



# We will be starting soon!

*Thanks for joining us*



# The Case for Practical Home Performance

Larry Waters, Electrify My Home

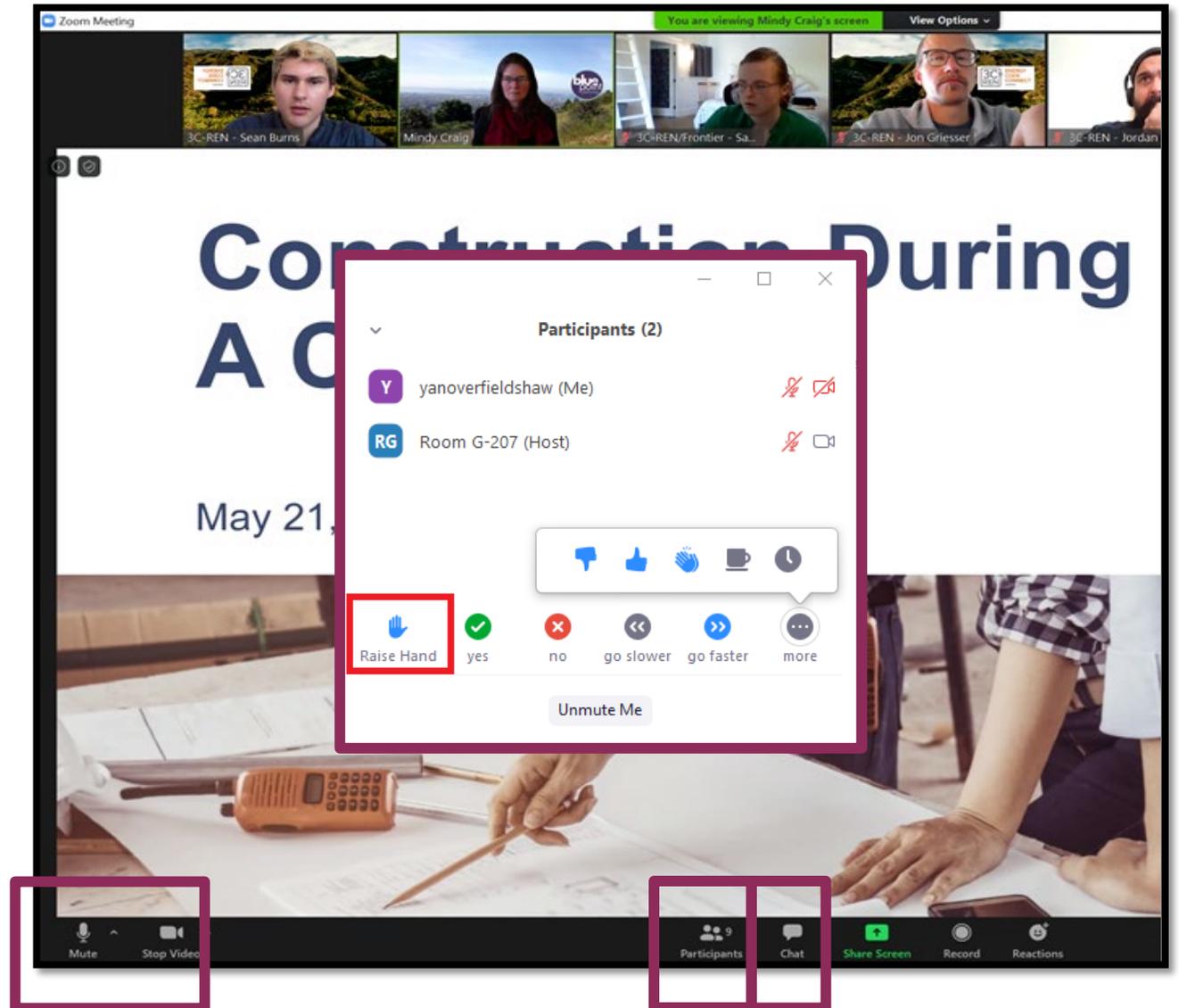
Alex Sloan, Electrify My Home

July 14th, 2023



# Zoom Orientation

- Please be sure your full name is displayed (for our reporting)
- Please **mute** upon joining
- Use "Chat" box to share questions or comments
- Under "Participant" select "Raise Hand" to share a question or comment verbally
- The session may be **recorded** and posted to 3C-REN's on-demand page. Feel free to ask questions via the chat and keep video off if you want to remain anonymous in the recording.



# 3C-REN: Tri-County Regional Energy Network

- Three counties working together to improve energy efficiency in the region
- Services for –
  - **Building Professionals:** industry events, training, and energy code compliance support
  - **Households:** free and discounted home upgrades
- Funded by ratepayer dollars that 3C-REN returns to the region



# 3C-REN Programs

- **Energy Code Connect (ECC)**
  - Industry Trainings and Regional Forums
  - Energy Code Coach: Title 24 Compliance Support Hotline (805) 220-9991
- **Building Performance Training (BPT)**
  - Industry Trainings & Certification for current and perspective building professionals
  - Helps workers thrive in an evolving industry
- **Home Energy Savings (HES)**
  - Flexible Home Energy Upgrades
  - Multifamily (5+ units) & Single Family (up to 4 units)



# About Larry Waters



🔌 HVAC trade from UTI in 1982



🔌 In the trade before the first cordless drill



🔌 Nate certified



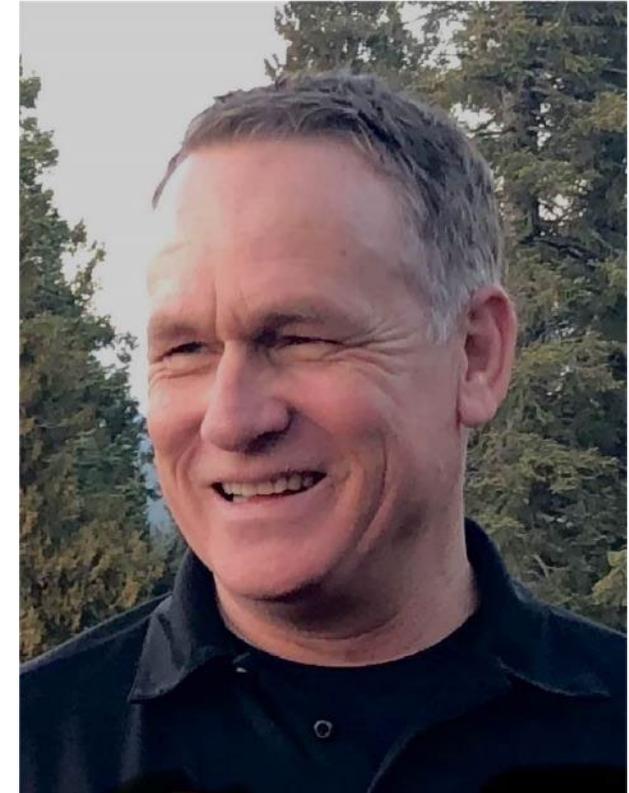
🔌 2009/ 2010 BPI certification



🔌 Installing only heat pumps since 2015



🔌 Founded Electrify My Home in 2020



# Electrify My Home – Electrification Pioneers

## Our Mission:

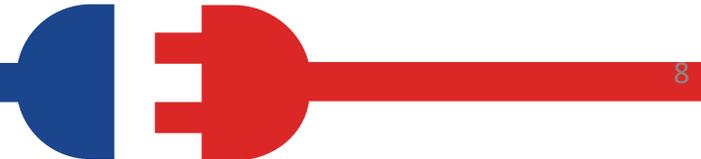
*To provide the **most efficient** cost-effective electrification solutions to California homeowners, to practice **good stewardship** of the electrical panel, and to **train and influence** other contractors to do the same.*



**ELECTRIFY**  
**MY HOME**

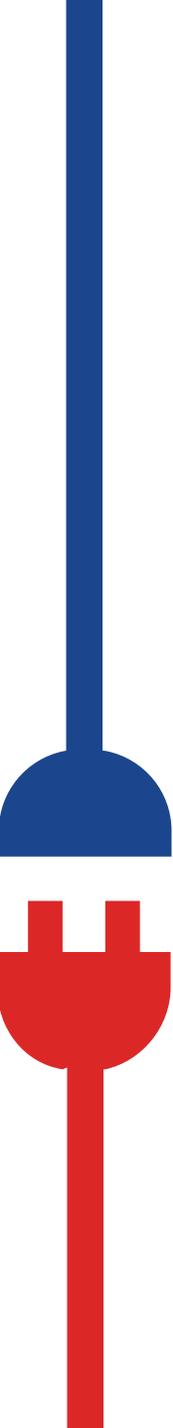
# Agenda

- ⚡ Introduction to home performance electrification
- ⚡ Unintended consequences of heat pump box swaps
- ⚡ Why sizing matters
- ⚡ How far to go with home performance?
- ⚡ Project example
- ⚡ Closing and Wrap up



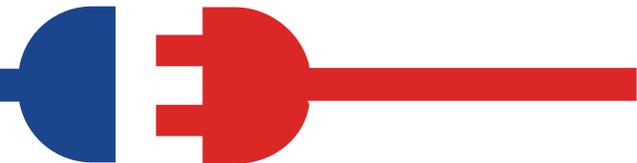
# What is Home Performance?

