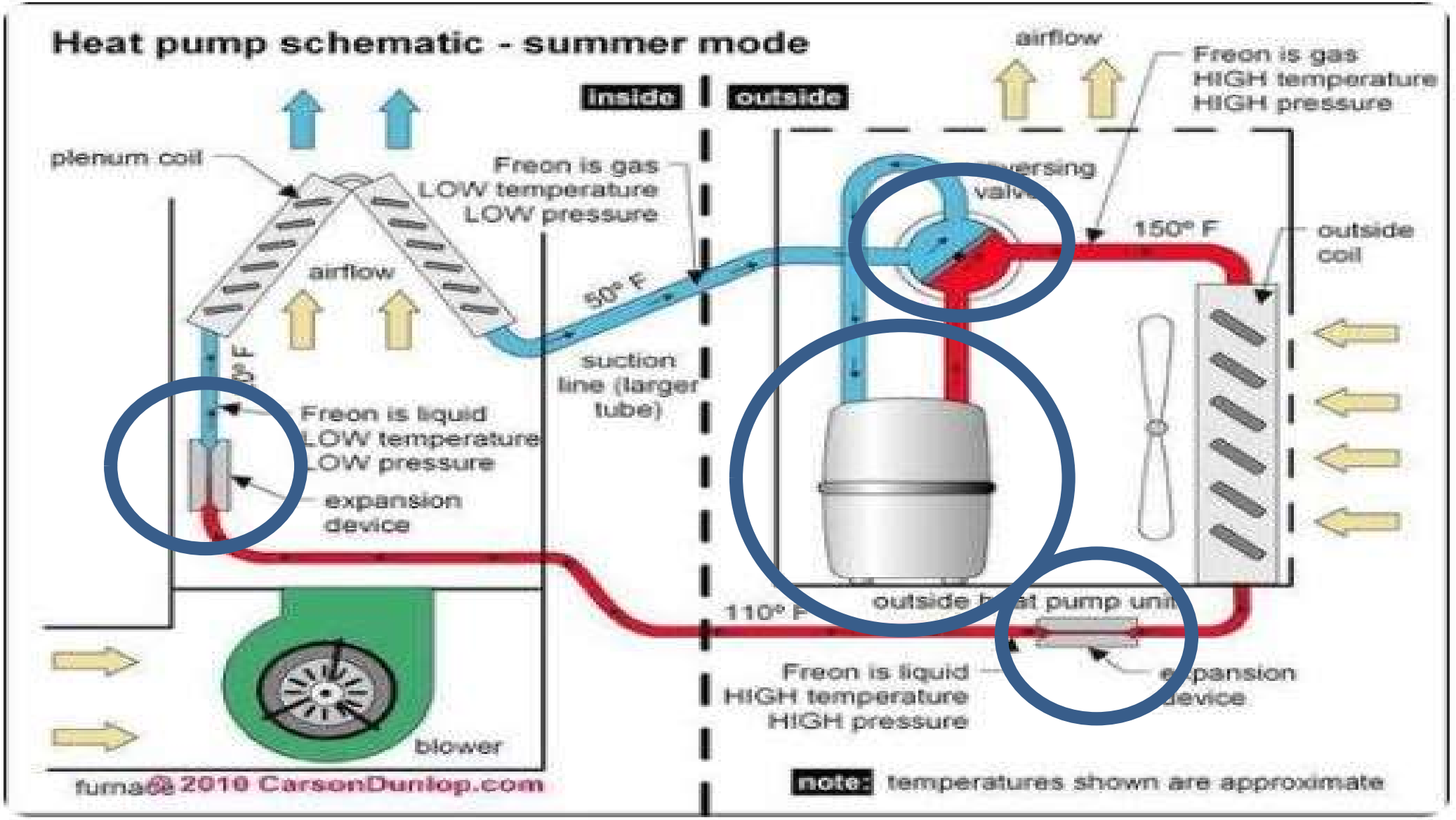
Heat pump schematic - summer mode
inside
outside
airflow
Freon is gas
HIGH temperature
HIGH pressure
plenum coil
Freon is gas
LOW temperature
LOW pressure
airflow
150° F
outside
coil
50° F
suction
line (larger
tube)
Freon is liquid
LOW temperature
LOW pressure
expansion
device
110° F
Freon is liquid
HIGH temperature
HIGH pressure
blower
furnace 2010 CarsonDunlop.com
note: temperatures shown are approximate

2. Types of Heat Pumps

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Uses and Types of Heat Pumps

Space Conditioning – Heating and Cooling

- Single speed – legacy
- Multi-speed and variable speed - communicating
- Ductless mini-split
- Ducted mini-split
- VRF

Water Heating

- Split System
- Unitary System

Single Speed Split - Legacy

Multi-Speed or Variable Speed Split System - Communicating

SEER 18 - 24

HSPF 8 - 13

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Ductless Mini-Splits

Single Head

SEER 19-30.5

HSPF 8-13

Multi-Head

SEER 18-22

HSPF 8 - 11

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Wall Mount – Single Head

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Ceiling Cassette

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Multi-Head Ductless Mini-Splits

Ducted Mini-Split – slim duct

SEER 20
HSPF 11

Ducted Mini-Split – Mid Static

SEER 19
HSPF 10

Ducted Mini-Split – Multi Position

SEER 18
HSPF 10

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VRF

SEER 16-19

HSPF 8-12

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3. Heat Pump Benefits

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Advantages of Heat Pumps

- Allow buildings to move to “Zero Carbon”.
- Allow building owners to be inline with California Climate Goals. Shutdown the gas distribution system.
- Gas Appliances will become obsolete at the time the gas infrastructure goes offline.
- Current operating cost can be lower for heat pumps than gas appliances.

Advantages of Heat Pumps – North Coast Specific

- Reduce indoor air quality hazard by reducing indoor combustion.
- Some units have a dry mode, which provides dehumidification.
- Reduces reliance on propane infrastructure, delivery issues and price gouging in winter.
- Offers very large cost saving when paired with Solar PV.

The Math – Cost to Deliver One Million Btu of Heat

Natural gas furnace as typically found (80% furnace, attic ducts):

10 Therms (MMBtu) * $2.33/Therm / (80% * 50%) = $58.25

New natural gas furnace and new duct system (95%, new ducts):

10 Therms (MMBtu) * $2.33/Therm / (95% * 85%) = $28.85

Natural Gas pre-2022 rate hike, future rate hikes?

The Math – Cost to Deliver One Million Btu of Heat

Propane furnace as typically found (80% furnace, attic ducts):

10.93 Gallons (MMBtu) * $3.64/Gallon / (80% * 50%) = $99.46

Propane furnace and new duct system (95%, new ducts):

10.93 Gallons (MMBtu) * $3.64/Gallon / (95% * 85%) = $49.27

The Math – Cost to Deliver One Million Btu of Heat

New ducted heat pump, ducts as typically found (HSPF-12.2, attic ducts):

293 KWH (MMBtu) * $0.34/KWH / (360% * 50%) = $55.34

"Box swaps" with heat pumps are a really bad idea

The largest operating cost savings appear when heat pumps are combined with onsite generation.

The Math – Cost to Deliver One Million Btu of Heat

New electric ducted mini-split heat pump (HSPF-12.2):

293 KWH (MMBtu) * $0.34/KWH / (360% * 85%) = $32.55

New electric ducted mini-split heat pump (HSPF-12.2, ducts inside):

293 KWH (MMBtu) * $0.34/KWH / (360% * 100%) = $27.67

The Installed efficiency of ductless systems is higher than anything else available.

You can choose single head installs for the highest efficiency.

You can choose multi-head installs to lower upfront costs.

You can choose VRF systems, which allow a much larger building to be served by one outside unit and lots of indoor heads.

