Climate Resilient HVAC

Where the Rubber meets The Road

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Introductions

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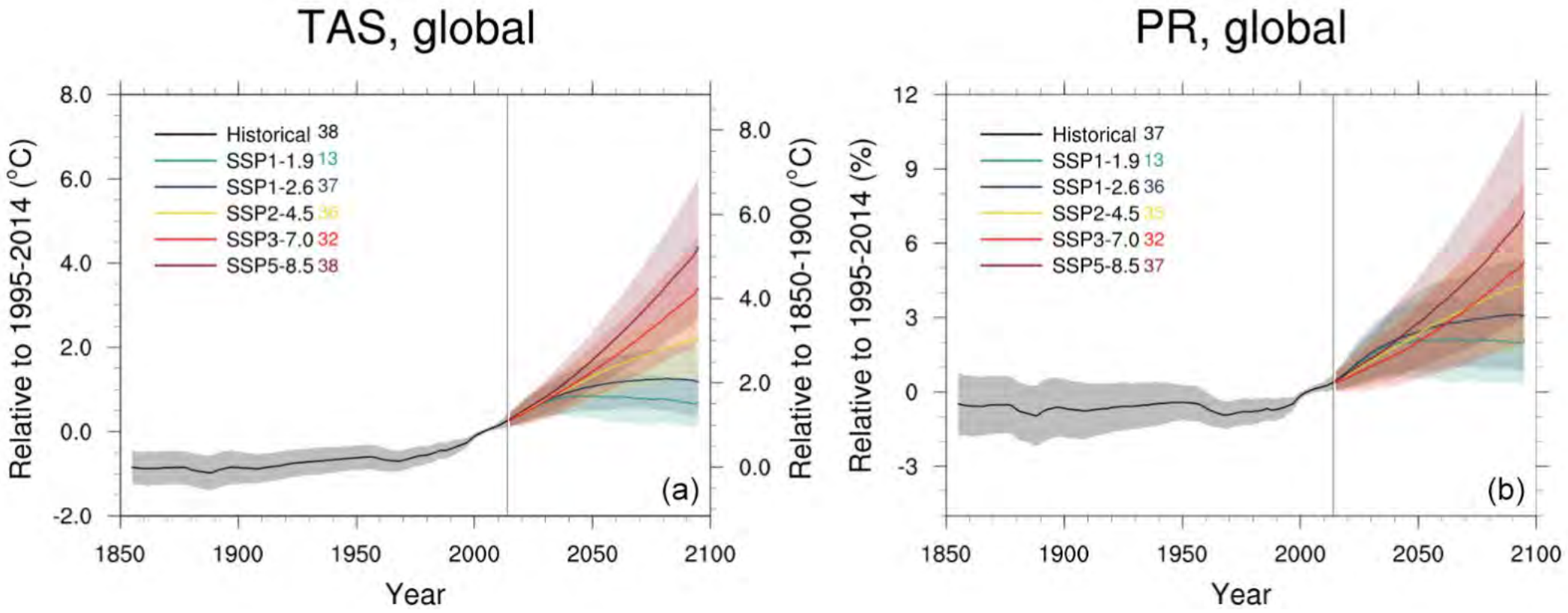
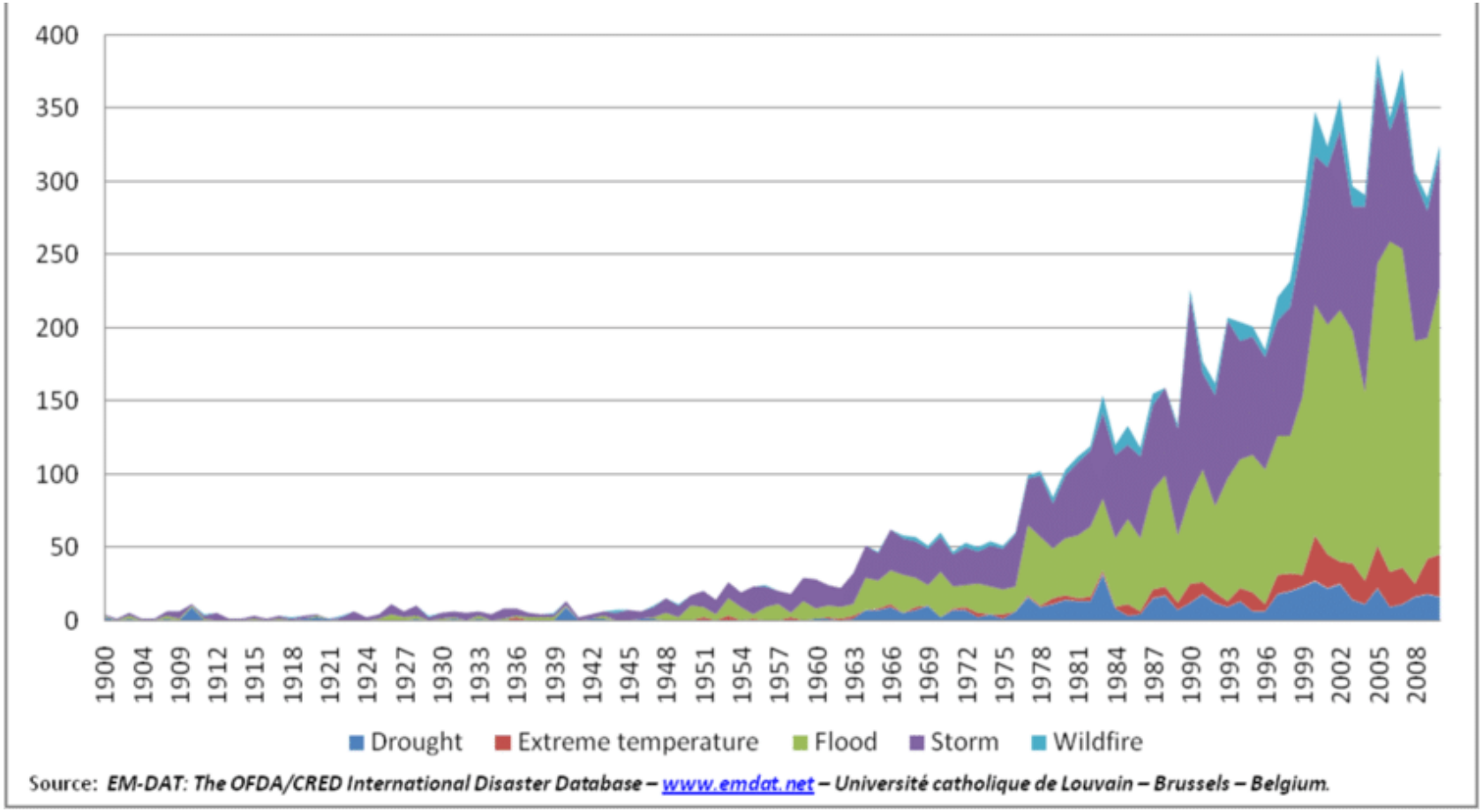
The State of our Climate – an inevitable warmer, wetter future



