High Performing Heat Pumps Eliminating Electric Resistance Heat

Determine if ducted heat pump sites required electric resistance back up

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Content

- High Performance High Capacity Heat Pump Field Study Project Overview
- Sizing Balance Points and Design Temperatures
- Site Examples of no (and yes) ER use
- Trend Analysis – Predictors of ER use
- Conclusions

High Performance High-Capacity Heat Pump Study

Major Project Goal:
Eliminate, or greatly reduce, ER heating in heat pump systems

- Multi-year Field Study (1, 2, or 3 heating seasons)
- 57 residential sites
- Heating Zones 1, 2, and 3 (mostly 1 and 2)
  - Corresponds to IECC Zones 4C, 5, and 6
- Centrally Ducted Heat Pumps (CDHP) and Multi-Zone, Whole-Home Ductless (DHP): ~50/50 split
- Today's focus is on the Centrally Ducted HP Sites

Report Available Here https://www.bpa.gov/-/media/Aep/energy-efficiency/emerging-technologies/2026-hphchp-finalreport_web.pdf

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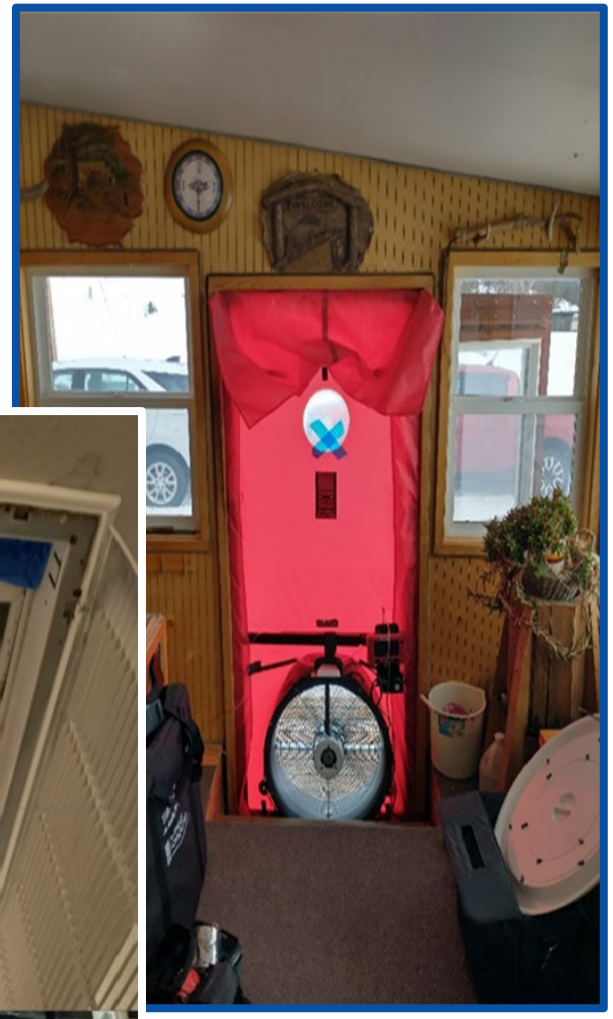
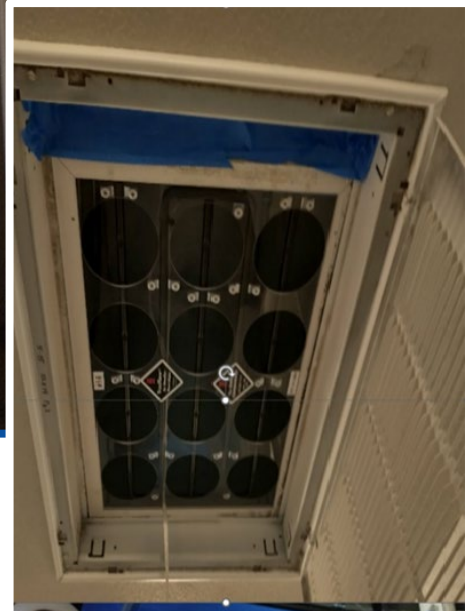
Equipment Studied

- High Performance Equipment Installed
  - 7 manufacturers, 34 unique outdoor units
  - **Sized to 20F balance point or colder**
  - Necessary flow at air handler verified (improved where needed)
- Heat Loss Survey conducted at every site
  - Conductive Losses (UA) and
  - Blow Door, Duct Blaster, TrueFlow
- Heat Load Calculated
  - HVAC SIZING TOOL





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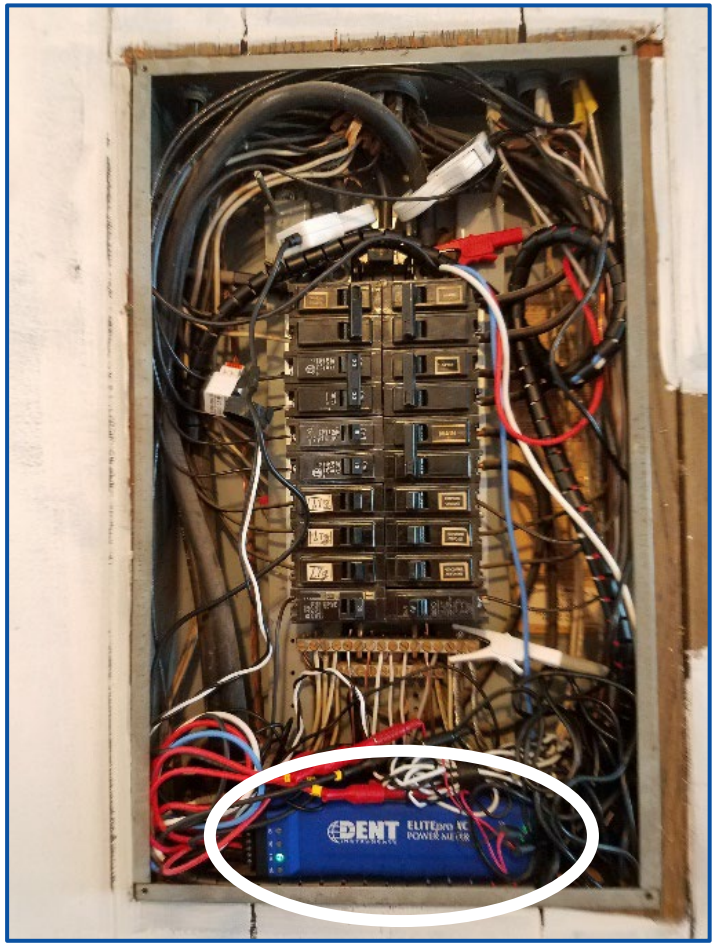
Field Measurements