*The Basics*



# What is Home Performance?

- 🔌 **Describes how all aspects of a home work together as a single system**
- 🔌 **A science-backed approach based on the premise that homes should be:**
  - Safe
  - Healthy
  - Comfortable
  - Durable
  - Efficient
  - **Quiet is one we add!**



# “Think Beyond The Box”

*Our motto of the day!*

*The best outcomes for heat pumps come when multiple  
elements of the home are considered*

*...AND IT'S NOT THAT HARD!*

# Basic Physics - 2<sup>nd</sup> Law of Thermodynamics

Energy flows naturally from **high to low** concentrations

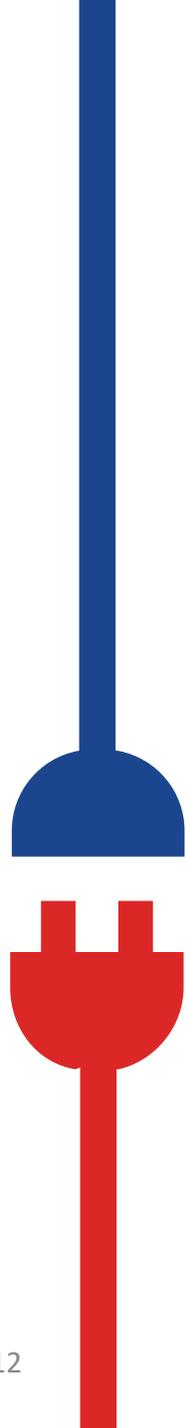
Pressure flows from **HIGH** to **LOW**

Heat flows from **WARM** to **COLD**

Moisture flows from **MORE** to **LESS**

Energy In = Energy Out

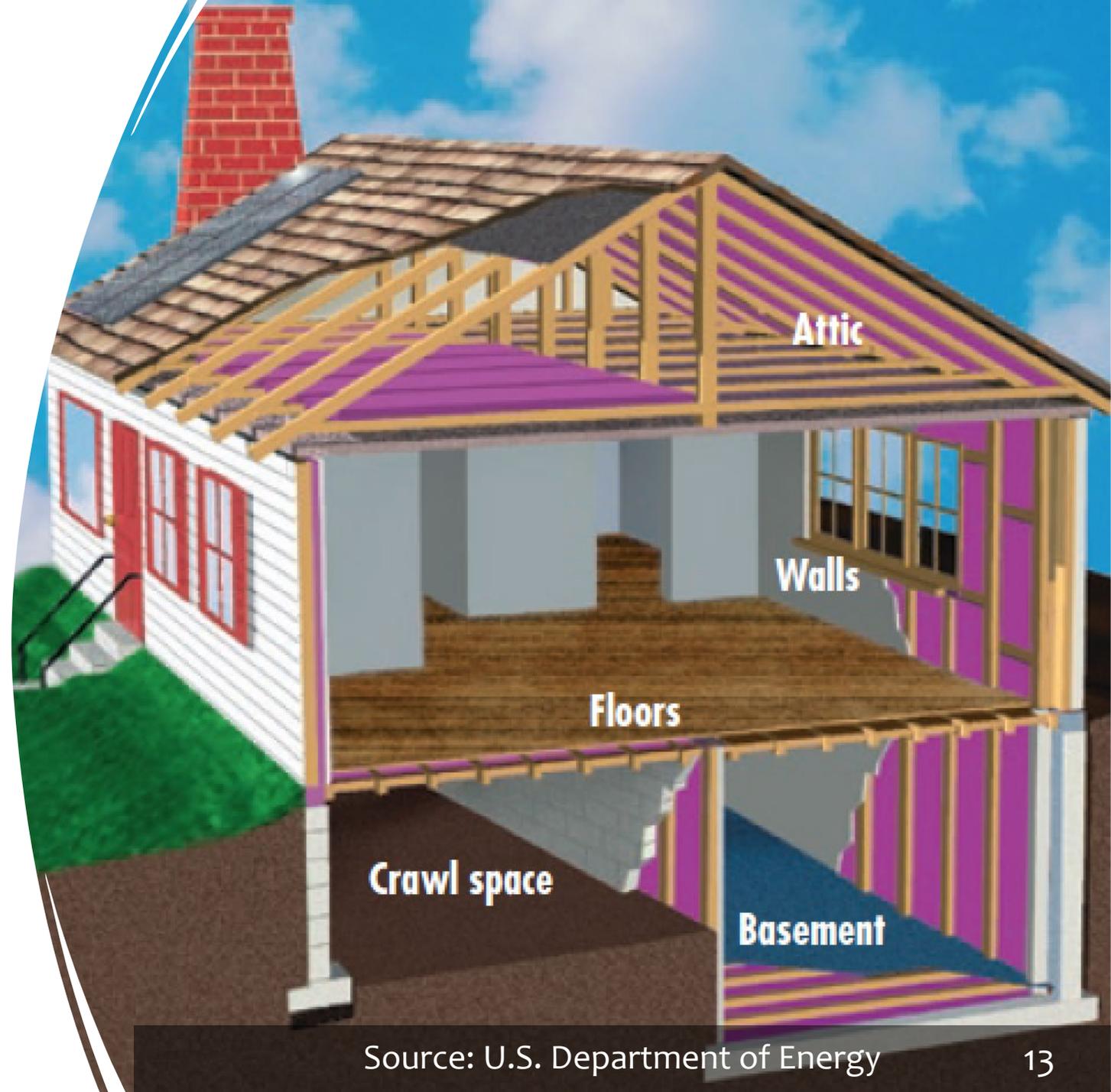
1 CFM In = 1 CFM Out



# The 3 Critical Elements of the Building Enclosure

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- 🔌 Air Barrier
- 🔌 Pressure Boundary
- 🔌 Thermal Boundary