Case Studies

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Heat Pump Case Study

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Retrofit Details

- Improve building air barrier - attic and crawlspace
- Insulate attic R60
- Install crawlspace ground source vapor barrier
- Seal crawlspace ventilation
- Insulate crawlspace knee walls – R21
- Replace gas water heater with electric tank
- Replace 2 furnace / air conditioner systems with Heat Pumps
- Replace both duct systems
- Replace gas car with electric car

Energy Retrofit Results

	PRE	POST	%Change
Electricity	1,706 kwh	9,644 kwh	+400%
Propane	760 gallons	60 gallons	-92%
Auto Fuel	433 gallons	0 gallons	-100%
Total Energy	39,833 kwh	10,992 kwh	-72%

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Heat Pump Case Study - 2

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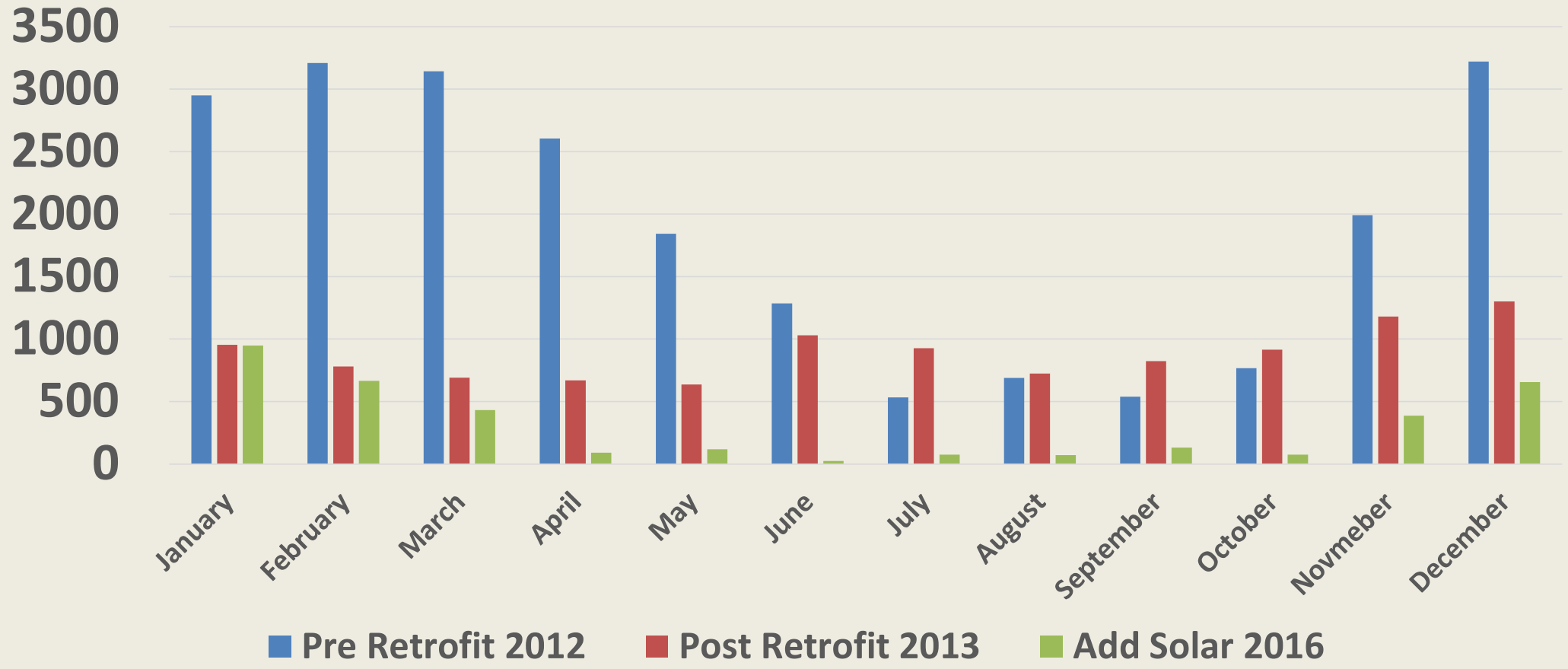
Retrofit Details

- Improve building air barrier – Attic and crawlspace
- Rebuild roof assembly – Insulate sealed roof assembly – R-60
- Install ducted heat pump system in new conditioned attic space
- Install HRV ventilation system in new conditioned attic space
- Install ground source vapor barrier
- Insulate crawlspace stem walls – R-21
- Replace gas water heater with electric tank unit
- Replace range with induction unit

Energy Consumption KWH



Annual Energy Totals - KWH

- Pre Retrofit – 22,778
- Post Retrofit – 10,632
- After Solar – 3,677

Reduction = 84%

4. Refrigerants and the Environment

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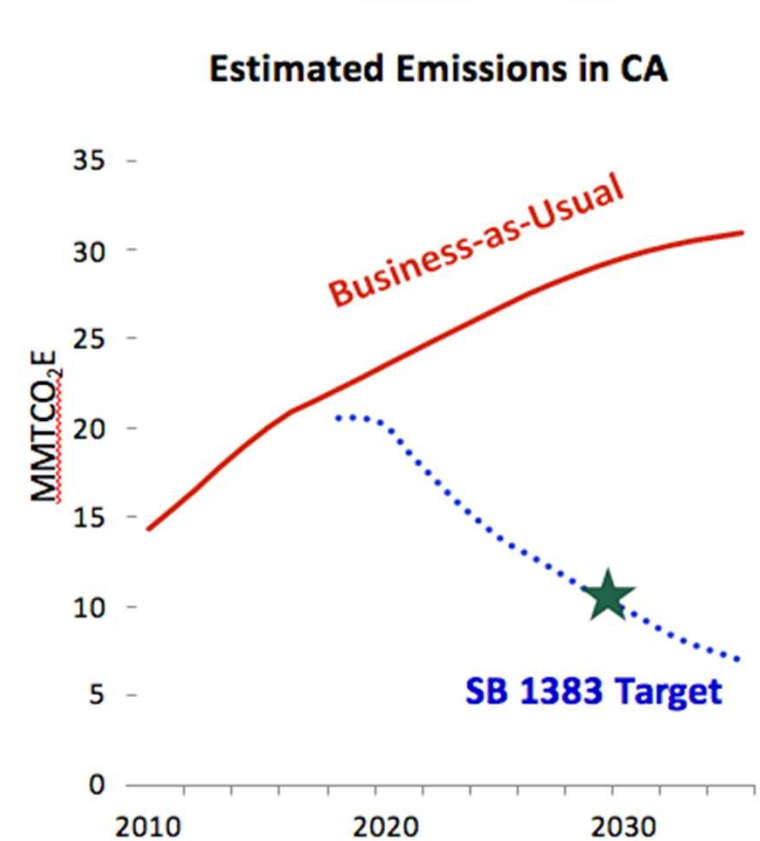
How Heat Pumps Interact with Global Climate Change

- Leaking systems are very common.
- Leaking refrigerants have a huge global warming impact.
- Proper installation techniques are needed to limit leaks.
- Normal service and maintenance activities can dramatically undermine our carbon reduction efforts.

To succeed in lowering carbon emissions, we need new service procedures & new refrigerants – NOW!

In California HFCs are the Fastest Growing Source of Greenhouse Gases

- Currently 4% of California GHG Emissions
- Emissions projected to double over 20 years
- SB 1383 reduction goal: 40% below 2013 levels by 2030