- 1-minute logging of
  - Outdoor Unit Power
  - Indoor Unit Power
    - Blower & ER
  - Supply & Return Air Temperature
  - Air Handler Flow
    - Proxy: current measurement with one-time calibration
  - Indoor Air Temperature

Equipment output capacity and efficiency calculated from measured data



Findings

- Heat Pump installs with no ER heat can be done in the Northwest
  - In fact, they have been done (if it exists, it must be possible)
  - HZ1 – completely practical
  - HZ2 – still possible
- The evidence
  - Clear examples of heat pumps not using ER heat, including 2 in HZ2
  - Several examples of heat pumps using ER heat, but the measurements suggest they would have been fine without
- Also: Thermostat setbacks drive a lot of ER heat

- What's the necessary condition?
  - Adequate heat pump output capacity relative to heating load (sizing)

Quick Overview

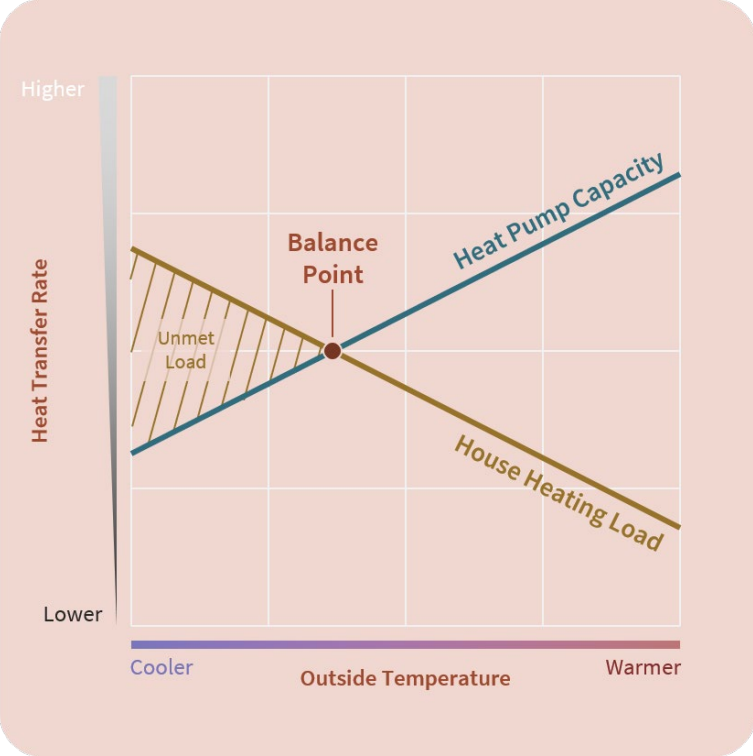
- 25 sites evaluated*:
  - HZ1:
    - Clear no ER heat needed - 5
    - Minimal ER used, for defrost or setback recovery - 7
      - *These generally appear not to need it.*
    - Used ER due to control settings - 2
      - *1 with major ER use on setback recovery even though HP capacity adequate*
      - *1 ran without but homeowner switched to emergency mode during cold snap (apparently due to "cold blow")*
  - HZ2:
    - Clear no ER heat needed - 2
    - ER at very low outdoor temperatures - 2
    - ER required - 7

HZ1 – ~13 of 14 sites did not need ER

HZ2 – 2 of 11 sites did not need ER

**29 central ducted sites in study; 4 excluded from this analysis due to significant fuel burning or data problems*

Balance Point



Design Temperature

- Coldest expected (or planned-for) outside temperature

- **If balance point below the design temperature, by definition, heat pump has enough capacity to heat the house without auxiliary.**
- **Below balance point, either auxiliary heat needed or indoor temperature will decrease.**

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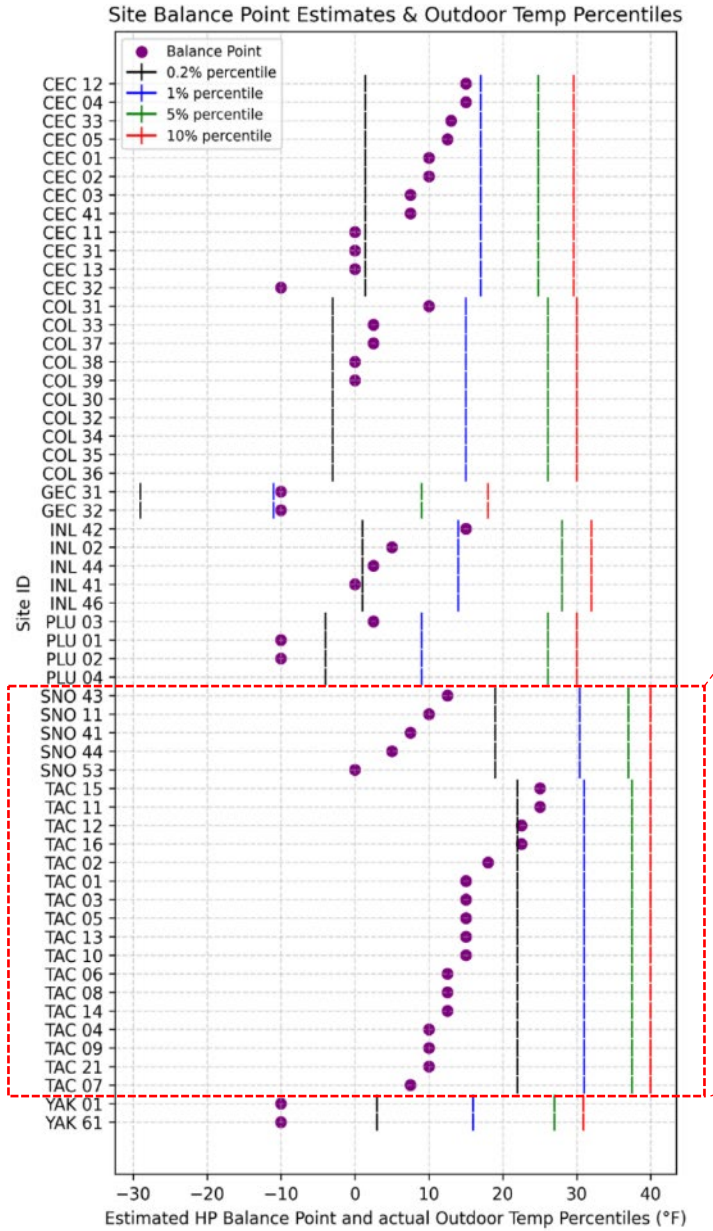
Adequate Output Capacity