https://esd.copernicus.org/articles/12/253/2021/

Increasing Extreme Weather Events



https://www.researchgate.net/figure/Numbers-of-extreme-weather-events-globally-by-year_fig4_283653329

Building Electrification:

Pros

Cons

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The Electrical Grid – Reliable or Not?

Workforce changes

The trees

A winter storm

Backup Power

Utilities increasingly spend less on crews/services/maintenance = more outages, slower response.

Extreme weather events continue to increase. More power outages and increased need for cooling & heating.

Investments *could* include reliability but expect tax + rate increases.

More renewables on the grid could reduce reliability if investment in storage and technology can't keep up.

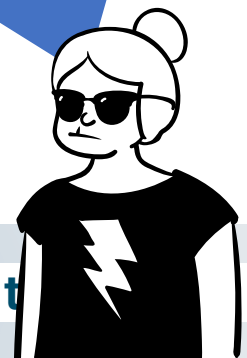
Can we rely on our electricity?

Will electricity cost a lot more in the future?

Utilities are regulated monopolies. Paid a return for investments in "poles and wires".

"Electrify everything" will increase demand. Could increase costs and reliance on fossil fuel generation at critical peak times.

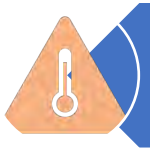
Good questions…



Climate Resilient HVAC Goals

Dramatically reduce emissions relative to fossil fuel heat sources

Limit negative impacts on electricity grid reliability



Handle potential for higher average temperatures and more extreme weather events

Provide essential services (e.g. heating) in an extended grid outage event

Provide pricing flexibility through peak demand management and/or fuel flexibility

Examples of Climate Resilient HVAC Systems

All Electric

- Variable capacity heat pump
- Demand-response thermostat and controls with pre-conditioning and coasting capability
- Large solar array + batteries, whole home generator, large portable generator

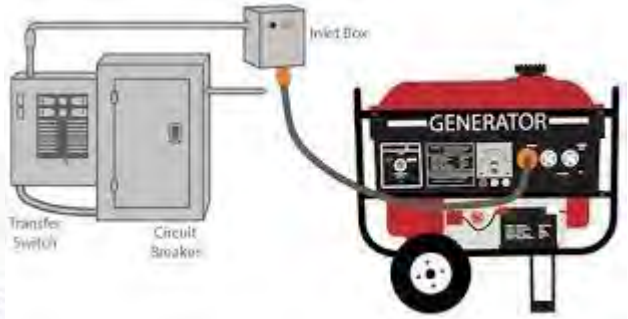
Hybrid

- Dual fuel heat pump with furnace
- Demand-Response thermostat and controls with pre-conditioning and coasting, and fuel switching capabilities
- Small dedicated generator

Economy Hybrid

- Code minimum heat pump
- Wood Stove or Gas Fireplace for Emergency Backup

Backup Power



Heat Pump, All Electric

Dual Fuel

$50,000+

Generac Protector 30000-Watt...

US$11,497.00

Lowe's

★★★★★ (4)