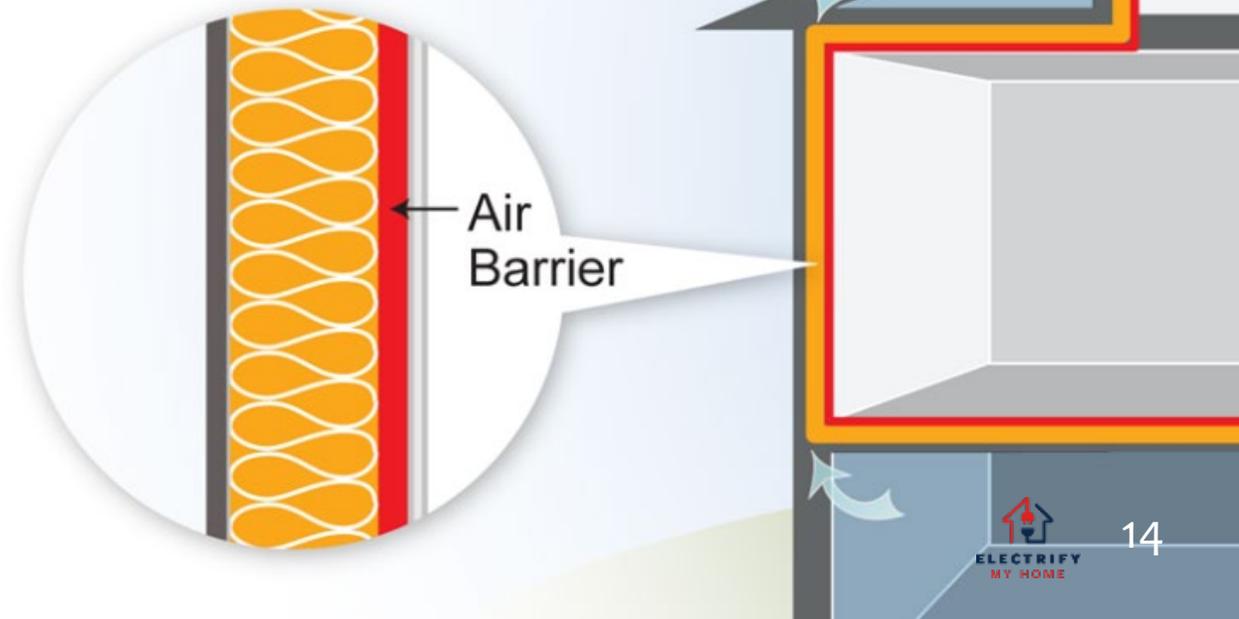


# Air Barrier

System of materials designed to control airflow between a conditioned space (indoors) and an unconditioned space such as outdoors or a garage.

## An effective air barrier must be:

- ❖ Impermeable to air flow
- ❖ Continuous over the entire building enclosure
- ❖ Able to withstand the forces that may act on them during & after construction
- ❖ Durable over the expected lifetime of the building
- ❖ Define the location of the pressure boundary

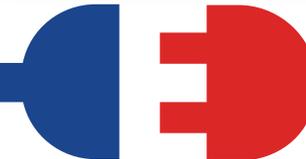


# Pressure Boundary

The boundary point is the point at which inside air and outside air are separated, stopping air and vapor penetration into building cavities

- ✓ The boundary where air sealing should occur
- ✓ Separates garages from conditioned space, making this the “gas barrier”
- ✓ Thermal and pressure boundaries should be aligned

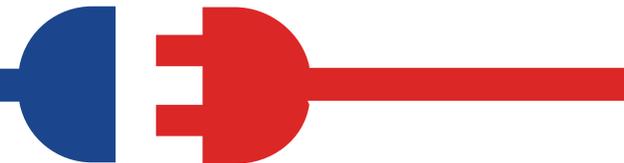
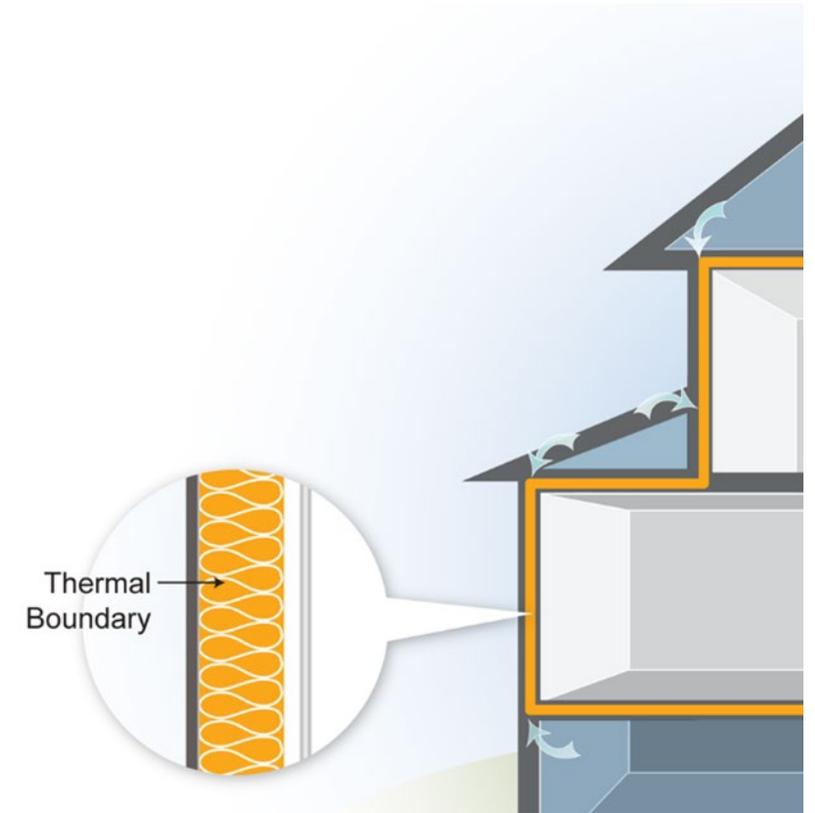
A “break” in the pressure boundary



# Thermal Boundary

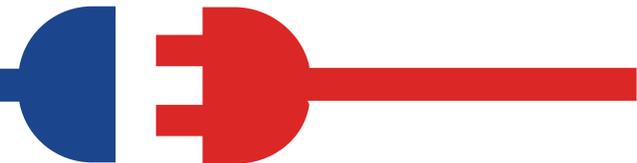
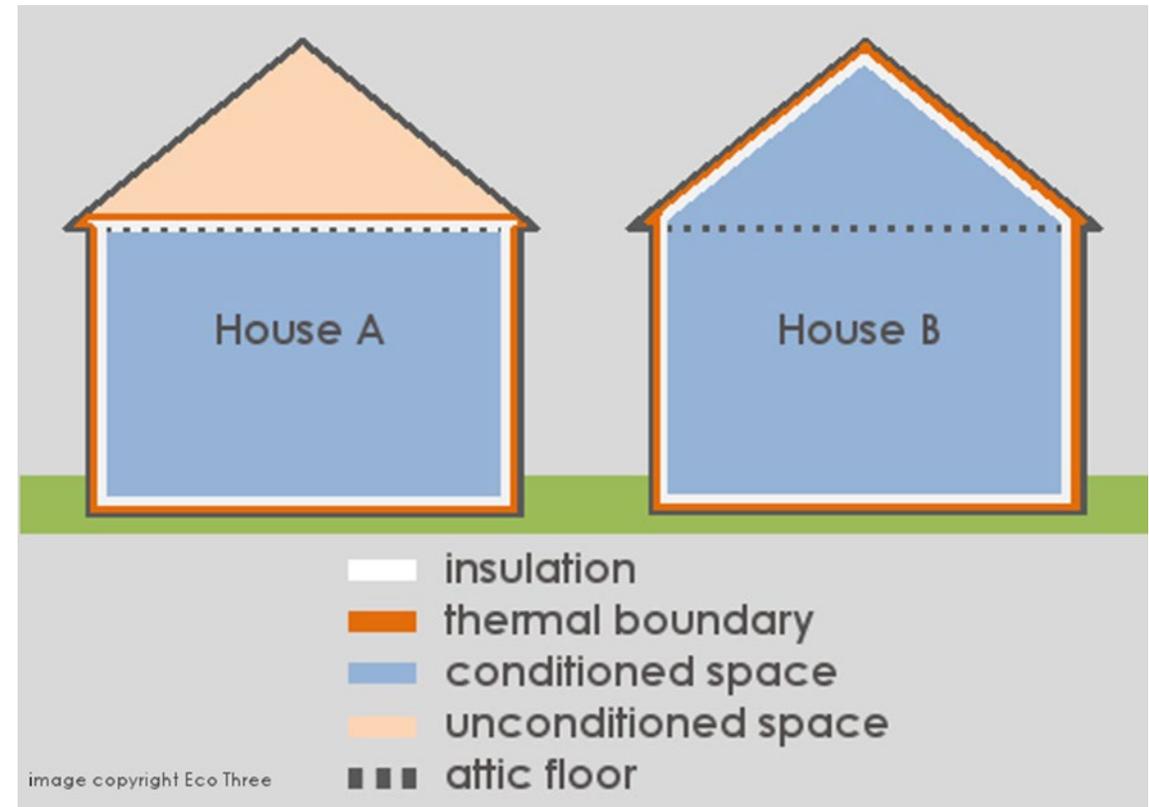
The plane of the building **surrounding the space** that is intentionally heated and cooled. This is where insulation should be located.