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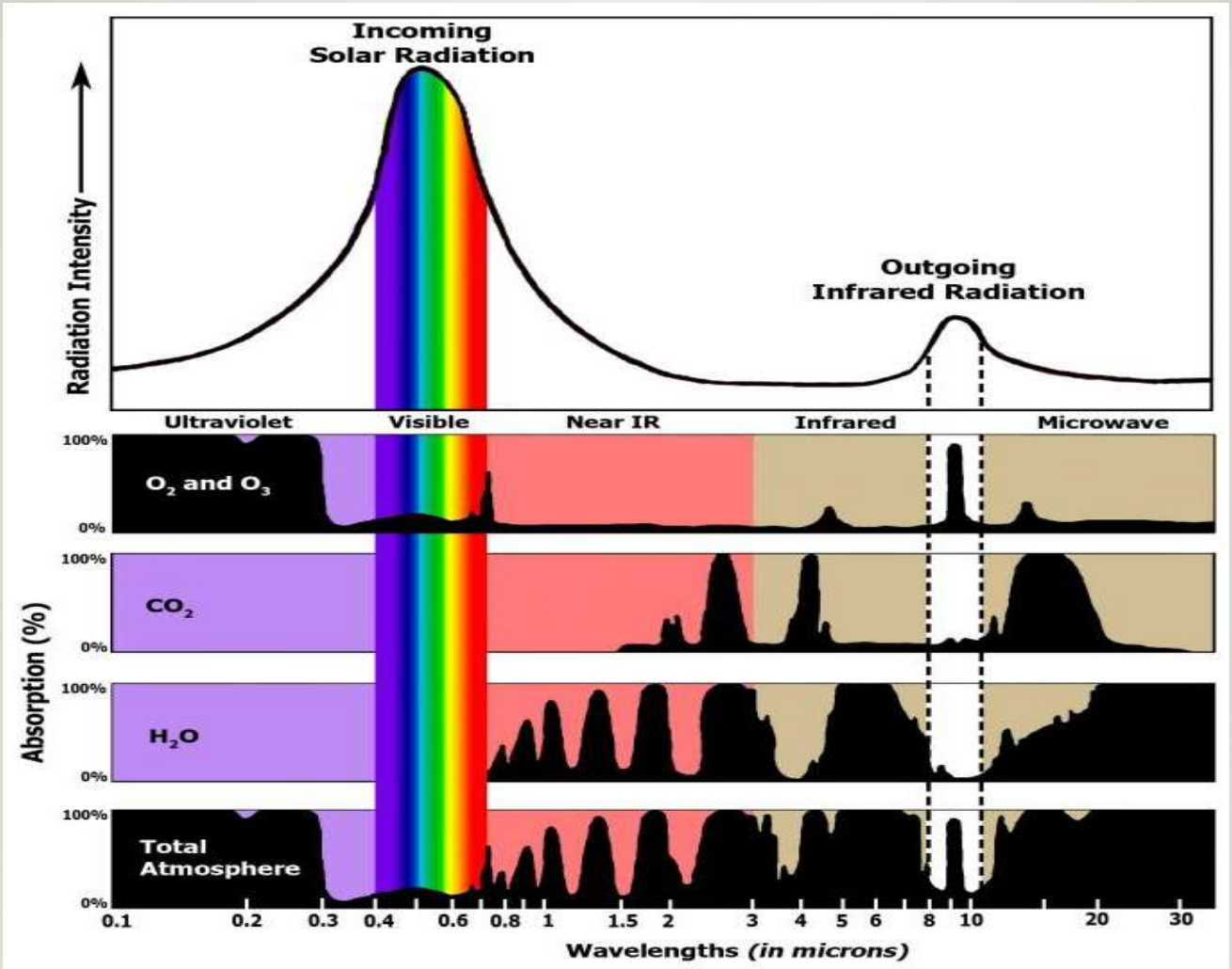
100 Year Global Warming Potential

Gas	GWP_{100}
CO_2	1
Methane CH_4	25
N_2O	298
R-12 (CFC) ozone depletion	10,900
R-22 (HCFC) less ozone depletion	1810
R-410A (HFC)	**2090**
Propane R-290	3
Ammonia	0



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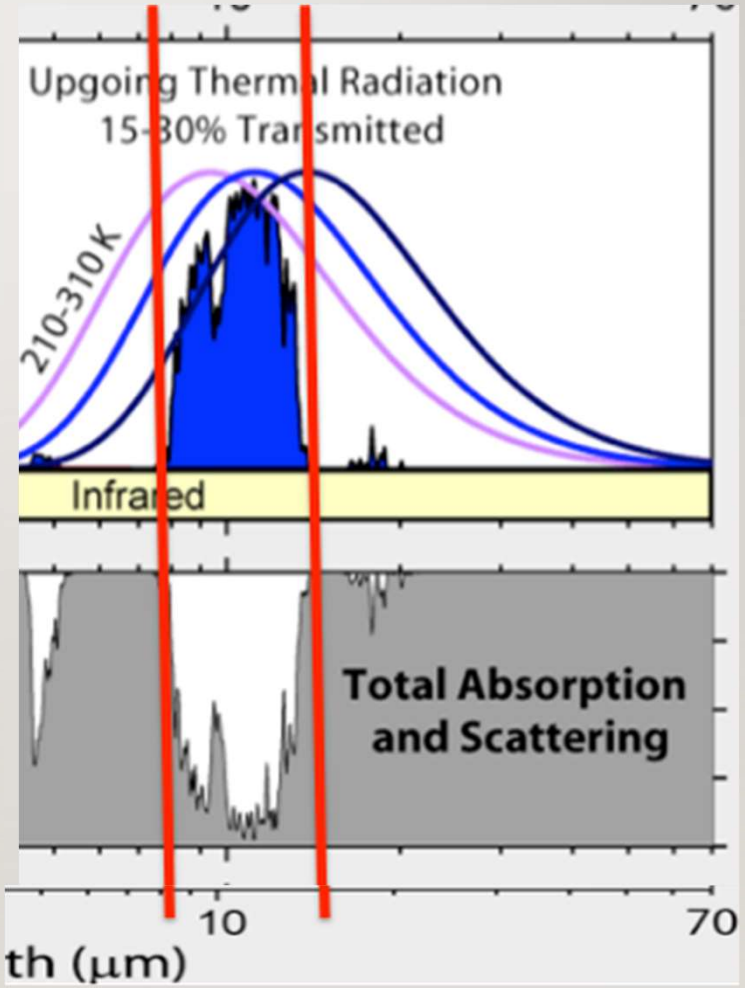
This is Effectively Earth's Outgoing Thermal Radiation Window

8 to 11 Microns



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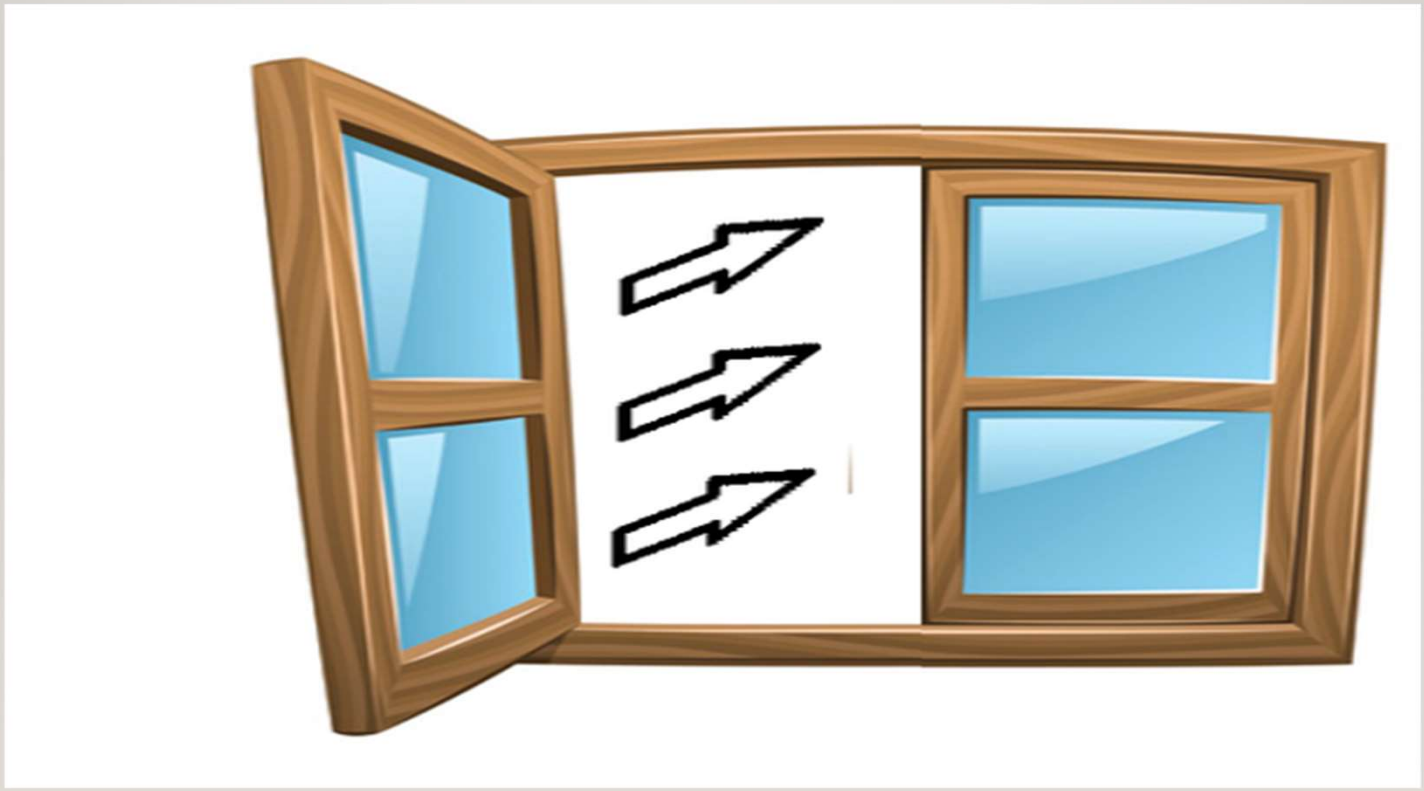
R410A Closes Part of that Window



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Refrigerant Leakage

What percentage of new systems leak?