DuroMax 10,000W Portable Gas Power Camping RV Generator, XP10000E

4.6 ★★★★★ 457

Portable · Gasoline

$1,099.00

Yamaha EF1000iS 1000-Watt 120-Volt 8.3-Amp Portable inverter Generator

Portable · With Inverter

$475.00

Automart Marine

$99.00 delivery

Heat Pump Retrofit Design and Install Guidance – Customer Discussion

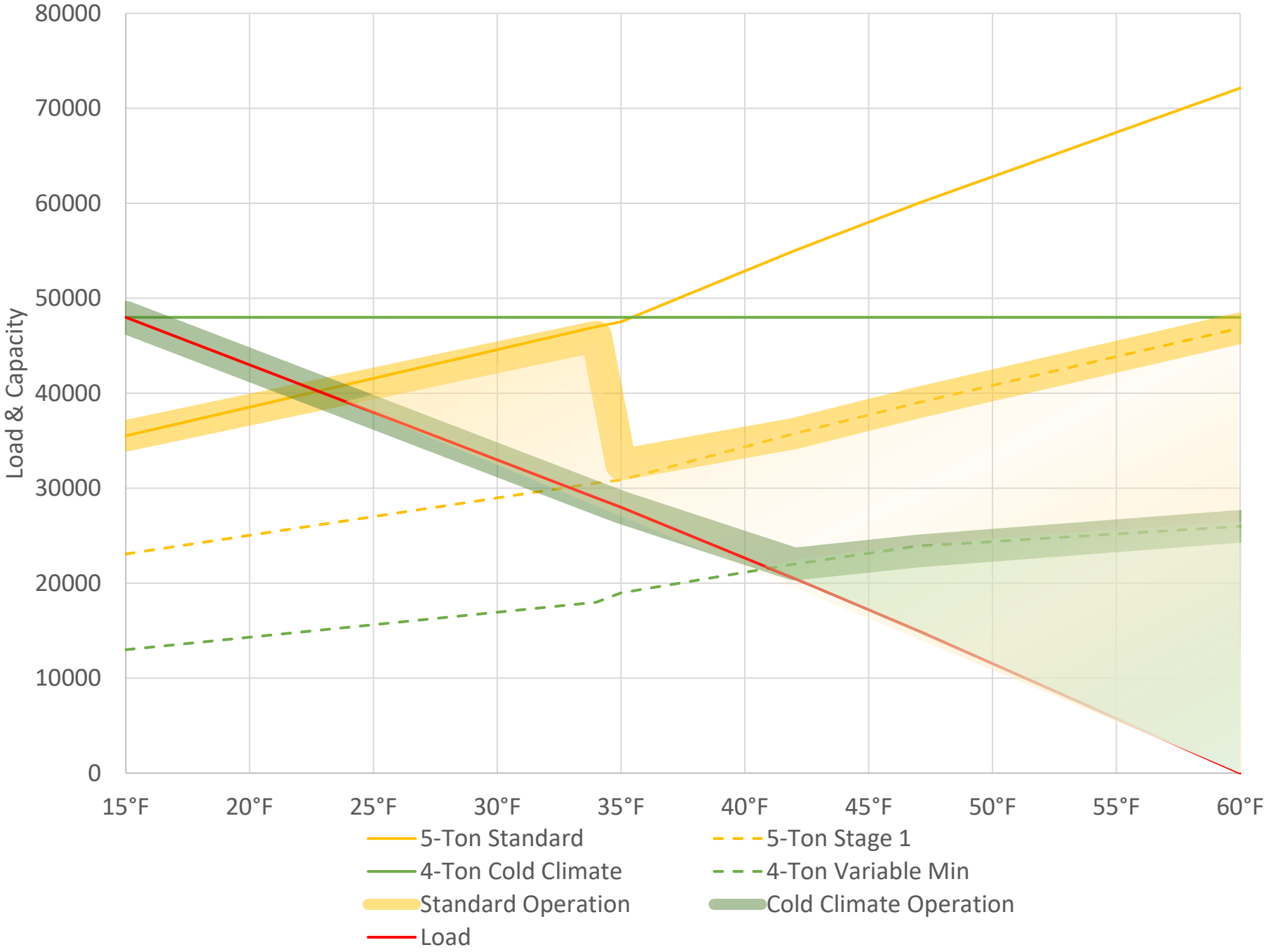
1. Assess need for emergency heat with customers
   - Emergency heat required/desired?
   - History of grid reliability and utility crew responsiveness
   - Likelihood for severe winter storms in the area
2. Discuss budget and preferences
   - Provide options for all-electric, hybrid, and/or economy hybrid that meet customer needs and budget
   - Take into consideration existing heat source(s) – gas/oil/propane furnace, gas fireplace, wood or pellet stove, electric resistance, etc.?

Heat Pump Retrofit Design and Install Best Practices – Building and System Assessment

1. Assess existing building, HVAC, and electrical systems
   - Ceiling/attic configuration and insulation, crawl/slab/basement configuration and insulation, window areas and locations, age of home, duct sizes and visual inspection, electrical service and panel capacity
   - Preferred: Blower door test, duct leakage test, existing equipment static pressure and airflow test
   - Note any existing backup generator and/or solar/battery systems
2. Perform load calculations
   - Perform design day calculations for heating, cooling, and dehumidification if in a humid area
   - Preferred: Alternate load calculation(s) with building shell and duct insulation and sealing upgrades

Heat Pump Retrofit Design and Install Best Practices – Equipment Selection

1. Assess load calculation results
   - Heating or cooling dominant? Difference between heating and cooling loads? Dehumidification needs?
2. Identify potential equipment
   - Cooling dominant dry climate – size for cooling load
   - Heating dominant dry climate – size for heating load
   - Humid climate – size for cooling load and provide supplemental heat and/or dehumidification necessary to meet loads
   - Cold/very cold climate – select from “Cold Climate” products: https://ashp.neep.org/#!/
3. Assess and select options
   1. Use expanded performance tables to assess performance at design conditions, **do NOT use nominal or AHRI rated capacities**
   2. Remember to assess dehumidification if in a humid climate. Select integrated or self-contained dehumidifier if required


80000
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Load & Capacity
15°F
20°F
25°F
30°F
35°F
40°F
45°F
50°F
55°F
60°F
5-Ton Standard
5-Ton Stage 1
4-Ton Cold Climate
4-Ton Variable Min
Standard Operation
Cold Climate Operation
Load

Heat Pump Retrofit Design and Install Best Practices – Dual Fuel Options

Existing furnace <~10 years old

- First look for a compatible AHRI-matched heat pump and coil from same manufacturer
- If no compatible options, select a “universal” solution -or-
- Select a basic single stage heat pump and source third party dual fuel controls with outdoor air changeover

Existing furnace >~10 years old

- Recommend replacement with full duel-fuel or hybrid system from a single manufacturer

Heat Pump Retrofit Design and Install Best Practices – Duct System Sizing

1. Heat pumps require 50% to 100% more CFM per BTU than furnaces
   - If you're retrofitting a right-sized furnace system, it's highly likely you'll need to upsize ducts and/or improve fittings, grilles and registers
2. Duct upgrades closest to the equipment generally have the highest impact
   - A return plenum and return duct upgrade may be sufficient in many cases
3. Supply register upgrades and placement can have a large impact on comfort
   - Proper register type and placement are more critical since heat pumps produce lower temperature air than furnaces

Heat Pump Retrofit Design and Install Best Practices: Home Performance Improvements

- If building shell and/or duct system upgrades are potentially in scope, assess and communicate the HVAC benefits
  - Equipment downsizing (reduced equipment costs)
  - Potential avoidance of electrical system upgrades and associated costs
  - Lower operating costs
- Document load calculation upgrade selected and provide specifications for third party insulation and/or air sealing bids

Heat Pump Retrofit Design and Install Best Practices: Installation and Commissioning

1. Install strictly according to manufacturer instructions
2. Shorten, straighten, and properly support all flex duct runs
3. Flex duct is for straight runs, if you have to make a bend or curve use a metal duct fitting
4. Seal duct connections with mastic or UL listed foil HVAC tape
5. Double check refrigerant lineset length and charge requirements. Weigh in additional charge per manufacturer spec
6. Test all operation modes: normal cooling and heating, supplemental or emergency backup, dehumidification
7. At minimum, check Total External Static Pressure (TESP) and Airflow against requirements. Adjust blower speed.
8. Test refrigerant superheat and subcooling if conditions permit, schedule follow-up if necessary