- ✦ Created by the **presence of insulation** in complete and continuous contact with the air barrier
- ✦ Restricts or slows the **heat transmission** through the building enclosure
- ✦ Cannot exist without an **air barrier**
- ✦ A **necessity** for an energy-efficient building



# Thermal Boundary

- ⚡ Thermal boundaries can exist in different spaces, depending where the air barrier is insulated



# Air leakage

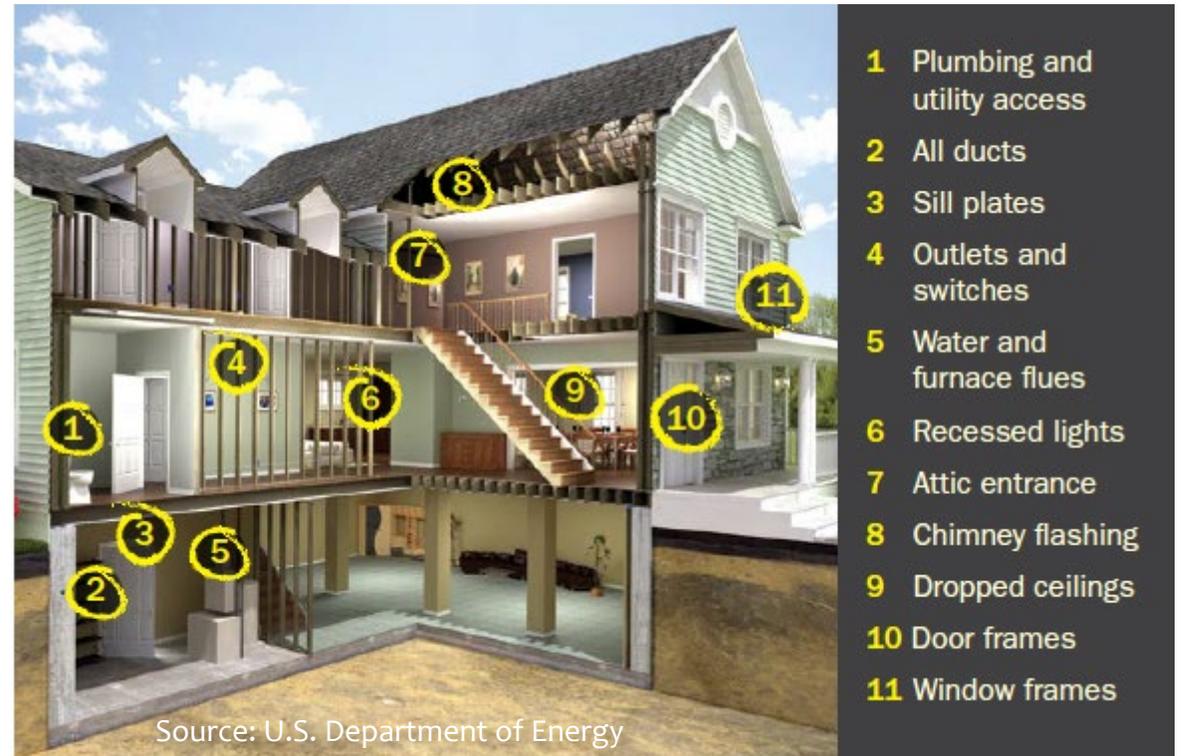
(The Invisible Thief)

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# Infiltration and Exfiltration

- ✦ Air flows into and out of our building enclosures through construction flaws that rob homes of comfort and energy and degrade indoor air quality
- ✦ Air leakage in buildings represents 5% to 40% of space-conditioning costs



For typical ducts in attic:

“Supply Leaks SUCK, Return Leaks BLOW”

I.e., Supply leaks lead to infiltration, return leaks cause exfiltration



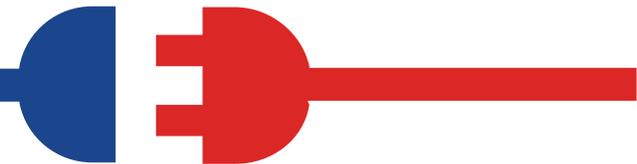
Air Leakage Before  
and After

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Attic & underfloor can be fixed

# When Electrifying, Open Walls & Combustion Vents Must Be Sealed





# Insulation Problems

# Poor Application of Foam Under Roof in an Attempt to Save Energy

- ❗ Foam was applied under the roof
- ❗ Existing gable vent was left in place
- ❗ This is a misaligned thermal barrier
- ❗ Solution: foil back knee-wall insulation installed in proper alignment for thermal barrier



# R-Value as it Pertains to Insulation

- R-value is a measure of the resistance to the conductive flow of heat
- Measured R-Value varies per material
- R is resistance to energy (heat) flow
- Communicate as 1 degree resistance per R  
i.e. R50 = 50 degrees resistance



# Calculating the Duct Gain

- ✦ Square footage of the home X 0.4
- ✦ T/D of the attic and the cold air in duct 125-55=70 degrees
- ✦ Determine the R-value of the ductwork

$$\text{Duct Gain} = \frac{\text{square feet} \times 0.4 \times \text{temp. difference}}{\text{R - value of ductwork}}$$



EXAMPLE → 1500 sq ft home, 125 degree attic, 55 degrees supply air, R3 insulation

With R-3 ducts:  $\frac{1,500 \times 0.4 \times (125 - 55)}{3} = \frac{42,000}{3} = 14,000 \text{ BTU (1.2 TONS)}$

Buried ductwork (R-30):  $\frac{1,500 \times 0.4 \times (125 - 55)}{30} = \frac{42,000}{30} = 1,400 \text{ BTU (0.1 TONS) lost to the hot attic}$

That is over one ton of cooling lost to the attic space!

# Insulation/Radiation Savings Example

## Total attic BTU savings!

Ceiling Heating Loss or Gain Calc:  
*u factor × sqft × temp. difference*

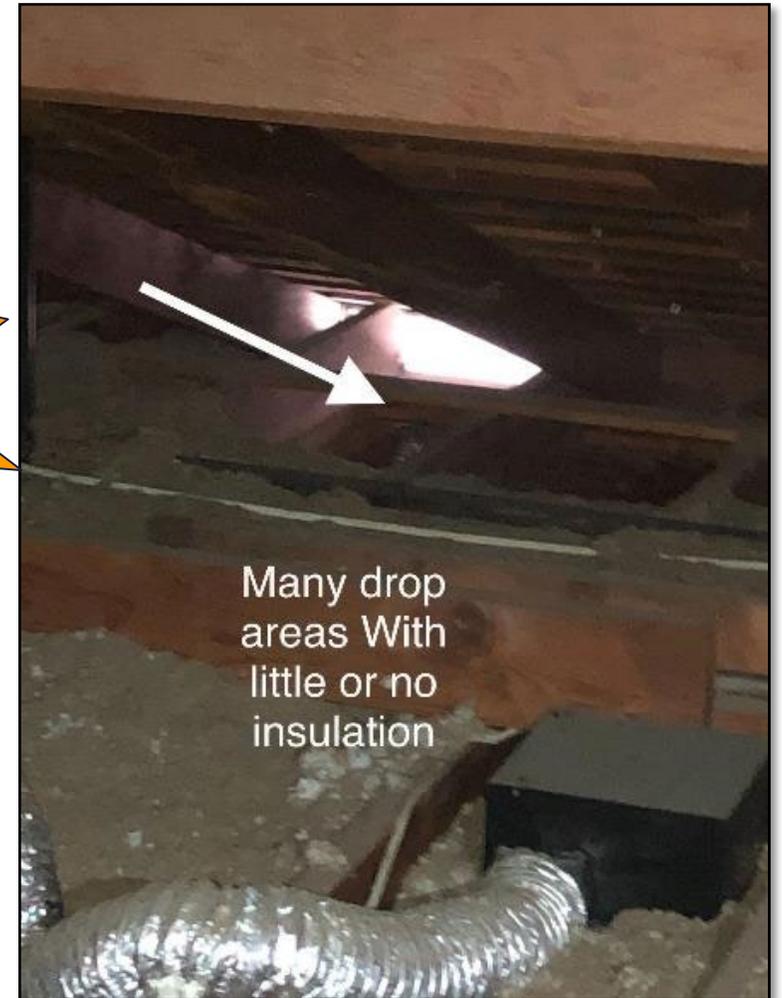
**Example:** 1,500 sq ft ceiling, Attic is 125°F, room is 75°F