- Accidentally leaking systems are not illegal, are not tracked or reported.
- Many technicians are trained to ineffective standards for line set building and testing.
- Many know the steps but don’t really have a standard for what passes or fails.

Selling refrigerant is very profitable

5. Expectations for Design and Installation

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Load Calculations and Design

To meet our criteria of comfort, efficiency and environmental goals we need design and planning tools.

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Design and Installation

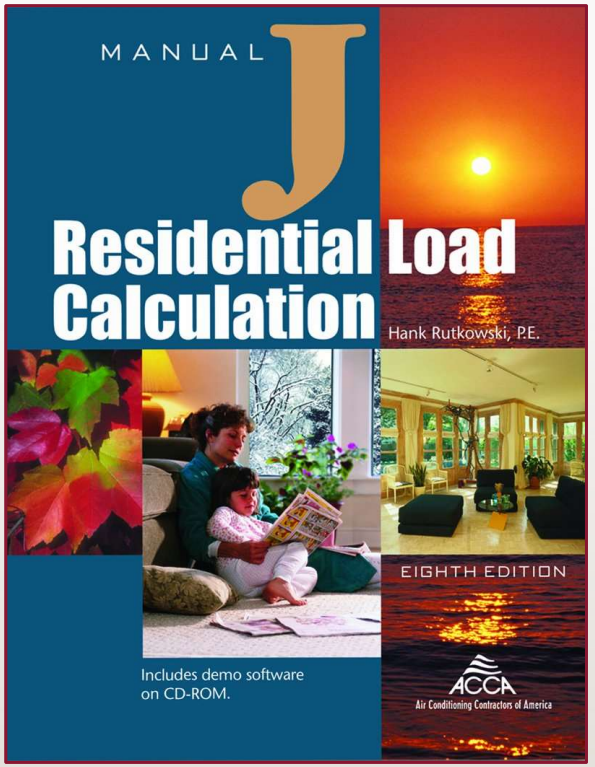
Industry standard practices **are inadequate** — result in a 50% loss of HVAC capacity

- Commissioning during and after install is necessary for systems to perform well
  - Manual J load calculation
  - Room by room airflow balance
  - Total airflow at dry climate level
  - Duct leakage at zero
  - Conductive losses at zero
  - Line set tested to zero leakage standard before startup
  - Charge set by appropriate method – super-heat and sub-cool to manufacturer's targets or weigh-in for mini-splits

Load Calculations!!!

All heating or cooling equipment should be sized for your house based on its construction and orientation.

This is done by performing a heating and cooling load calculation for every home.



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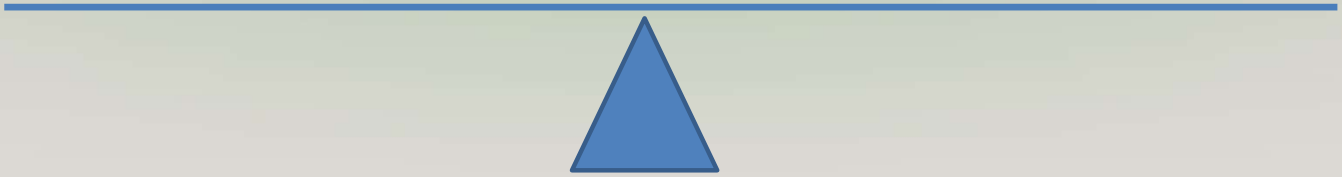
Ducts or No Ducts

- Air filtration proven effective
- Uniform comfort
- Quiet
- Less potential for lost refrigerant
- Can be optimized for dry climate
- Can be commissioned
- Can be adjusted to improve performance

- Higher rated efficiency
- No duct losses
- Quiet compressor – Outside
- Less mechanical space necessary
- Higher rate of lost refrigerant
- Can't be optimized for dry climate
- Cannot be commissioned



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It's Time to Re-envision what we do

Be open to multiple small systems

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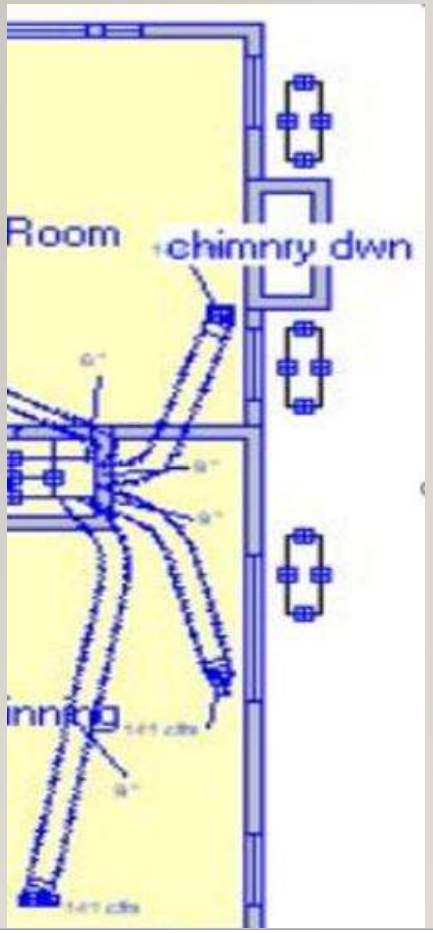
Heat Pump Design Advantage



We can do this!!!!

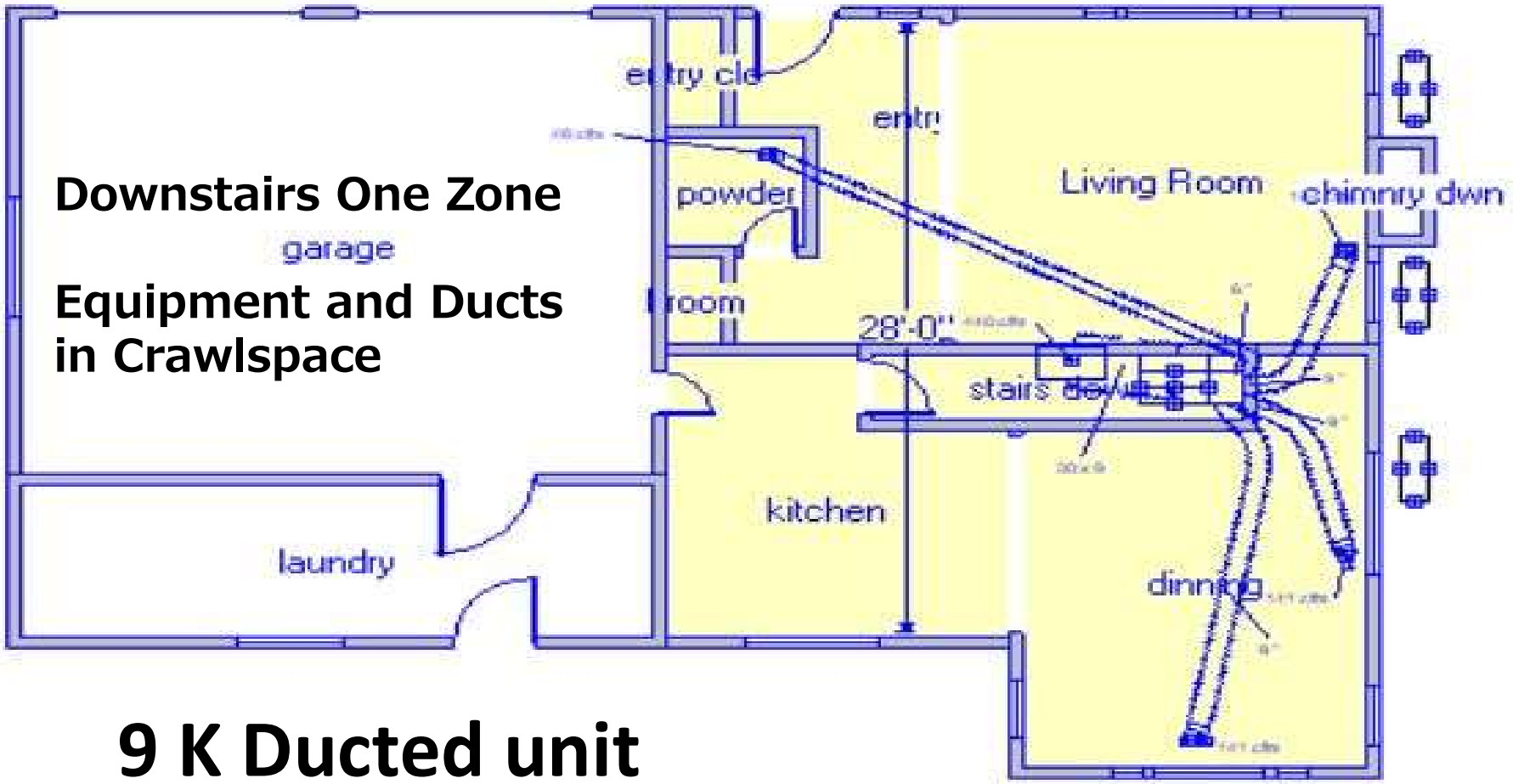
Three Zones!