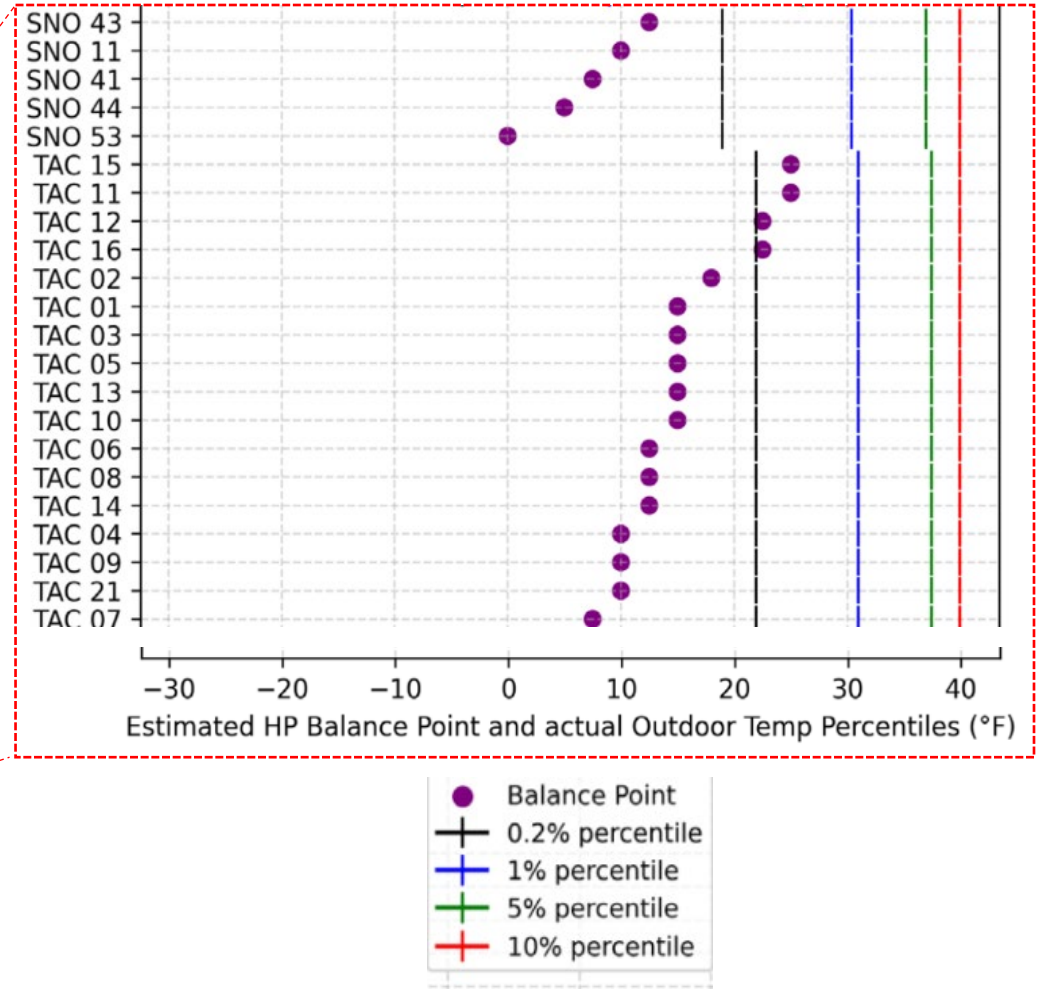
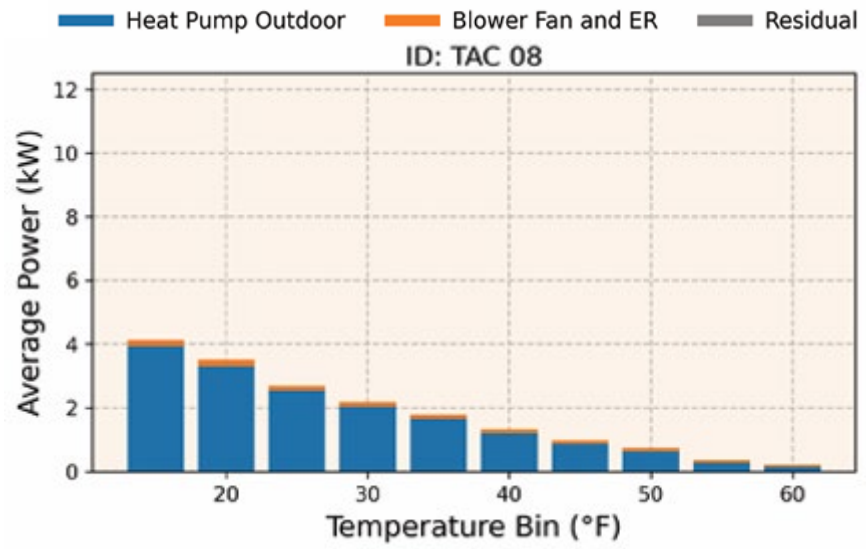


Figure 50. Estimated Heat Pump Capacity Balance Point and ODT Percentiles.