Heat Pump Retrofit Design and Install Best Practices: Installation and Commissioning *(continued)*

8. Preferred: Test entire system performance. Score using ASHRAE/ANSI 221 or Grade using ANSI/RESNET/ACCA 310
9. Discuss importance of proper maintenance with customer
   - The system you just installed is far more complex than the existing furnace/furnace+AC/stove or fireplace/or electric baseboards
   - MINIMUM maintenance is twice per year. Once in the spring and once in the fall.
   - Offer any maintenance agreement and extended warranty options your company may provide

New Construction is Not Immune:

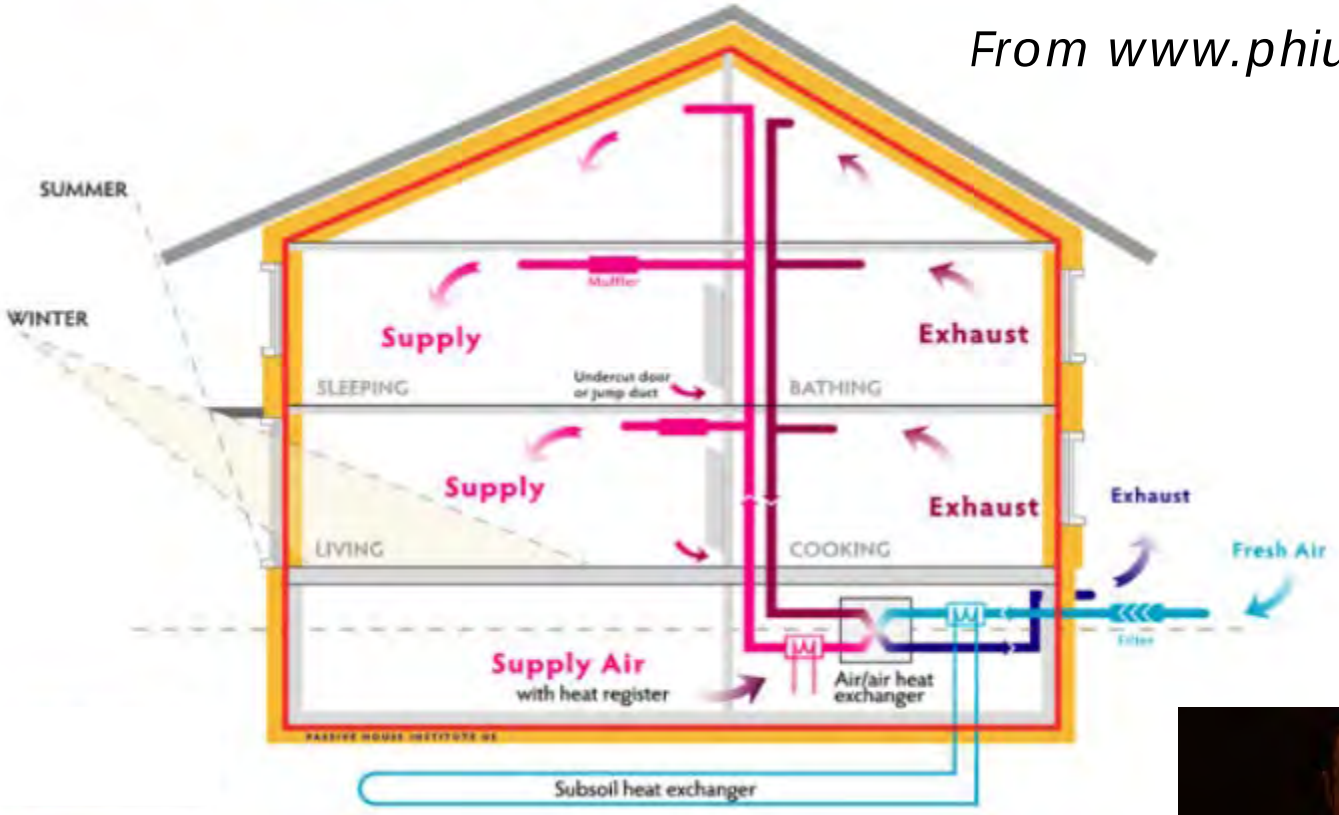
Lessons Learned -Construction

- Pretty Good House design
- Volumetric modular construction
- Factory built in Oct. 2019
- Set on site in Jan. 2020
- Occupied in Nov. 2020
- Climate Zone 5
- 2 Ton ASHP
- Ducted MiniSplit
- 4,400 sq ft (cond.)
- 790 CFM50
- NetZero achieved

PRETTY GOOD House Principles

- Continuous insulation & no thermal bridges
- Airtight construction
- High Performance windows
  - Double panes allowed
- manage solar gain
  - Shading
- HRV/ERV
- minimal HVAC system