With R-10 insulation:  $\frac{1}{10} \times 1500 \times (125 - 75) = 0.1 \times 1500 \times 50 = 7,500 \text{ BTU}$

With R-49 insulation:  $\frac{1}{49} \times 1500 \times (125 - 75) = 0.02 \times 1500 \times 50 = 1,500 \text{ BTU}$

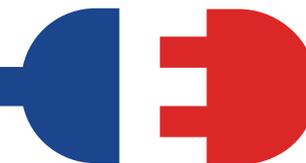
Differential:  $= 6,000 \text{ BTU}$

6,000 btus  
per hour  
savings  
½ ton



# High Performance Enclosure Specifications:

Enclosure Item	Specification
Enclosure leakage	< 0.5 CFM <sub>50</sub> /sq.ft.
Attic bypasses and unsealed interstitial cavities	None identified with an IR camera (>200DT)
Window performance	Verified (and accounted for in sizing calculations)



# High Performance Electric Home HVAC Ducted Mini Split Specifications

Item	Specification
Cooling SEER/EER	20/12
Heating HSPF	12
Maximum heating capacity	< 10 BTU/sq.ft.
Cooling capacity	> 1,200 sq.ft./ton
Duct & air handler location	100% conditioned space
Duct insulation	R-8.0
Supply grille delivery velocity	500 to 700 FPM on high speed
Return grille size	> 600 sq.in. per ton
Duct Leakage	< 5 CFM25 to the outside
Room temperatures	All the same temp within 3°F
Total static pressure	< 0.15" wc (with clean filters)



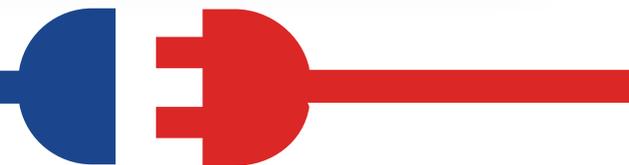
# High Performance Electric Home HVAC Unitary Heat Pump Specifications

Item	Specification
Maximum heating capacity, Duct Leakage, Duct Insulation, Cooling Capacity, Supply Grille Delivery Velocity, Room Temperatures	Same as ducted mini-splits (see last slide)
Cooling SEER/EER	16/12
Measured sensible EER	> 90% of manufacturer's performance data
Heating HSPF	10
Cooling capacity	> 1,200 sq.ft./ton
Cooling air flow	>550 CFM/ton
Verified refrigerant charge	SH and SC w/in 1°F of minimum allowed
Fan watt draw	<0.2 watts/CFM
Return grille size	> 600 sq.in. per ton
AC sizing confirmation	>70% run time at design temp
System standby watts	<10 watts
Return grille size	>400 sq.in. per ton
Total static pressure	< 0.25" wc (with clean filters)

# Unintended Consequences of “Box Swaps”

# Existing Gas Systems → Mostly Oversized

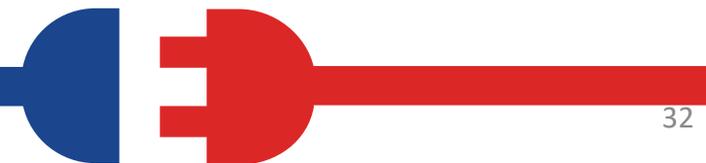
- ✦ 40 to 60 BTU per square foot.
- ✦ 1500 Sq ft home usually 60,000 BTU or larger!
- ✦ Waste heat makes building performance less noticeable
- ✦ Short Cycles in milder weather
- ✦ Their best reliable solution 2 stage
- ✦ 2 stages usually 60% low 100% high
- ✦ Low stage on 60k is 36kBtu



# Trying to “Plug & Play” Heat Pumps Can be Disastrous

Things we must keep in mind:

- ⚡ Fewer BTUs to deliver
- ⚡ Duct Sizing
- ⚡ Velocity (proper air mixing)
- ⚡ Wrong registers (uncomfortable drafts)
- ⚡ Low temps (warm not hot)
- ⚡ Defrost Cycle, winter performance
- ⚡ Panel Planning
- ⚡ Educating customers



# Furnace Outputs Much Higher Than Heat Pumps

**AHRI CERTIFIED**  
www.ahridirectory.org

## Certificate of Product Ratings

AHRI Certified Reference Number : 5953915      Date : 11-21-2021      Model Status : Active

AHRI Type : RCU-A-CB (Split System: Air-Cooled Condensing Unit, Coil with Blower)

Outdoor Unit Brand Name: [REDACTED]      **4TTX8024A1**

Outdoor Unit Model Number (Condenser or Single Package) : 4TTX8024A1

Indoor Unit Brand Name : ADP

Indoor Unit Model Number (Evaporator and/or Air Handler) : H,TG31(6,9)24      **H,TG31(6,9)24**

Furnace Model Number : \*UD2C080ACV4      **\*UD2C080ACV4**

Region : All (AK, AL, AR, AZ, CA, CO, CT, DC, DE, FL, GA, HI, IL, IN, IA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, VA, VT, WA, WV, WI, WY, U.S. Territories)

Region Note : Central air conditioners manufactured prior to January 1, 2015 are eligible to be installed in all regions until June 30, 2016. Beginning July 1, 2016 central air conditioners can only be installed in region(s) for which they meet the regional efficiency requirement.

The manufacturer of this ADP product is responsible for the rating of this system combination.

Rated as follows in accordance with the latest edition of AHRI 210/240 with Addendum 1, Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment and subject to rating accuracy by AHRI-sponsored, independent, third party testing:

Cooling Capacity (A2) - Single or High Stage (95F) : 25,000

SEER : 17.00      **SEER : 17.00**

EER (A2) - Single or High Stage (95F) : 12.50      **EER (A2) - Single or High Stage (95F) : 12.50**

**AHRI CERTIFIED**  
www.ahridirectory.org

Eligible for Federal Tax Credit.

## Certificate of Product Ratings

AHRI Certified Reference Number : 202195106      Date : 11-21-2021      Model Status : Active

AHRI Type : HRCU-A-CB-O (Mini-Split Heat Pump, with Remote Outdoor Unit Air-Source, Free Delivery)

Outdoor Unit Brand Name: [REDACTED]      **AOU18RGLX**

Outdoor Unit Model Number : AOU18RGLX

Indoor Type : Mini-Splits (Non-Ducted)

Indoor Model Number(s) : AUU18RGLX      **AUU18RGLX**

Rated as follows in accordance with the latest edition of AHRI 210/240 with Addendum 1, Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment and subject to rating accuracy by AHRI-sponsored, independent, third party testing:

Cooling Capacity (95F) : 18000      **Cooling Capacity (95F) : 18000**

EER (95F) : 13.40      **EER (95F) : 13.40**

SEER : 21.40      **SEER : 21.40**

High Heat (47F) : 21000      **High Heat (47F) : 21000**

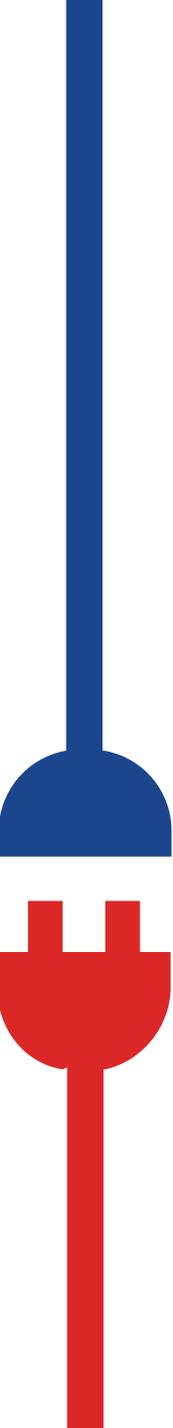
Low Heat (17F) : 12300      **Low Heat (17F) : 12300**