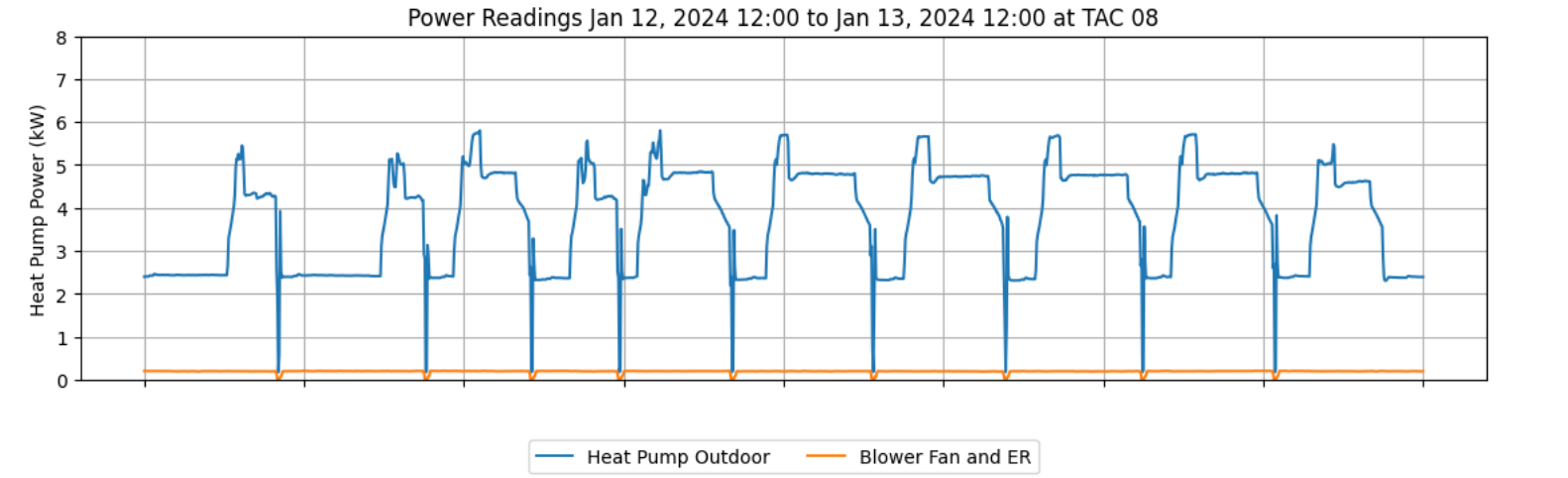
Site Examples

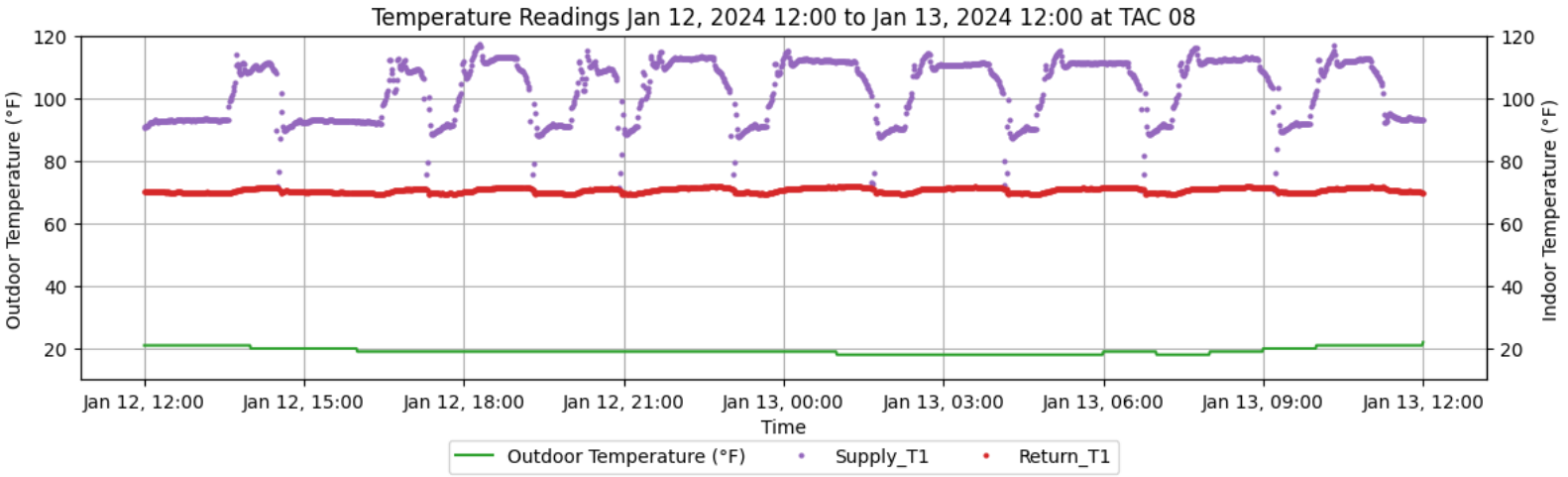
Average Power vs Outdoor Temperature Bin



- Average power, across all temperature bins by
  - **Outdoor Unit (blue)**
  - **Indoor Unit (orange)**
- Blower Fan (air handler) is the orange top to the blue bars
- No Electric Resistance heat used at any temperatures at this site

Example Very Cold(est) Day





- 20 °F outdoor
  - **(green line)**
- Return temperature is steady at 70-72 ° F
  - **(red line)**
- Conclusion: heat pump heats house and no ER used

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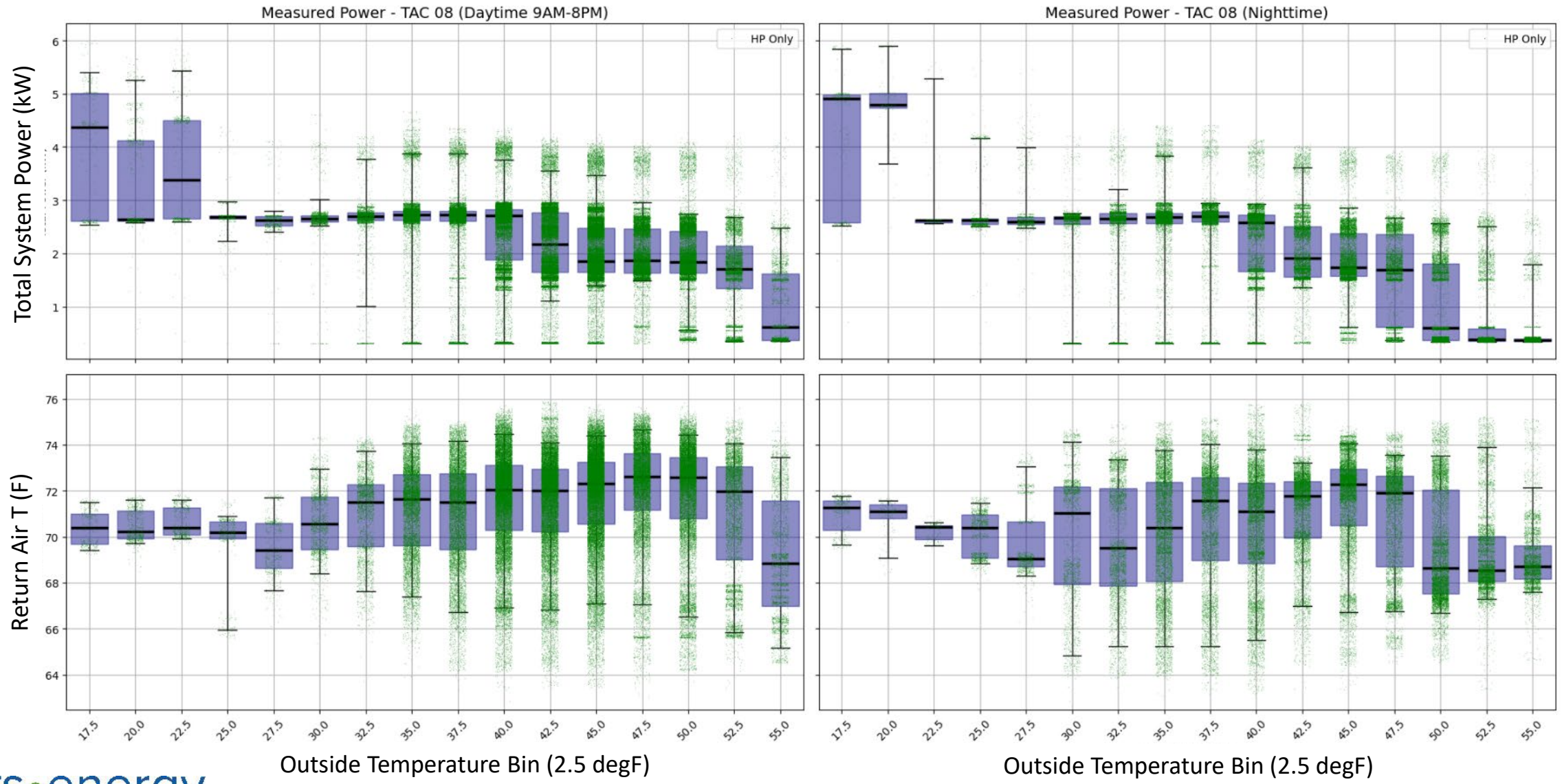
Indoor Temperature at all Hours