From www.phius.org

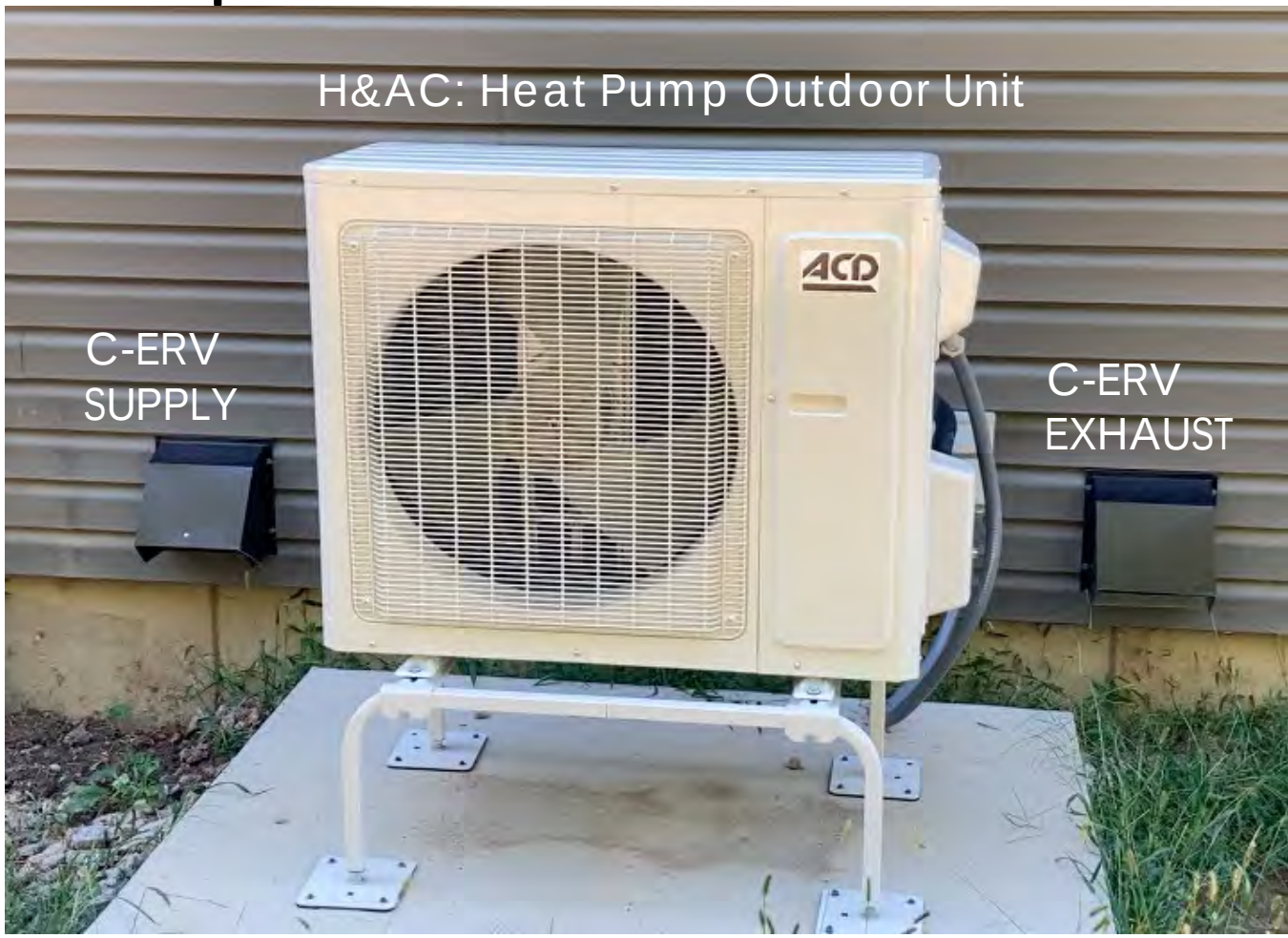


"It's about control."
www.HomeDiagnosis.tv

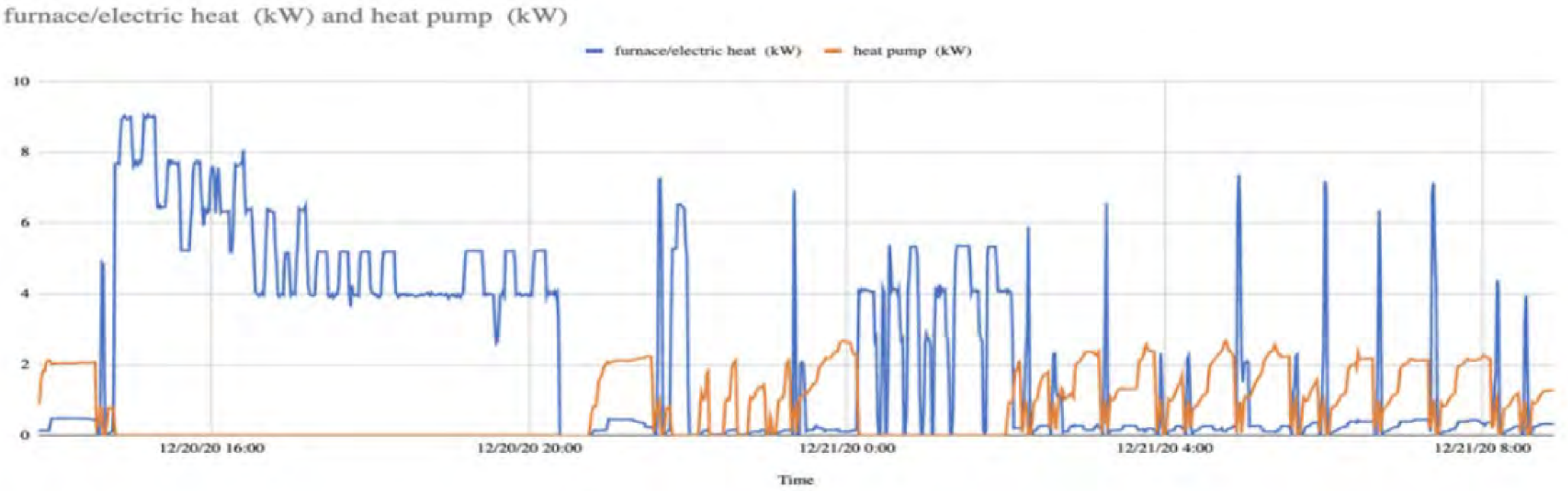
www.prettygoodhouse.org/pgh-20

New Construction is Not Immune:
Lessons Learned -Heat Pump Failure

- 3 Load calcs were done
  - PHPP
  - CoolCalc
  - KwikModel
- All in basic agreement
  - 24.5 kBTUh Heat loss
  - 21.2 kBTUh Heat gain
    - Sensible 91.3%
- Cooling was fine: May-Oct
- Moved in Nov
- ***What is up with the energy consumption?***