Three Systems!

Downstairs One Zone

garage

Equipment and Ducts in Crawlspace



9 K Ducted unit

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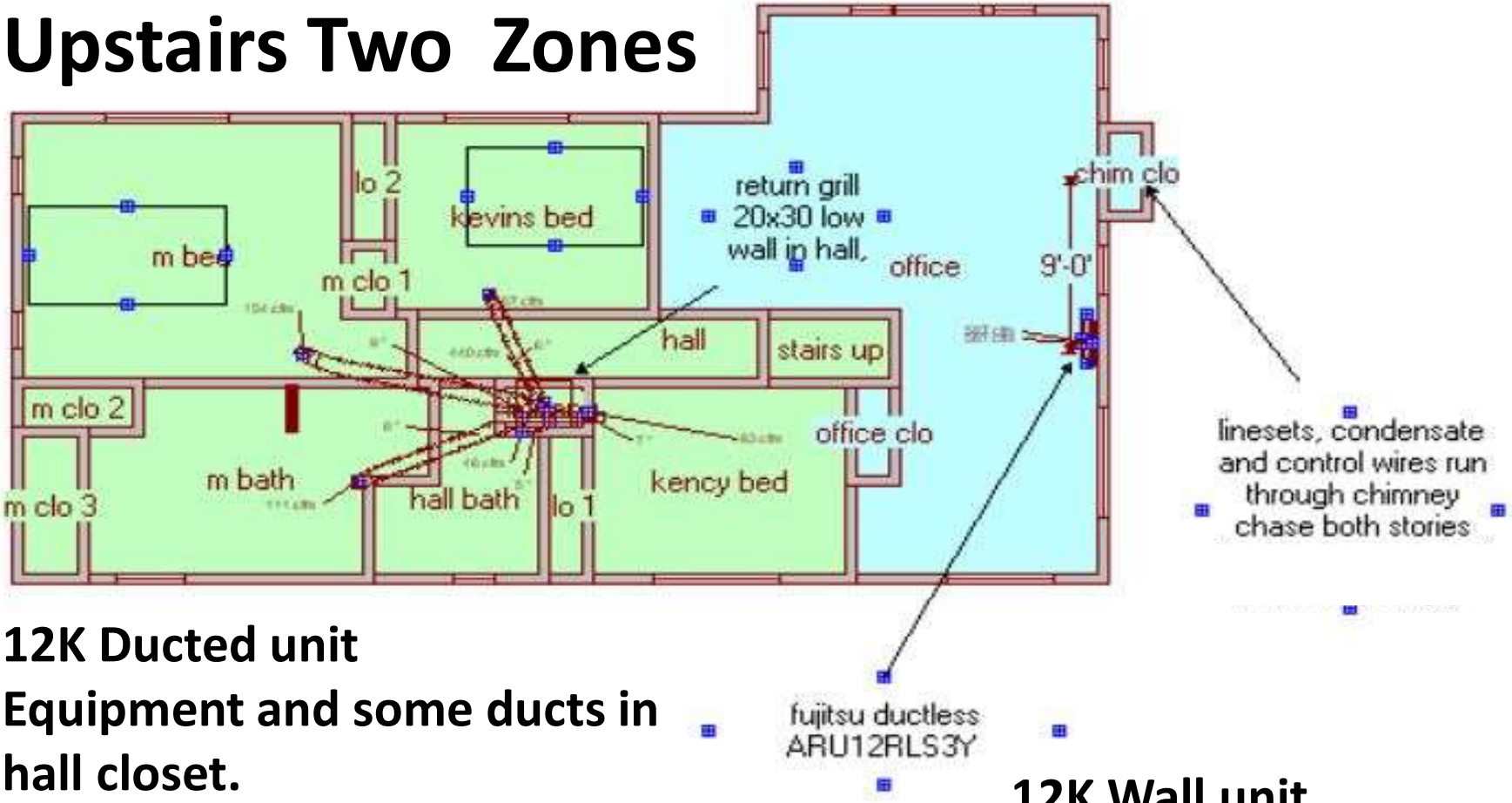
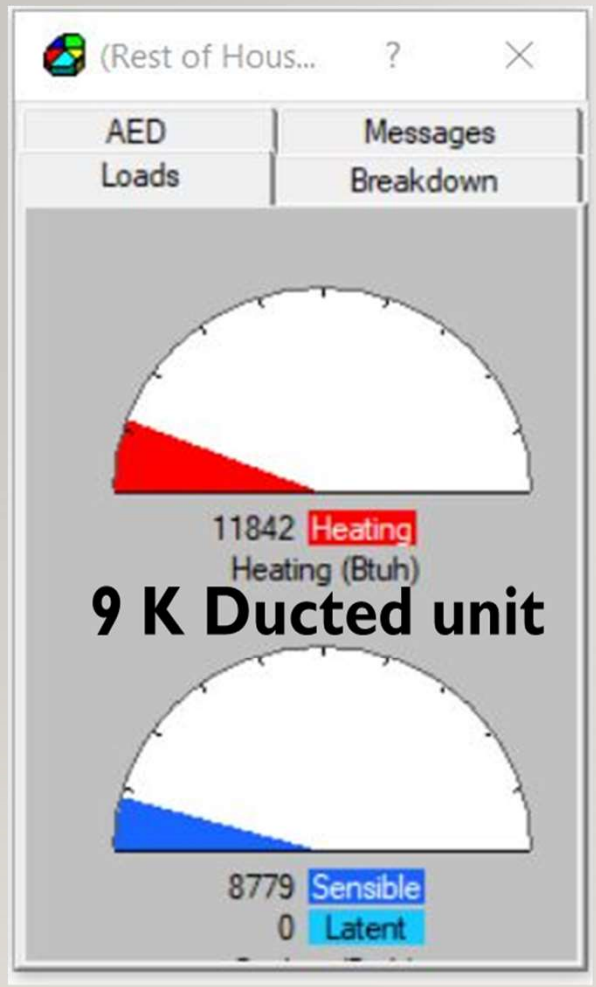
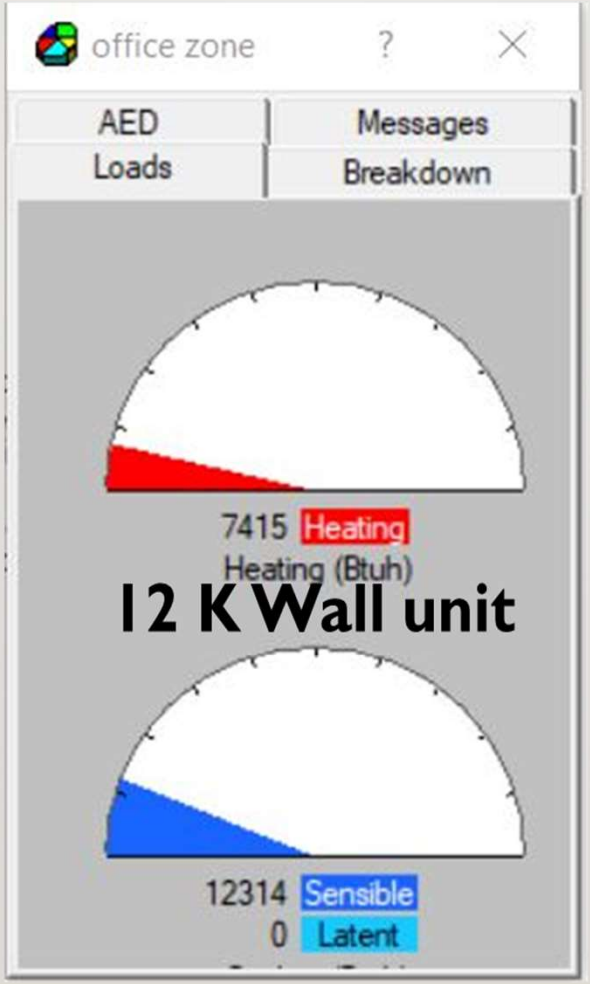
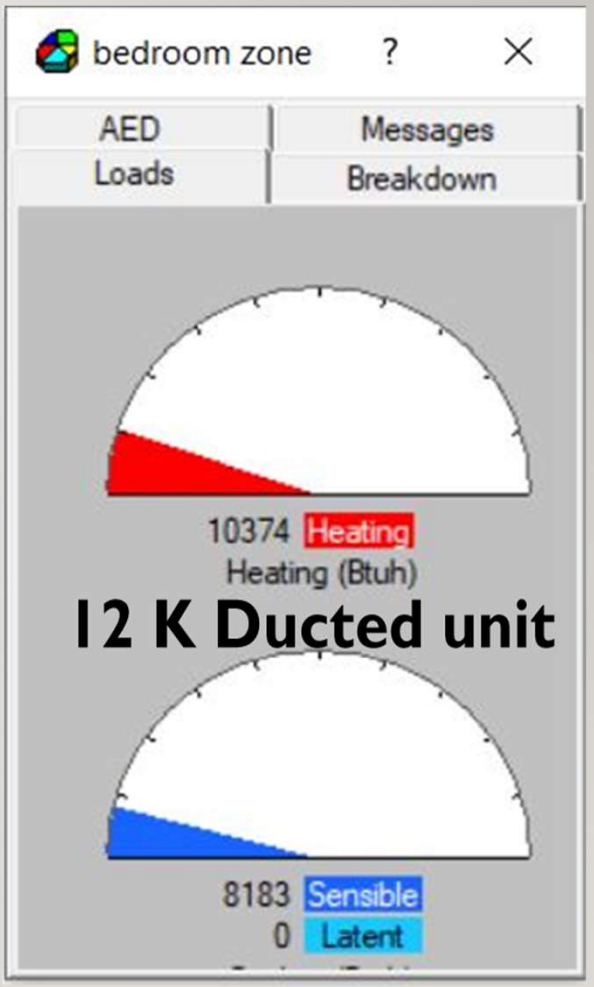
Upstairs Two Zones