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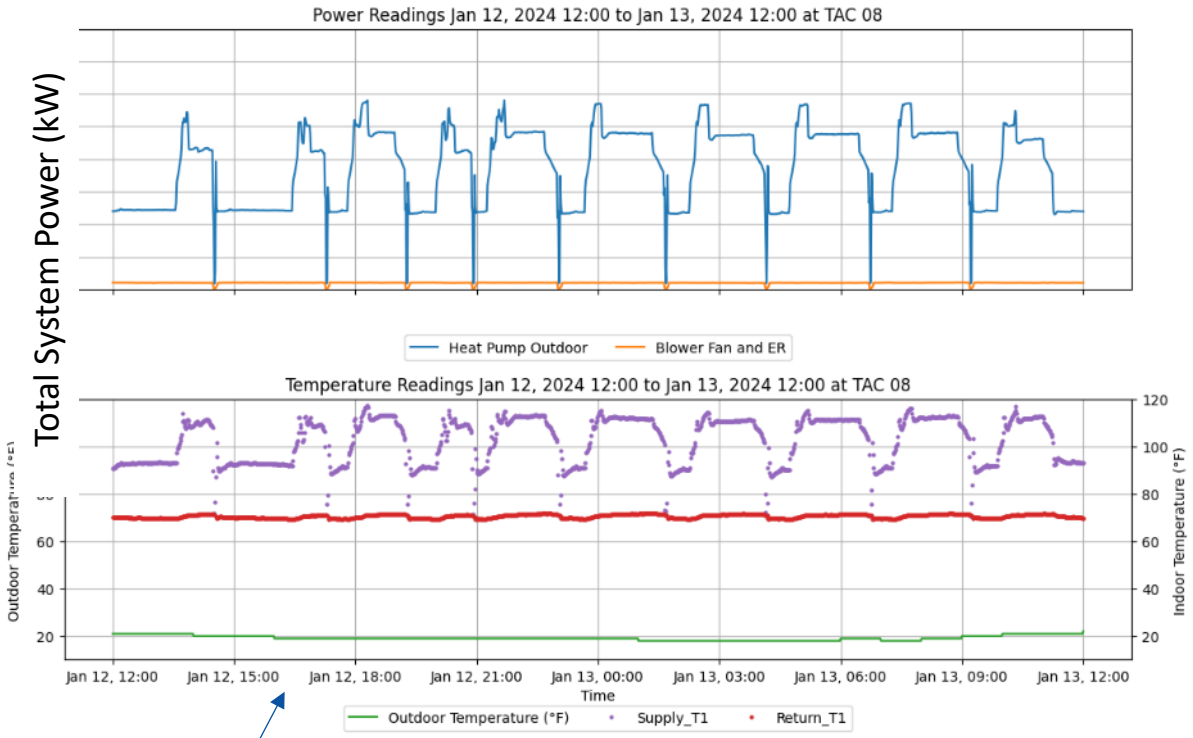
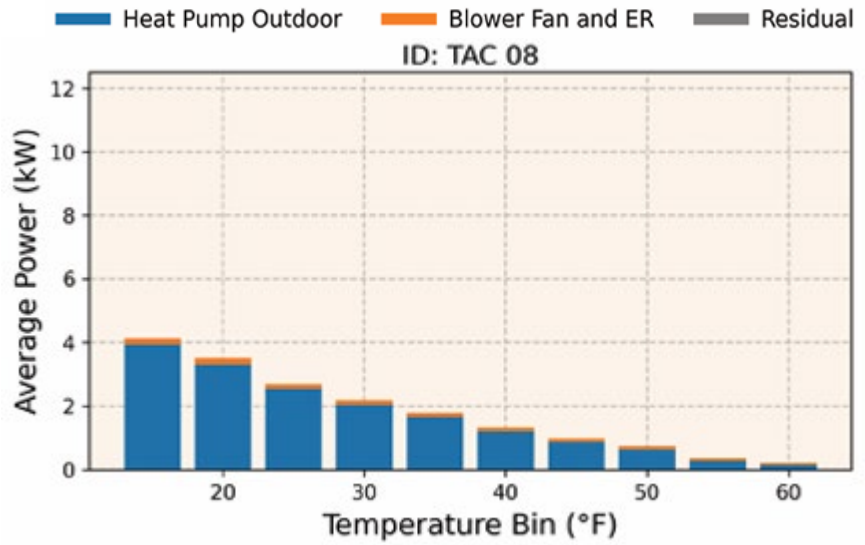
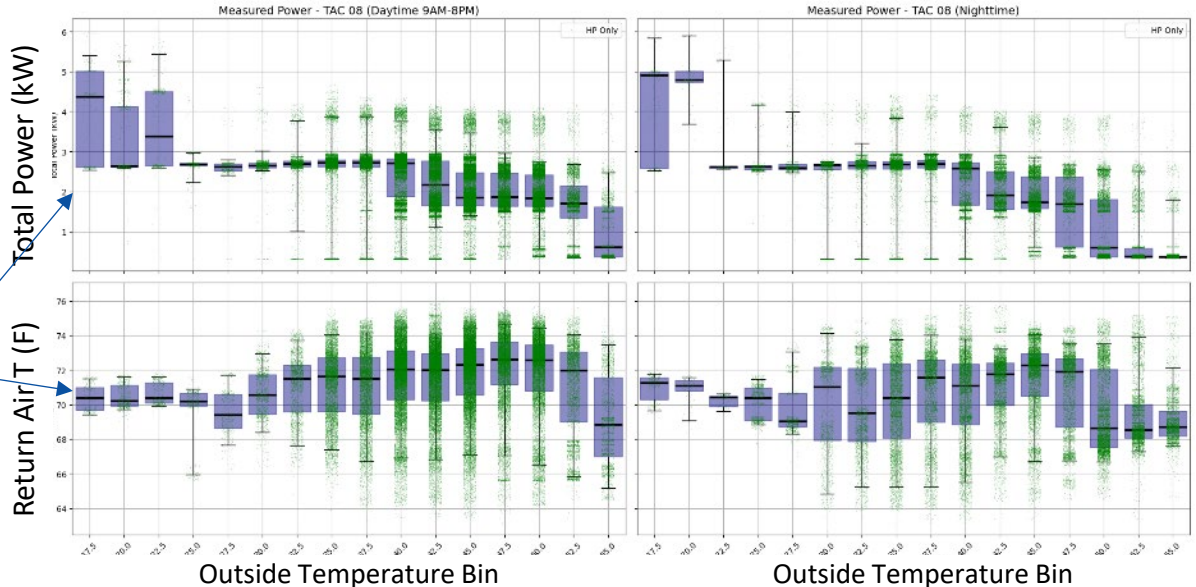
TAC 08 – HZ1, no installed ER, did not need