Unexpected electric consumption of system components

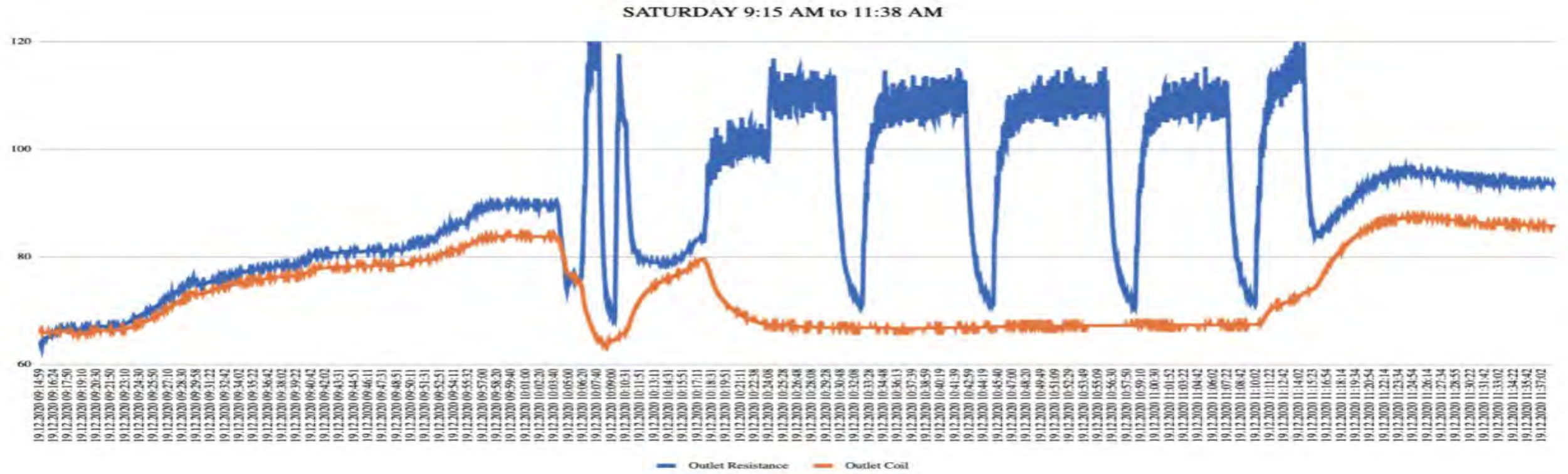


Orange line*- Heat Pump Outdoor unit*

Blue line *- Air Handler/Electric Furnace*

Troubleshooting:

Air Temperature measured at 2 points in duct



Orange line*- Heat pump coil exit temperature*

Blue line *- Strip heat exit temp*erature

New Construction is Not Immune:
Lessons Learned -Heat Pump Diagnosis

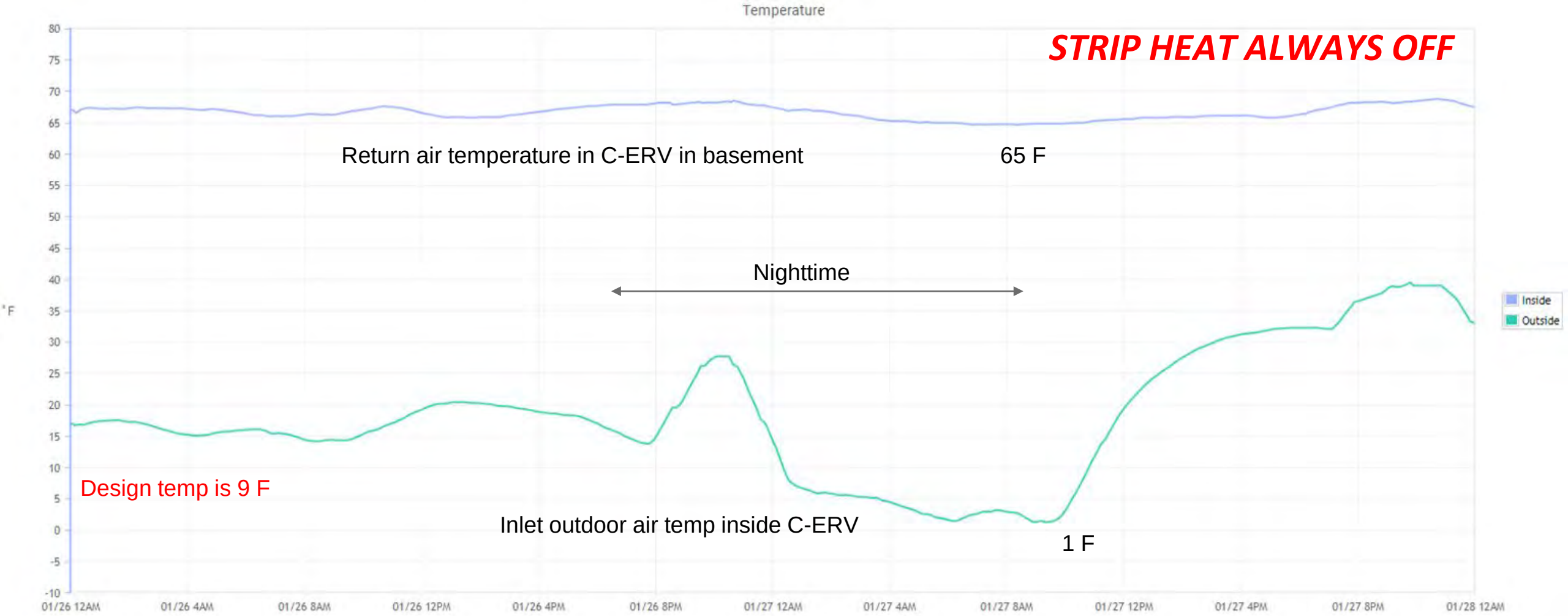
- Jan 2, 2021
  - Jim Bergmann tried to evacuate
  - Showed signs of lots of moisture in BluVac app
  - Hung up at 1350 microns
- Diagnosed: total loss of charge
  - Cracked flare pulled in moisture during HP mode, not AC mode
  - Destroyed the POE
  - “Your new car got totaled driving it off the lot.”