12K Ducted unit
Equipment and some ducts in hall closet.
Some duct in attic.







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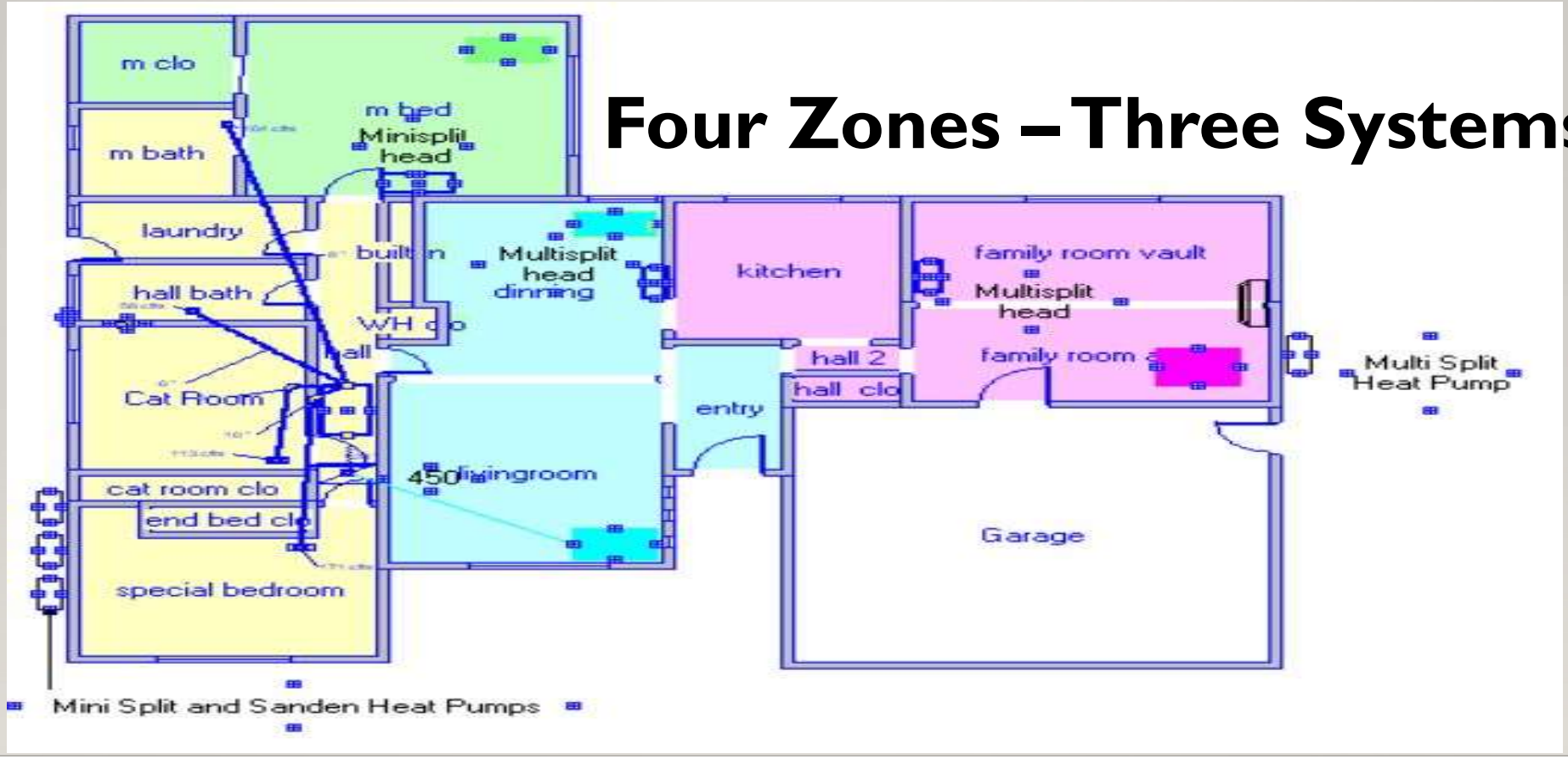
Heat Pump Design Advantage



Four Zones – Three Systems

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Heat Pump Design Advantage

If for no other reason, mini-splits are great because we can fit them in our building's structure.

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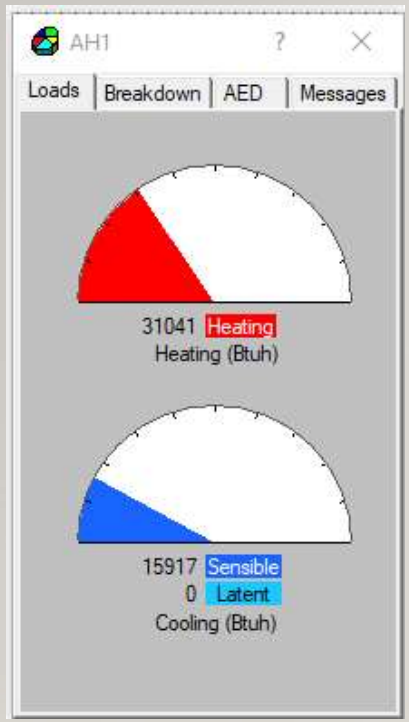
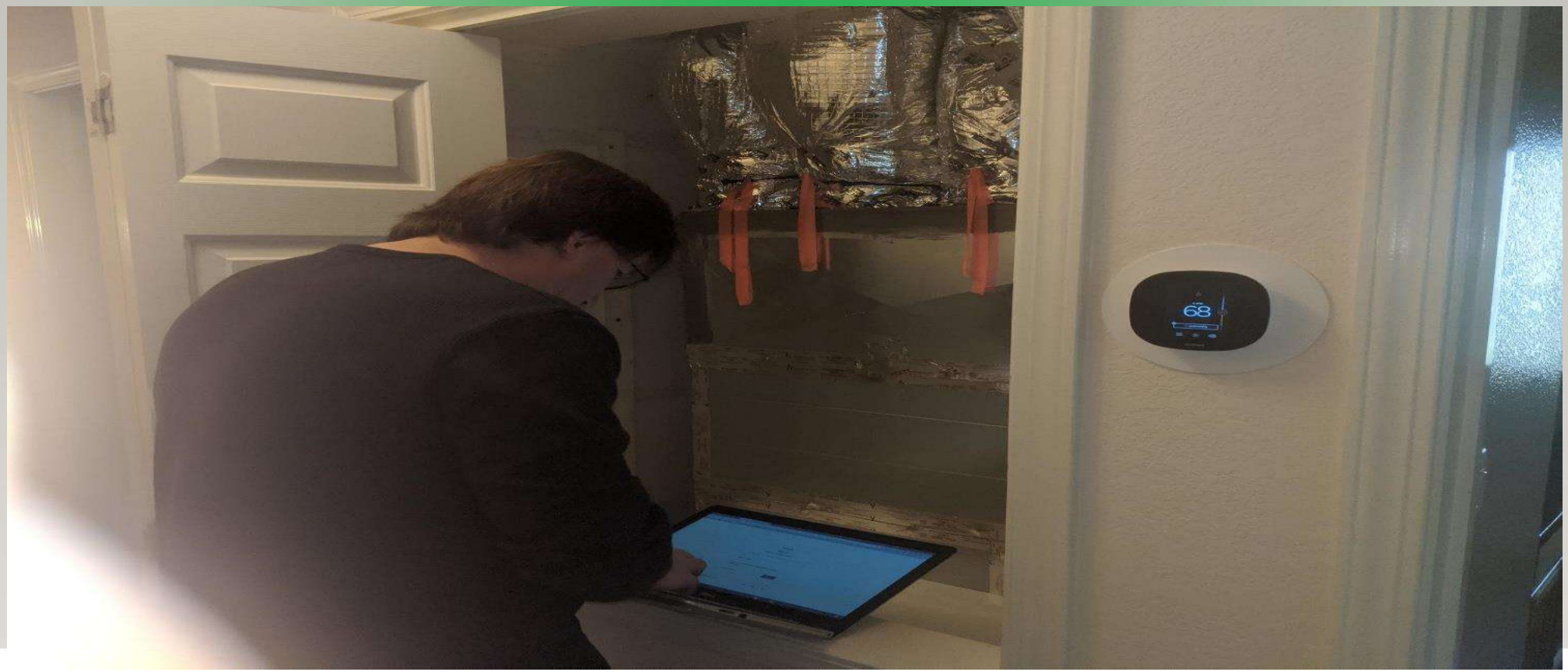