HSPF : 10.90      **HSPF : 10.90**

Sold in? : USA, Canada

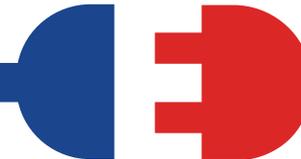
Sizing it's the most  
important step

Installing Smaller is Possible



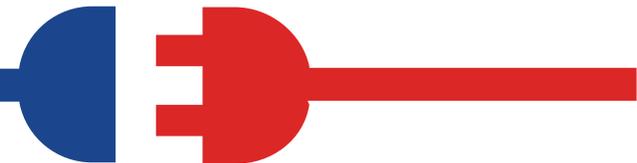
# Sizing: Critical for Lowest Operational Cost

- ⚡ Smaller systems use less energy and cost less to install
- ⚡ Loose houses need more capacity (larger systems)
- ⚡ Large systems cycle too much in milder cool and warm days
- ⚡ Large systems don't run long enough to create comfort
- ⚡ Every room needs a different amount of air
- ⚡ Doing this wrong will cause lack of comfort



# Why BTU to KW is Not a Reliable Sizing Method

- ⚡ Basing heat pump size on peak gas is a way to verify, not to size!
- ⚡ Does not consider homeowners habits and their efforts to save energy
- ⚡ Does not provide room by room load requirements
- ⚡ Does not consider multiroom options (Mini Splits)
- ⚡ Won't uncover problems with existing furnaces



# Big Opportunity, Big Risk (If Done Poorly)

90%

90% of CA homes rely on gas for **space or water heating** <sup>1</sup>

11.7  
Million

CA homes (96%) with gas or elec resistance **heating** <sup>2</sup>

85% of single-family use gas <sup>4</sup>

12  
Million

CA homes (99%) with gas or elec resistance **water heaters** <sup>2</sup>

93% of single-family homes have gas DHW <sup>4</sup>

3.4  
Million

CA homes with **no AC** <sup>3</sup>

<sup>1</sup> Decarbonization of Heating Energy Use in California Buildings. Synapse Energy Economics, Inc. 2018.

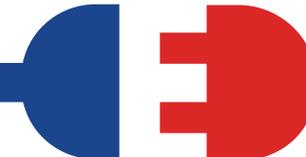
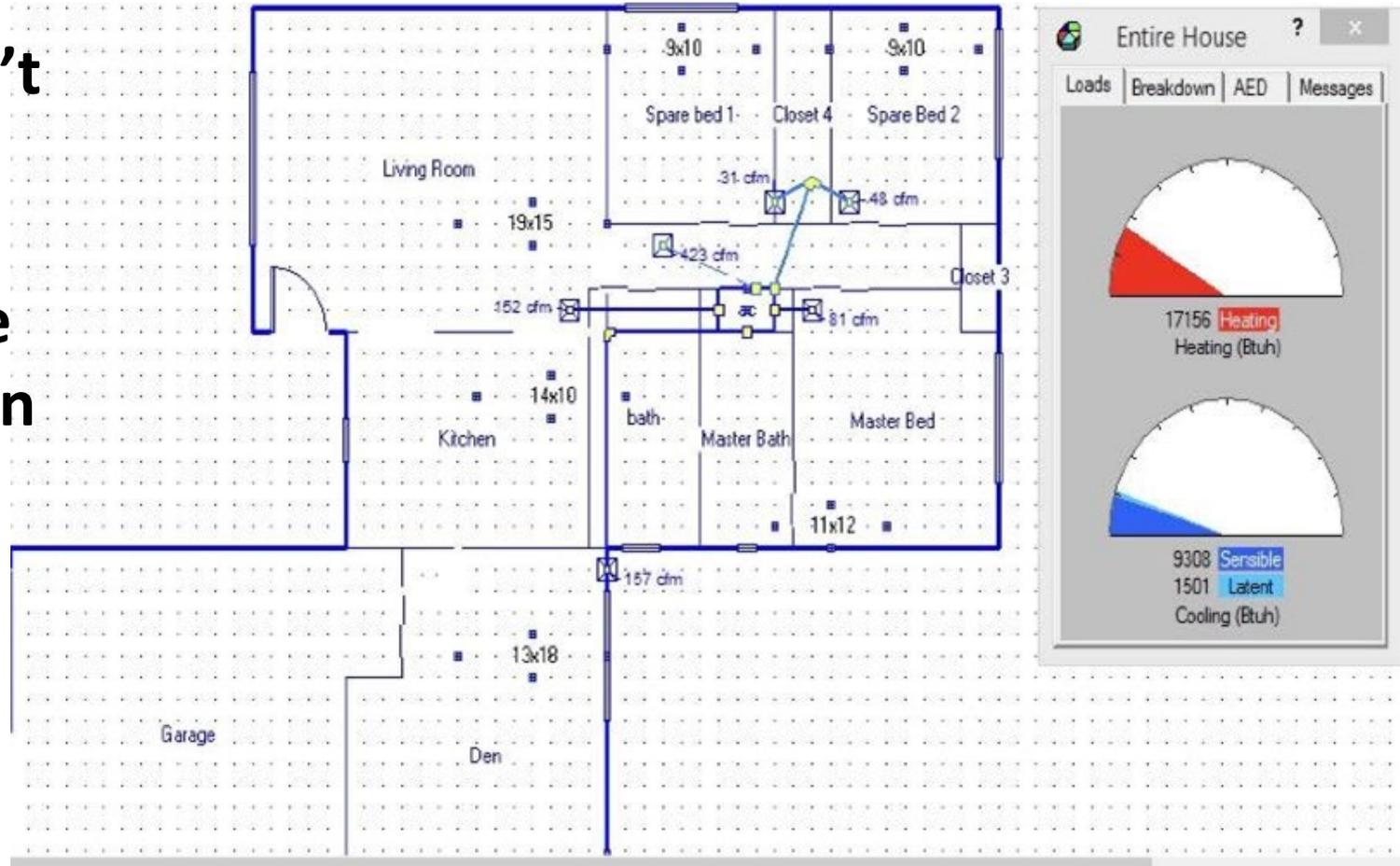
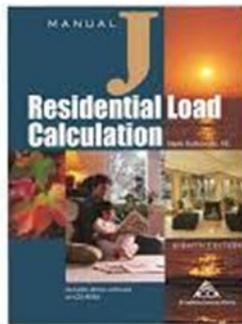
<sup>2</sup> CA Heat Pump Residential Market Characterization & Baseline Study. Opinion Dynamics. 2022.

<sup>3</sup> Canary Media. "California could ban new gas heaters after 2030. The goal: healthier air." 2022

<sup>4</sup> 2019 California Residential Appliance Saturation Study (RASS) . DNV-GL/CEC. 2021

# Real Load Calculations Show Reality Rules of Thumb are Just Guessing

- Homes in our climate don't need much capacity
- Sizing this house with rule of thumb would have been at least twice the size

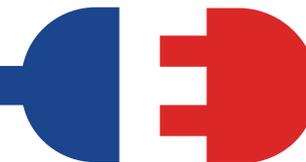


# Swapping Like for Like Sizing

- ⚡ Existing 1500 sq foot home with 3-ton system mostly have at least 60K BTU furnace
- ⚡ A 36k BTU heat pump is **40% less** heating capacity
- ⚡ Traditional heat pumps loose capacity when temps < 40 degrees
- ⚡ House may not have enough heat when temperatures drop < 40 degrees



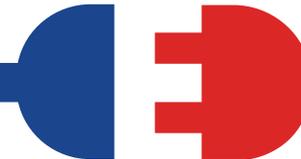
Photo Credit: Bailes, Allison (2014). My Big Fat Oversized Air Conditioner. Energy Vanguard.