New Construction is Not Immune:
Lessons Learned -Heat Pump Replacement

- Causes: Untrained installer used…
  - improper processes & tools (eg no torque wrench, improper evacuation)
  - “Factory flare” on lineset which cracked and bled charge in HP mode
- Cure:
  - Trained professional replaced complete refrigerant circuit (2 coils and line set) using proper tools and processes

New Construction:

Lessons Learned -HP comfort possible at Design Temp

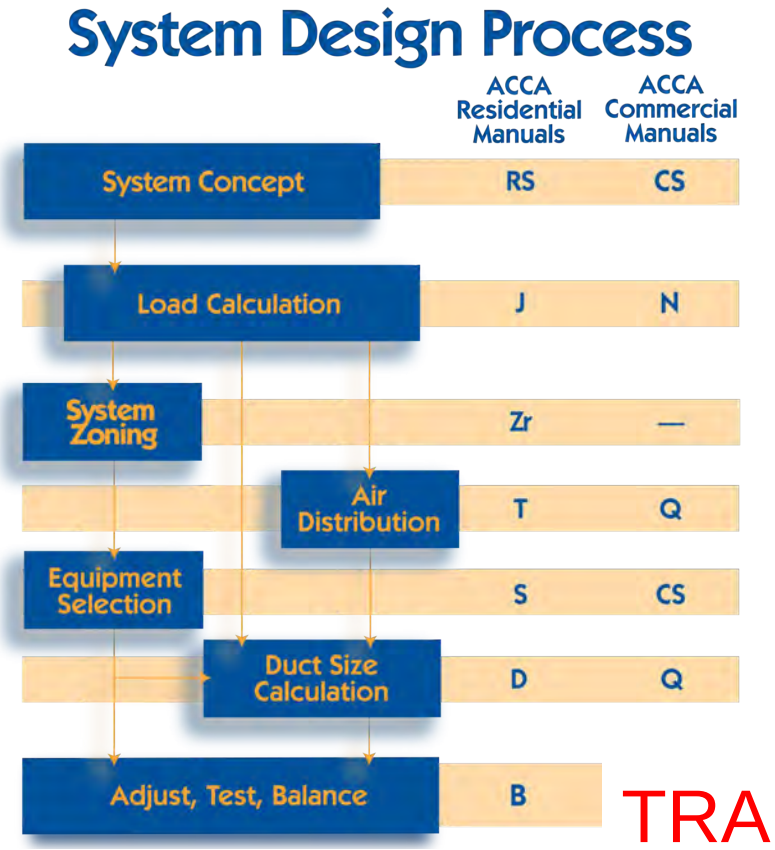


Tools and Resources for Climate Resilient Electrification-HVAC-1

Design
- ACCA Manuals

Load Calc Software
- Wrightsoft
- Elite Software
- CoolCalc
- Adtek
- EnergyGauge
  - Kwik Model
- Carmelsoft
- Avenir

COMING SOON
- Amply Energy
- Conduit Tech



TRAINING

full list: https://www.acca.org/standards/approved-software

Tools and Resources for Climate Resilient Electrification-HVAC-2

- Installation
  - Tubing tools
  - Evacuation

Bending


Flaring


Swaging

Brazing

Cutting


Braze-Free


Tubing Tool Kits

Vacuum Gauges \ Micron Gauges


Recovery Kits

Recovery Machines

Vacuum Pumps


Evacuation and Vacuum Kits

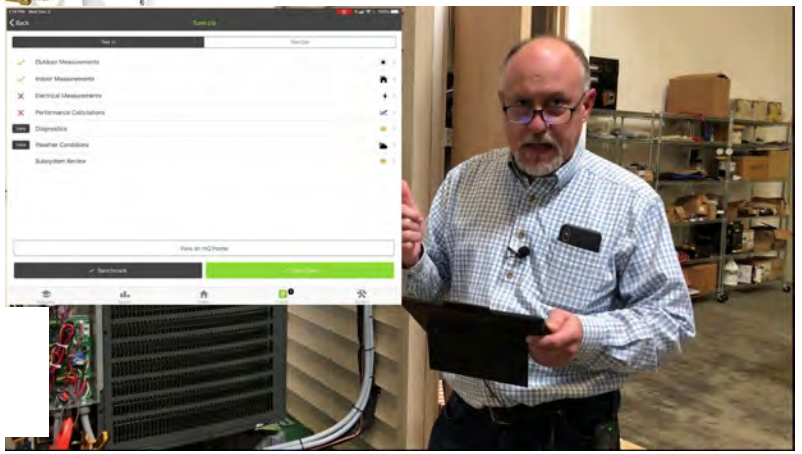

Vacuum Hoses and Manifolds

TRAINING

Tools and Resources for Climate Resilient Electrification-HVAC-3

- Commissioning & troubleshooting
  - Airflow
  - Temperature
  - Humidity
  - Software

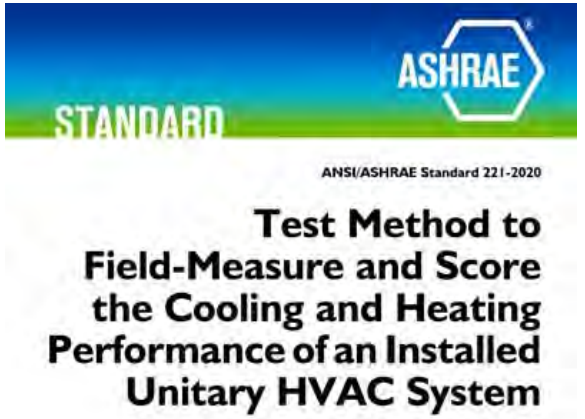
TRAINING



Tools and Resources for Climate Resilient Electrification-HVAC-4

- Resources
  - ASHRAE 221
    - Test Method to Field-Measure and Score the Cooling and Heating Performance of an Installed Unitary HVAC System
  - ACCA/RESNET/ANSI Std 310
    - Standard for Grading the Installation of HVAC Systems
  - ACCA QI-5
    - HVAC Quality Installation Specification