Solutions for mismatched heating and cooling load

1. Two stage heat pump, wire both stages for heating and only one for cooling.
2. Split the space into more equipment zones, use a wall head for the big common area and a smaller ducted unit for the bedrooms.
3. Increase the insulation levels and air tightness to bring the building load down to where a slim duct unit could meet the load.

Systems Must Be Commissioned



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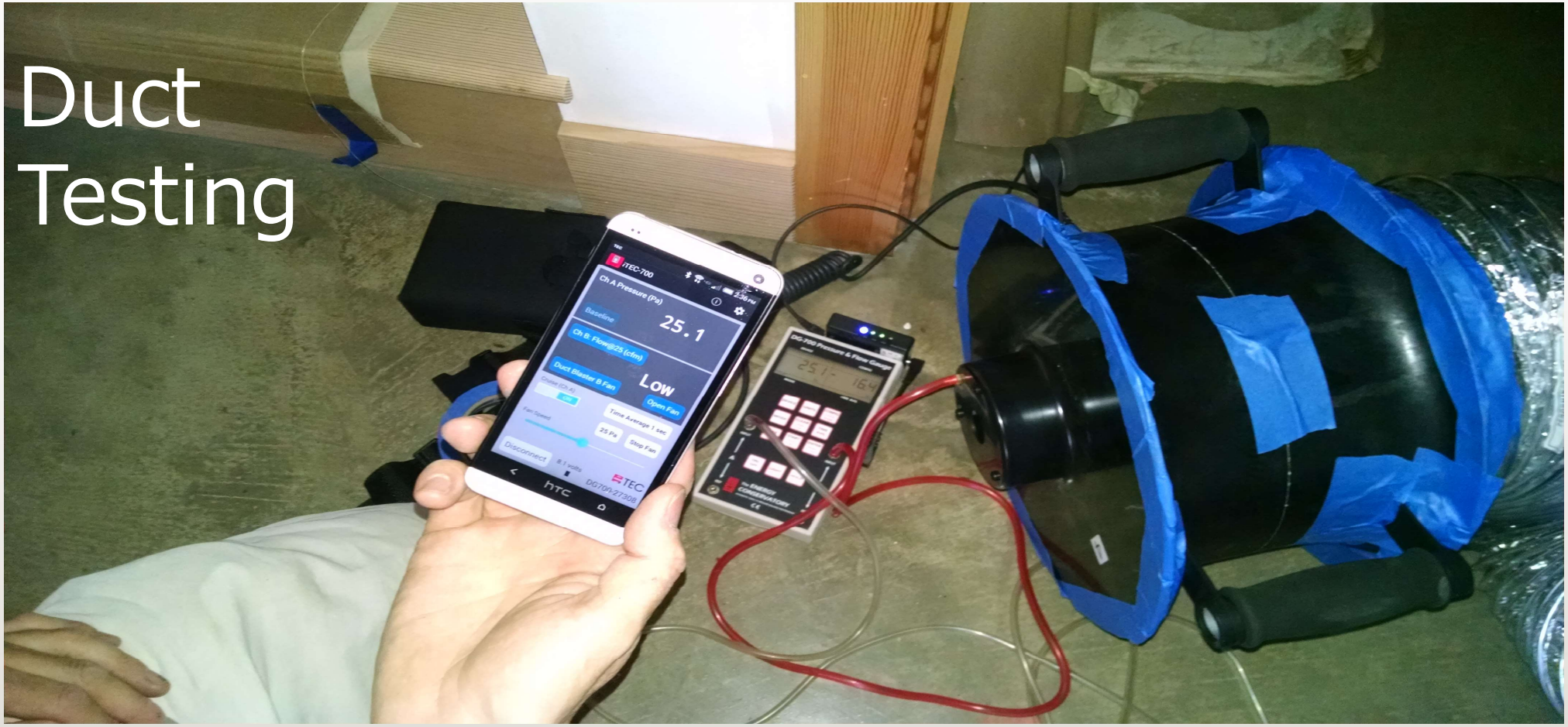
This is not the same as a code inspection or a HERS rating

Neither Inspectors nor HERS Raters have ALL the necessary training nor skills

You should expect and require the installing HVAC contractor to commission the system they install in your home

Ideally by the Install crew

Duct Testing



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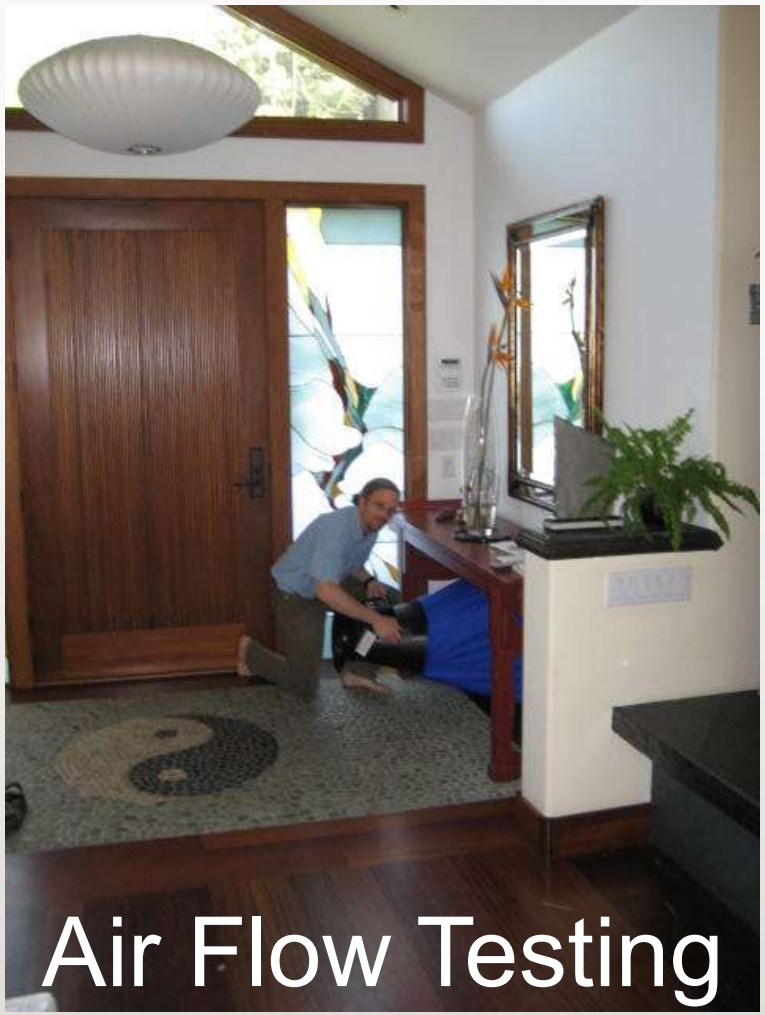