Example very cold day – heat pump runs nearly non stop and often at high power, but no meaningful dip in return air temp

No issue maintaining ID temperature in low ODT; heat pump is running a lot but not always full power



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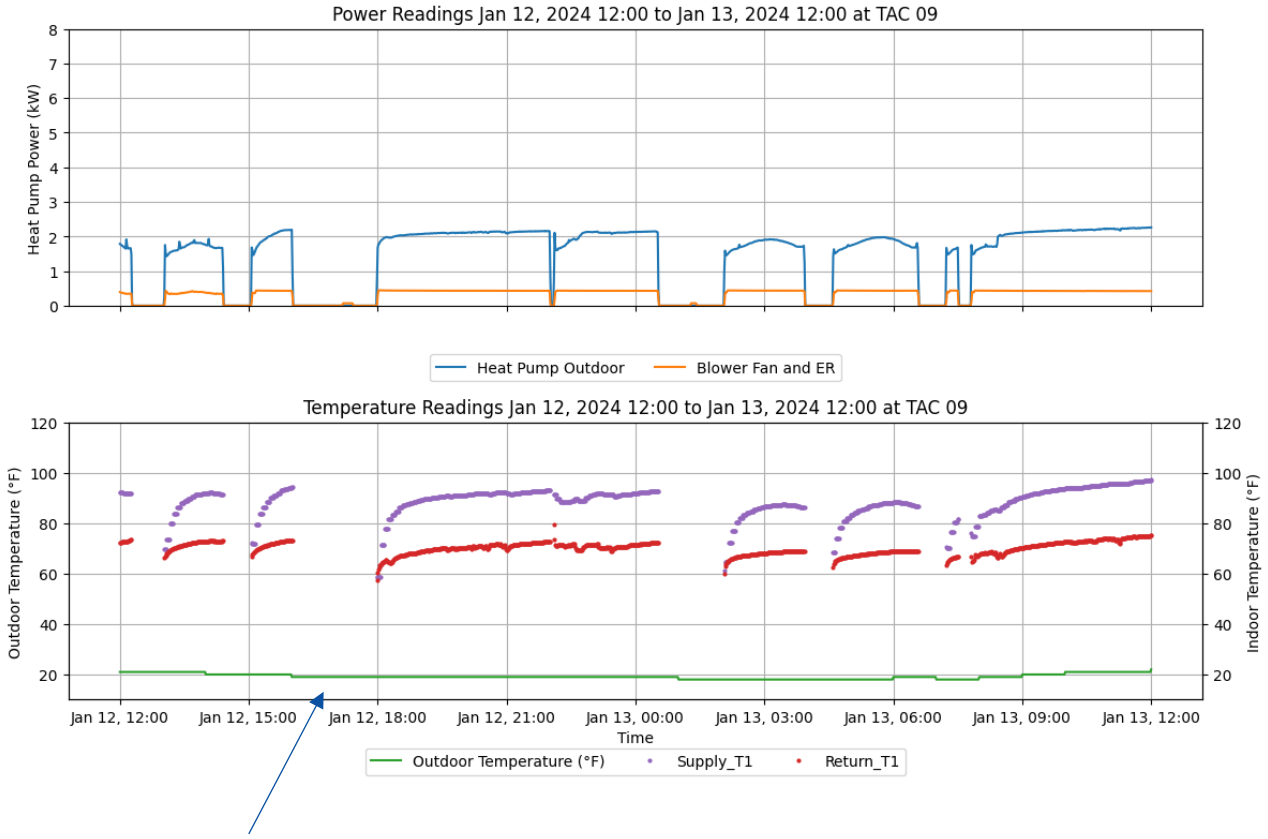
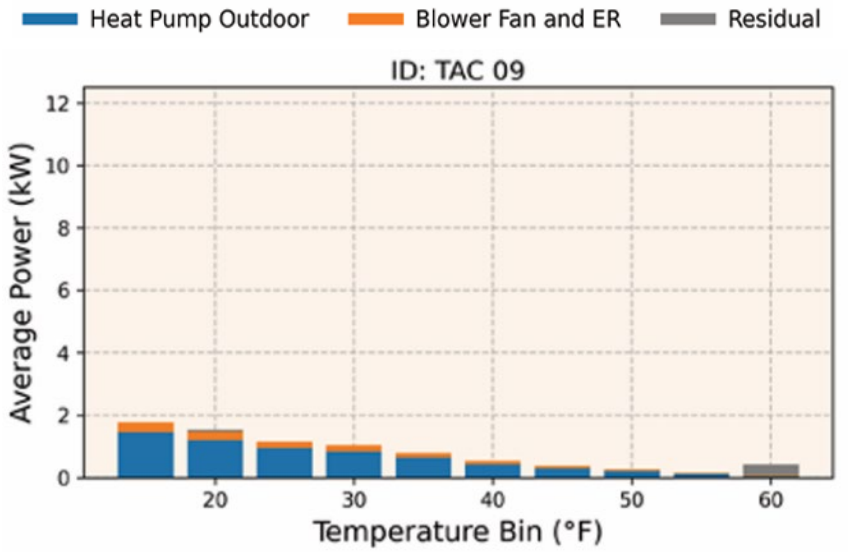
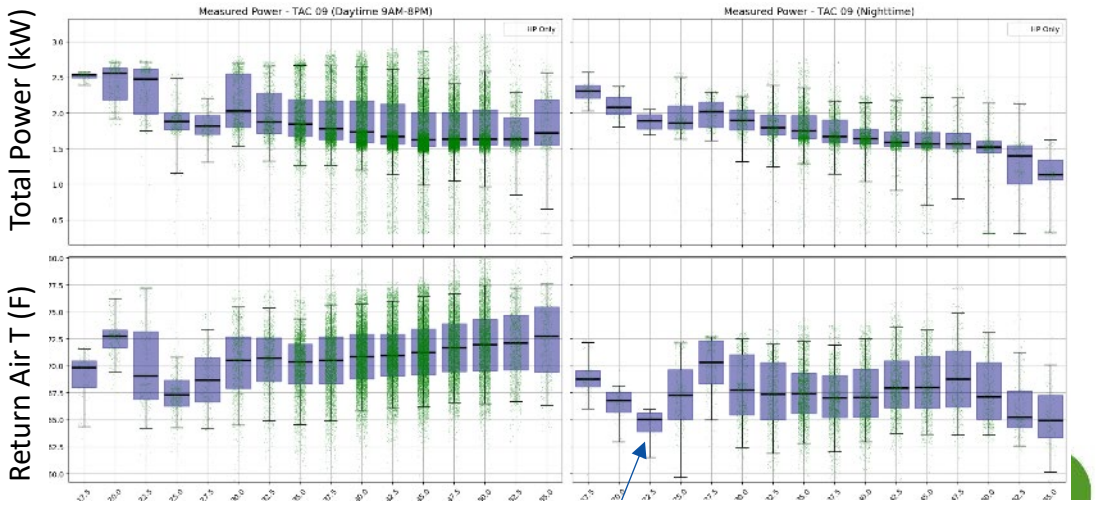
TAC 09 – HZ1, ER installed, but did not need/use