TRAINING



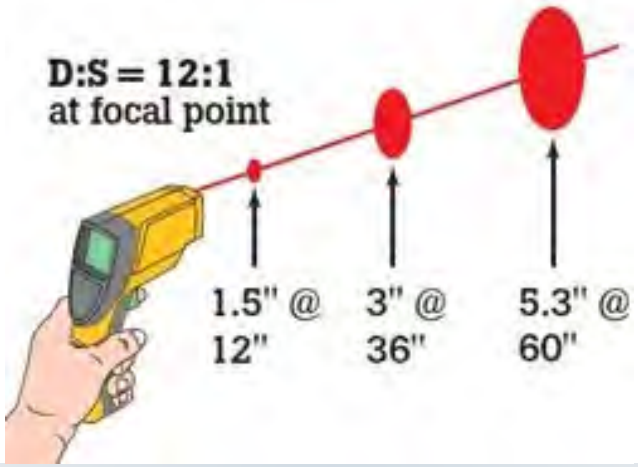
Tools and Resources for Climate Resilient Electrification-Building Performance-1

- Air leakage
  - Blower Door
  - Duct leakage tester
  - Smoke
- Resources
  - ANSI/RESNET/ICC 380
    - **Standard for Testing Airtightness of Building Enclosures, Dwelling Unit, and Sleeping Unit Enclosures, Airtightness of Heating and Cooling Air Distribution Systems; and Airflow of Mechanical Ventilation Systems**

TRAINING

Tools and Resources for Climate Resilient Electrification-Building Performance-2

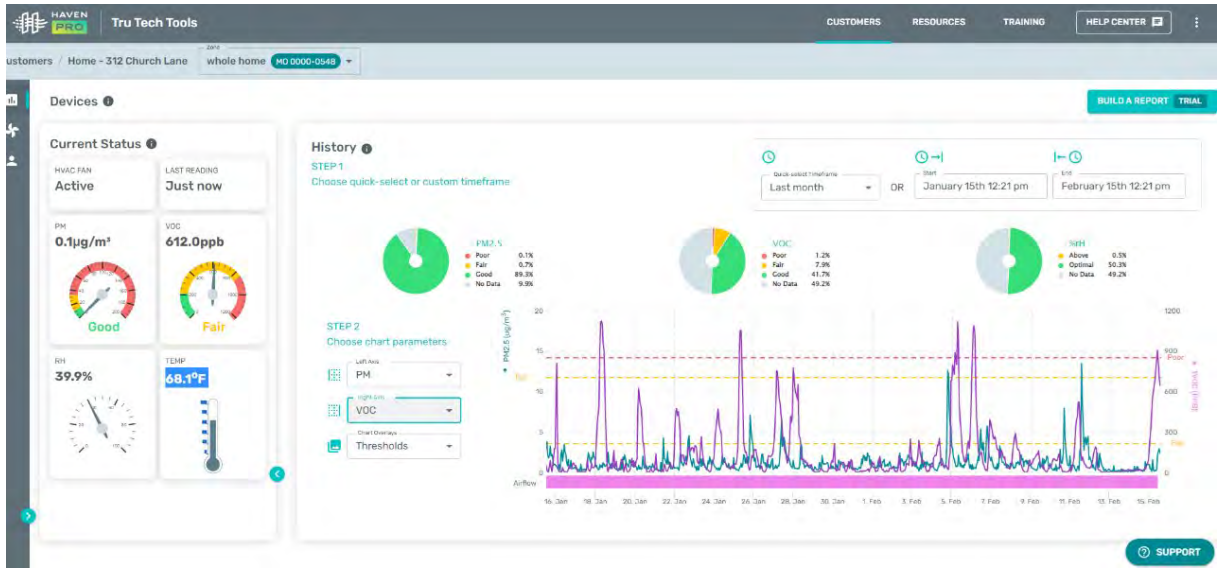
- Thermal loss & gain
  - Thermal imager
  - IR Thermometer
- Resources
  - Infraspection Institute
  - Snell Infrared
  - Monroe Infrared
  - FLIR-ITC
  - United Infrared



TRAINING

Tools and Resources for Climate Resilient Electrification-Monitoring

- System performance
- IAQ & Comfort
- Electrical Energy



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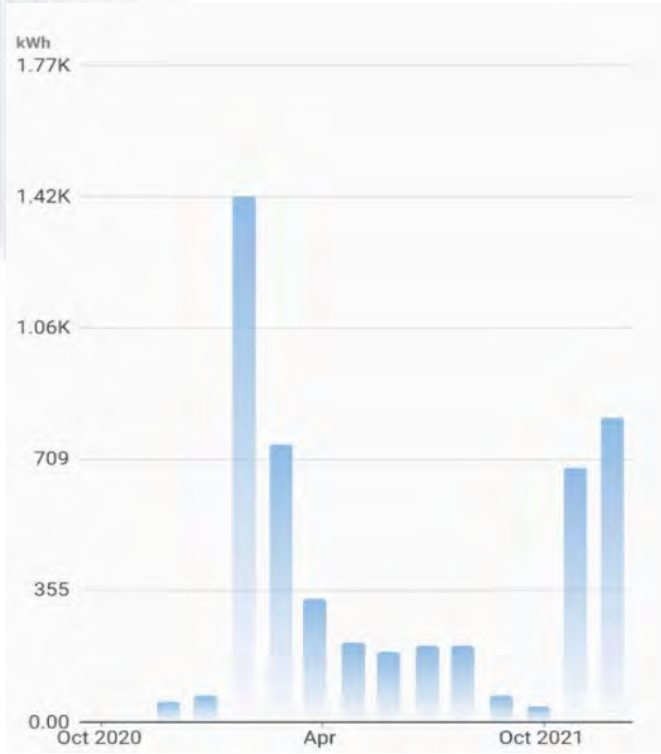

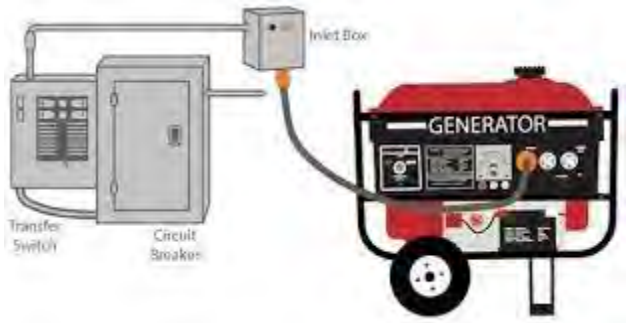

https://acworks.com/blogs/ac-works-connector/how-to-use-a-manual-transfer-switch-system-for-your-home