Air Flow Testing

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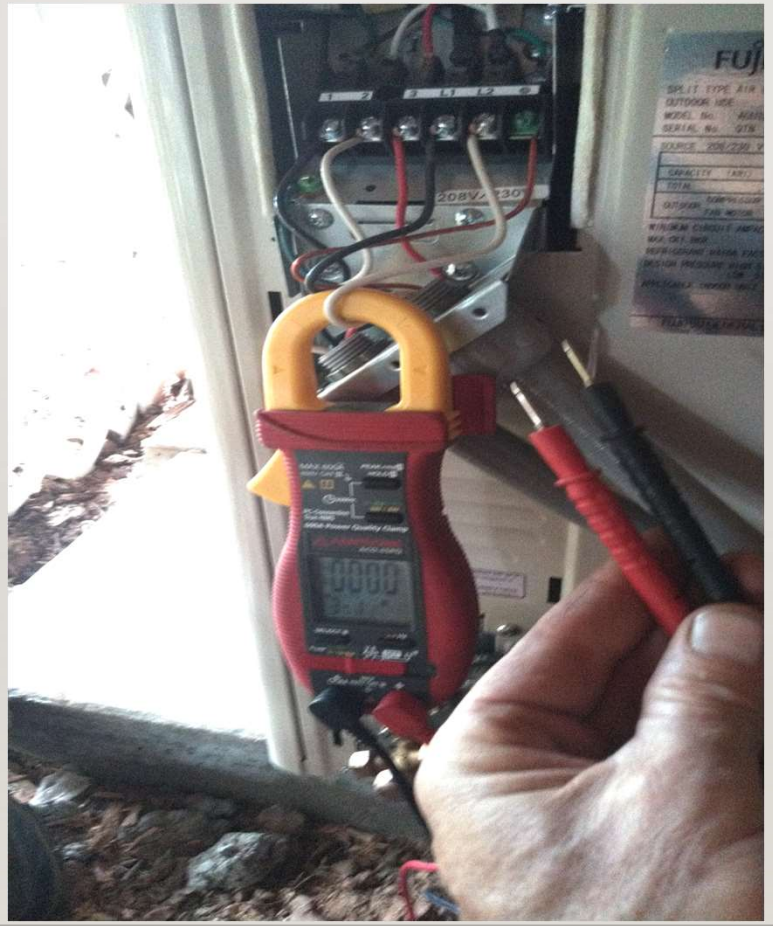
Power Measurement



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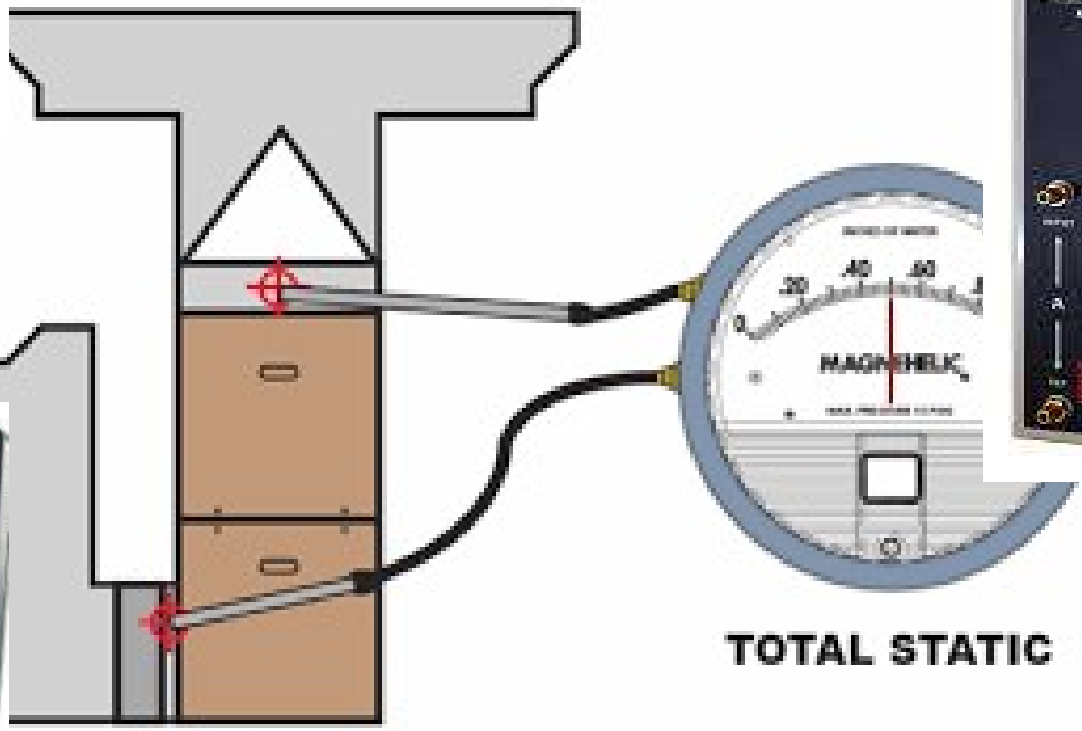
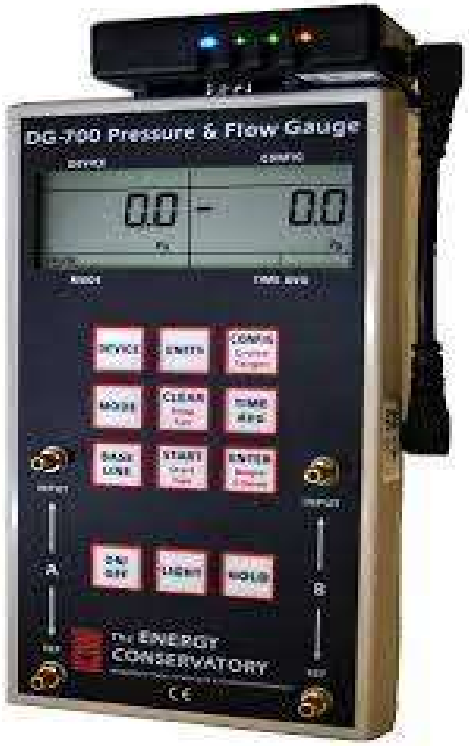
Static Pressure





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Goodman 30K Heat Pump Air Handler With Inline Hydronic Coil and 24KBtu Heat Pump

Room Name		Dinning	kitchen	Office	M bed	M bath	living	guest bed	guest bath					
Test condition	**tap or speed set**	**Supply1**	**Supply 2**	**Supply 3**	**Supply 4**	**Supply 5**	**Supply 6**	**Supply 7**	**Supply 8**	**TOTALS**				
plus 10%		334	99	80	167	96	161	152	73	1162				
											Supply static	**Return Static**	**Total Static**	**Watt**
minus 10%		276	82	66	138	79	133	125	60	960				
Manual J Target		304	90	73	152	87	146	138	66	1056				
balance 1 2/4/2016	C minus 5%	290	105	98	163	83	125	171	80	1115	0.2	0.1	0.3	
balance 2	C minus 10%	276	87	96	160	83	122	165	80	1069	0.862	0.0636	0.9256	
balance 3 final 2/5/2016	C minus 10%	284	105	72	167	85	150	138	66	1067	0.0953	0.0654	0.1607	174
balance 4										0			0	
balance 5										0			0	
balance 6										0			0	
final balance	C minus 10%	284	105	72	167	85	150	138	66	1067	0.0953	0.0654	0.1607	174
										0			0	

Dry climate airflow target met: measured airflow greater than 450 cfm per ton

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Key takeaways

1. Oversizing heat pumps is a significant source of inefficiencies.
2. Variable capacity does not allow over-sized heat pumps to run efficiently.
3. Doing load calculations for every job is necessary.
4. Doing duct design for every job is necessary.

Key takeaways continued

5. Heat pumps need high airflow to function well in our climate.
6. Installing a heat pump on an existing duct system is likely to cause poor efficiencies.
7. Refrigerant release is a huge environmental problem.
8. Electrical Panel condition and capacity is a significant barrier to electrification of homes, smaller draw electrical equipment is desirable.

Questions

?

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