# Replacement Without Planning

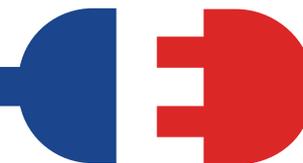
## Emergency replacement with a heat pump is ripe for poor results

- ✦ Most HVAC systems are sold by **maintenance and service techs** not designers
- ✦ Most HVAC techs only experienced with **gas furnaces** and AC
- ✦ Techs and maintenance people are rarely up to speed on the **best design and technology**
- ✦ Unfortunately, many techs are looking for a **quick easy sale**, no time to perform meaningful calculations
- ✦ Customers could end up with **energy guzzling systems** that require additional heat for backup

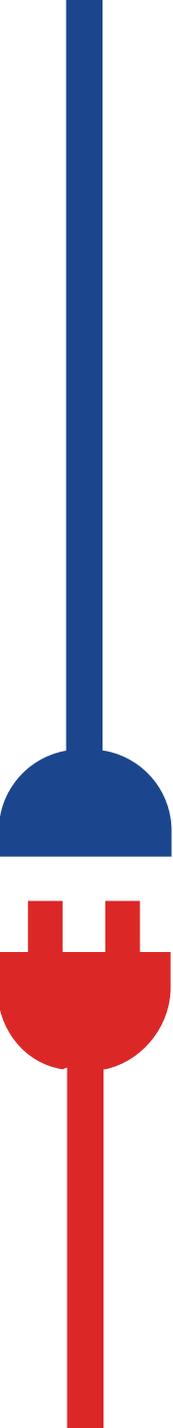


# Summary – Results of Poor Planning

- ⚡ Rush to get back online and unexpected expense drives rash decisions
- ⚡ Unplanned replacement often becomes low bidder option
- ⚡ HVAC professionals with no experience or knowledge of envelope performance
- ⚡ Results in larger loads and unnecessary panel upgrades
- ⚡ Expensive to operate systems that don't provide real comfort
- ⚡ More drag on the grid in cold weather



# How Far to Go With Home Performance?



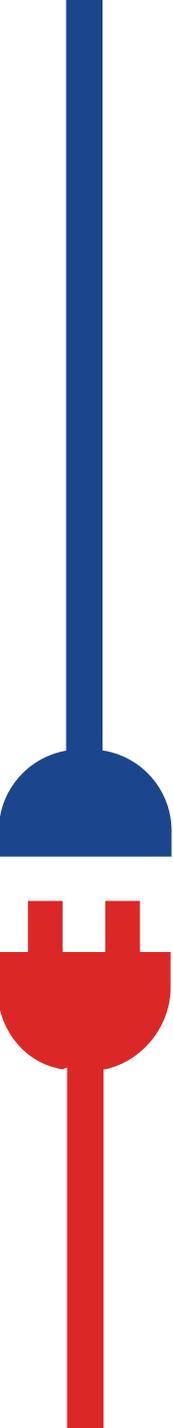


# It Doesn't Have to Be Complicated!

**There are a handful of things that need to be done just slightly better to deliver excellent outcomes!**

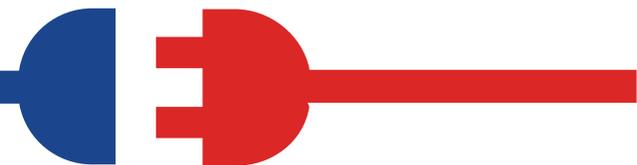
**Silver buckshot, not a silver bullet.**

**Take pride in your work. We can do it better!**



# Focus On These Items

- 1) Proper Load Calc**
- 2) Pay close attention to distribution (ducts)**
  - **Right sized, short, straight, pulled & sealed tightly, well insulated, minimal static pressure, correct registers, measure air flows**
- 2) Air seal major penetrations**
- 3) Insulate well**
- 4) Inverter or measured performance unitary**

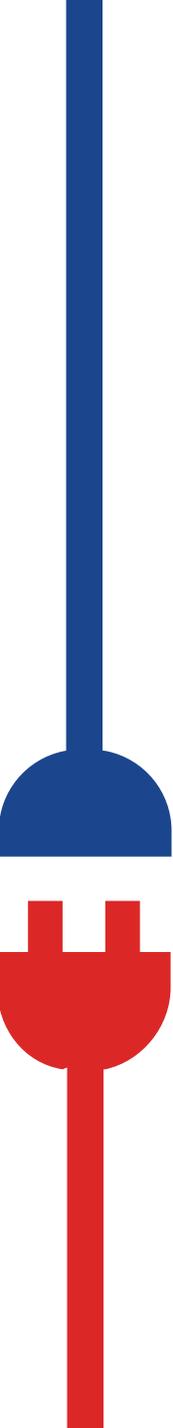


# Crew Training...

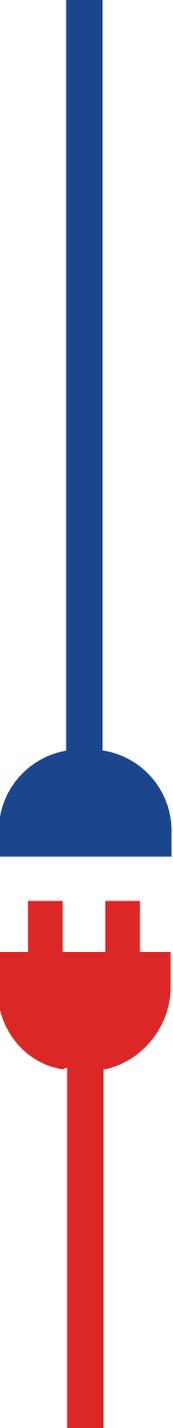
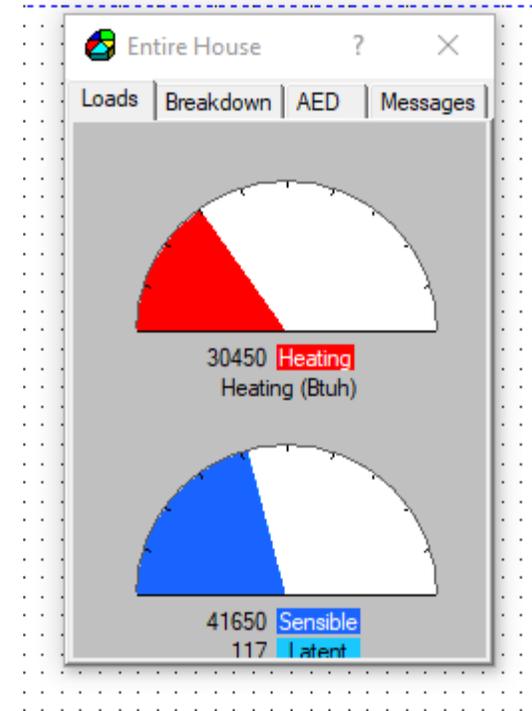
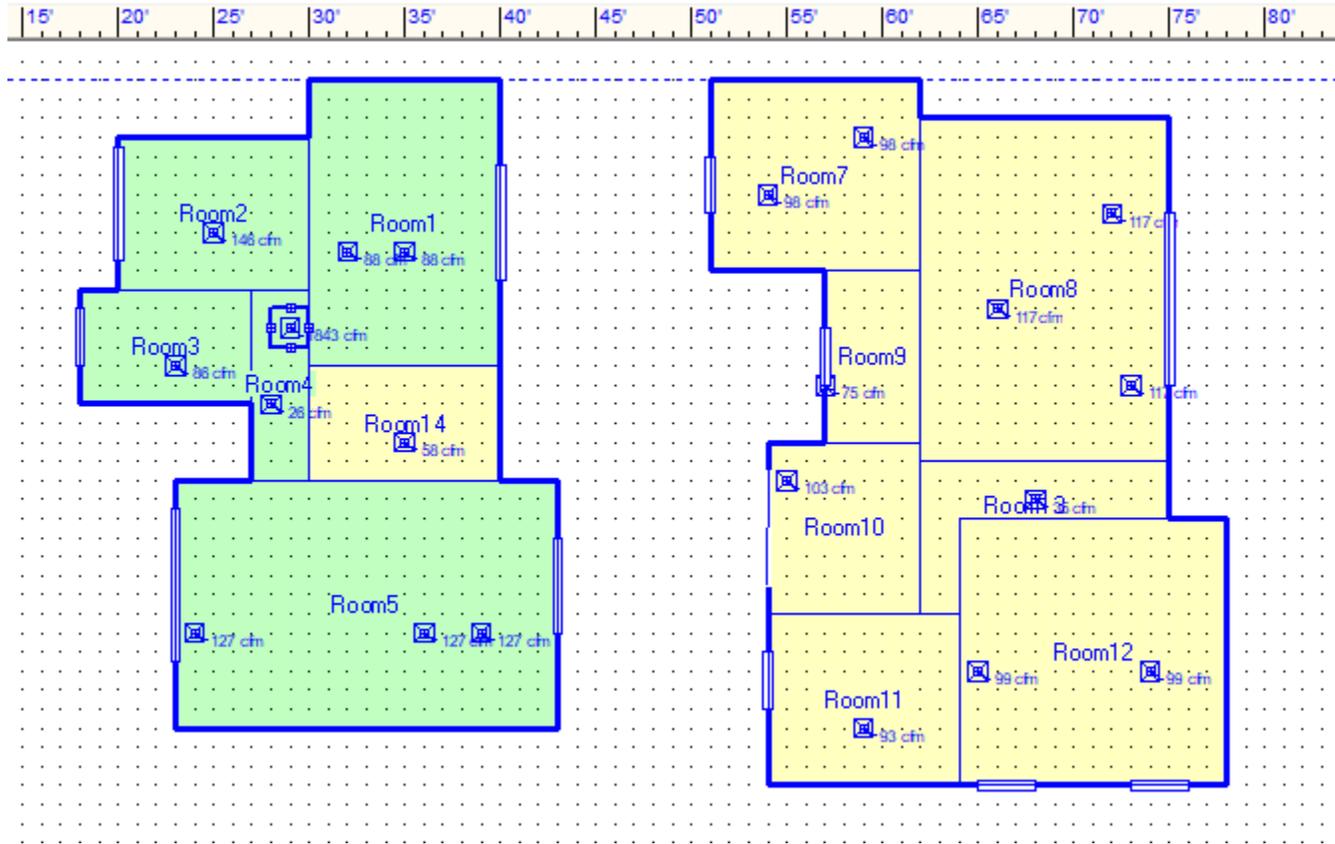
- ⚡ Performance testing is expensive if a third party does it
- ⚡ Performance testing is cheap if the installer does it
- ⚡ If the installers test their own work, they learn from the test results
  - ...so, require employees to test their work**
- ⚡ Home performance monitoring is expensive but tracking the home's performance by analyzing the utility bill is cheap and easy