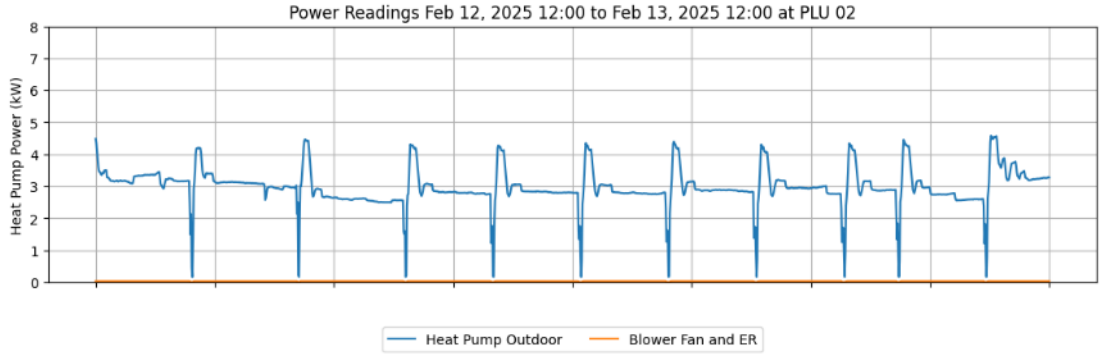
Example very cold day – heat pump runs less-than-full-time, no ER used.

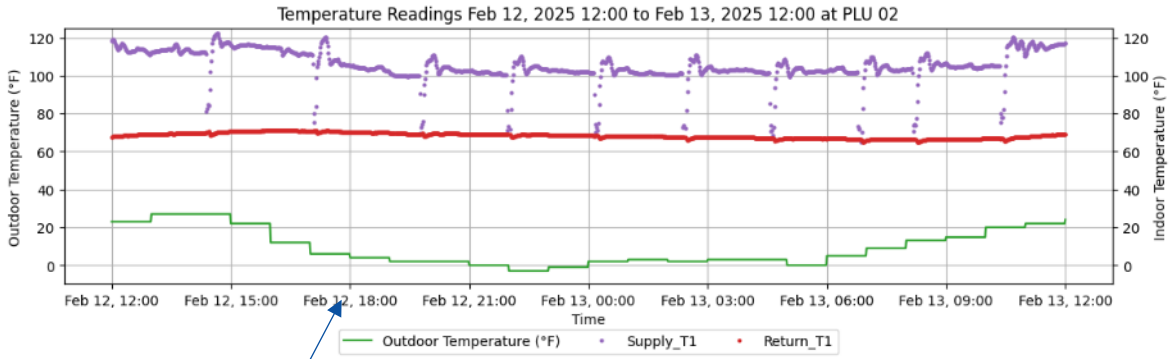
Note – initial return air temp dips likely reflects cold return register in crawlspace, not cold room

Fairly steady return temperature in low ODT; heat pump is running a lot and appears to reach full power in 17.5F bin