A decorative graphic consisting of a red horizontal bar at the top, a dark blue shape below it that tapers to the right, and a white background. The text is centered within the dark blue shape.

# Bay Area Family Benefits From Home Performance with a ½ Sized Heat Pump

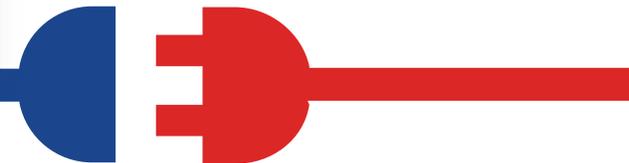
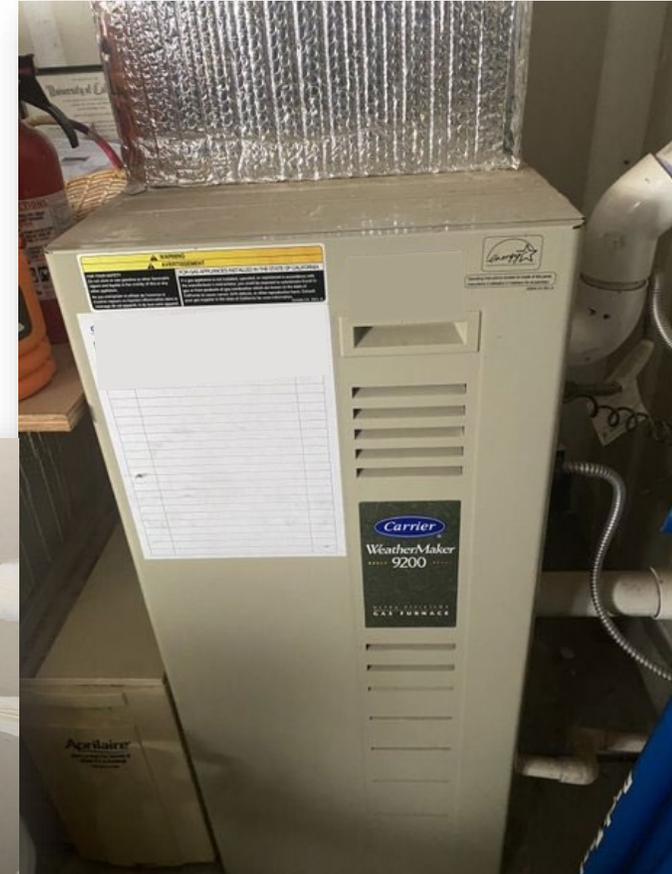


# Berkeley Home Load Calc

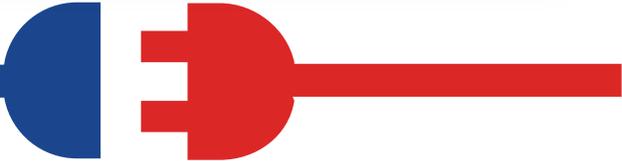


# Existing BGF 80,000 BTU

- ⚡ Found conditions
- ⚡ Existing Furnace 92% 80k BTU 74k delivered
- ⚡ Attic was bad massive envelope air leaks
- ⚡ Bad insulation
- ⚡ Fixed attic in 12-man hours
- ⚡ Relaced water heater as well



# Attic Was Bad, Jr Air Sealer at Work!





After sealing  
and  
Reinsulating

# The Installed Mechanicals

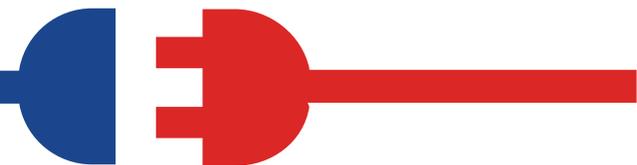


- 🔌 65-gallon Bradford White Heat Pump Water Heater
- 🔌 Complete design and installation of a mini split inverter heat pump
- 🔌 36 kbtu Mitsubishi SUZ-KA36NAR1 outdoor unit and SVZ-KP36NA air handler
- 🔌 Modified existing newer ductwork to be suitable for heat pump and air balancing

# A Happy Customer With a Half-Sized System

★★★★★ a month ago

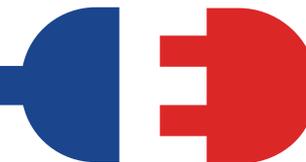
Electrify My Home does great work for a reasonable price. We had them install a heat pump, hot water heat pump and insulation. They were super knowledgeable and informative about options, as well as rebates. They also provided all we needed for the final inspection from the city of Berkeley. Both the heat pump and hot water heat pump work great and are much cheaper to run. The heat pump is also much quieter than our previous gas furnace. And the extra insulation that was added has been a major improvement – even without the heat pump our upstairs rooms are much more stable in terms of temperature – both summer and winter. Highly recommend Larry, Alex and the rest of the Electrify My Home team.



# Questions?



Larry Waters | 707-840-3411 | [www.electrifymyhome.com](http://www.electrifymyhome.com) | [info@electrifymyhome.com](mailto:info@electrifymyhome.com)



# Closing

- AIA Learning units
  - Contact [lan.logan@ventura.org](mailto:lan.logan@ventura.org) for AIA LUs
- Coming to Your Inbox Soon!
  - Slides, Recording, & Survey
- Other 3C-REN resources you should be aware of:
  - All other upcoming events: [www.3c-ren.org/events](http://www.3c-ren.org/events)
  - Free energy code technical support: [www.3c-ren.org/code](http://www.3c-ren.org/code)
  - Incentive program for enrolled contractors: [www.3c-ren.org/contractor-participation](http://www.3c-ren.org/contractor-participation)





**Thank you!**

For more info:  
[3c-ren.org](https://3c-ren.org)

For questions:  
[info@3c-ren.org](mailto:info@3c-ren.org)  
or  
[Ian.Logan@ventura.org](mailto:Ian.Logan@ventura.org)



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