Note that this is very few data points so “cold return warm-up” dominates

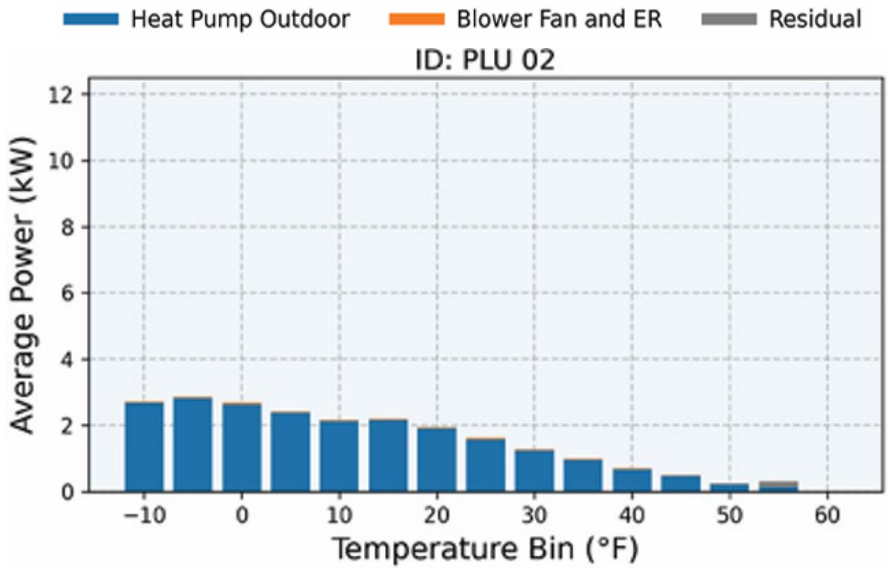
PLU 02 – HZ2, No ER installed, did not need*

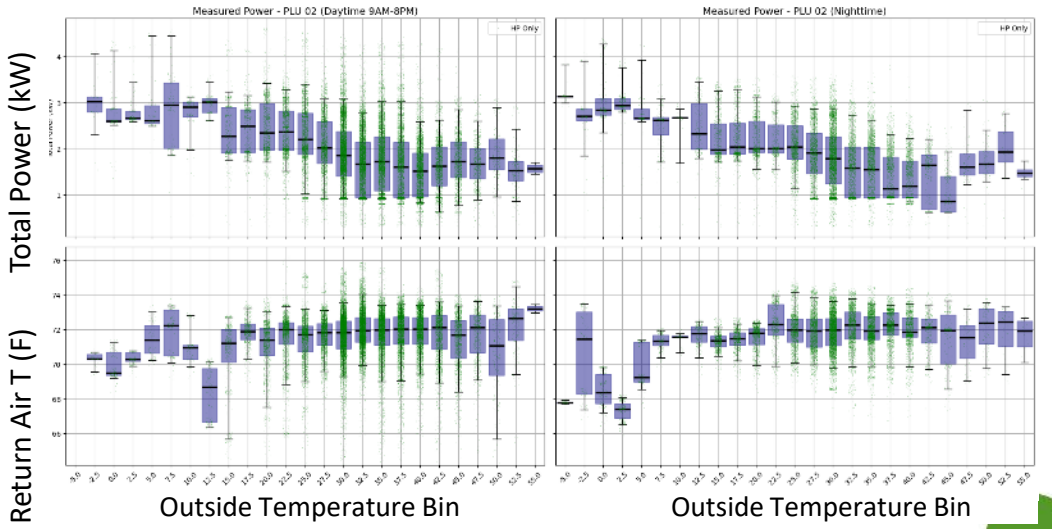




ID Temp ranged from 71F daytime to 66F overnight. System does run non-stop – so we're approaching the edge here

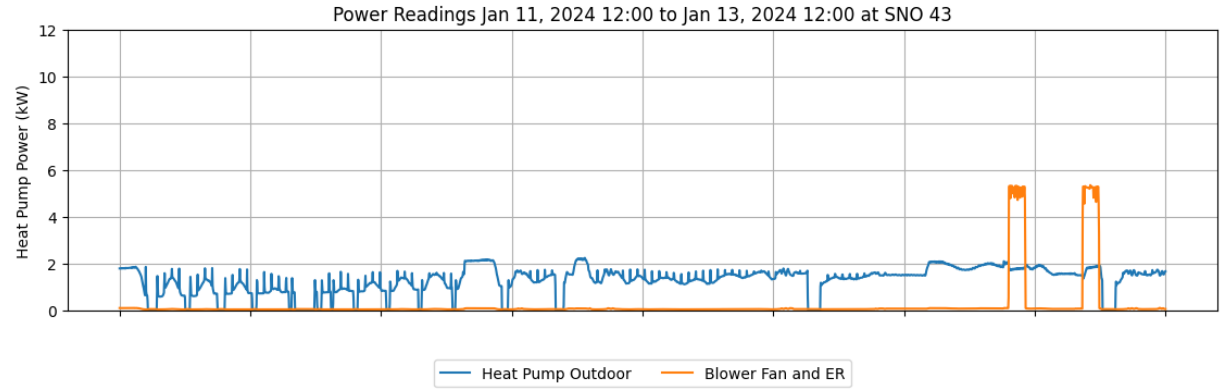
*one could argue "need" here since return air temp departs a little

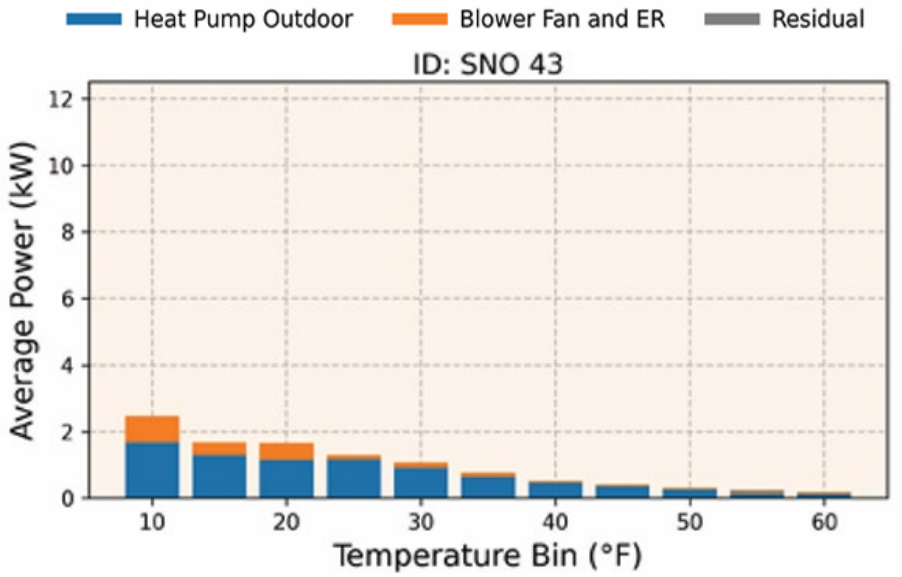


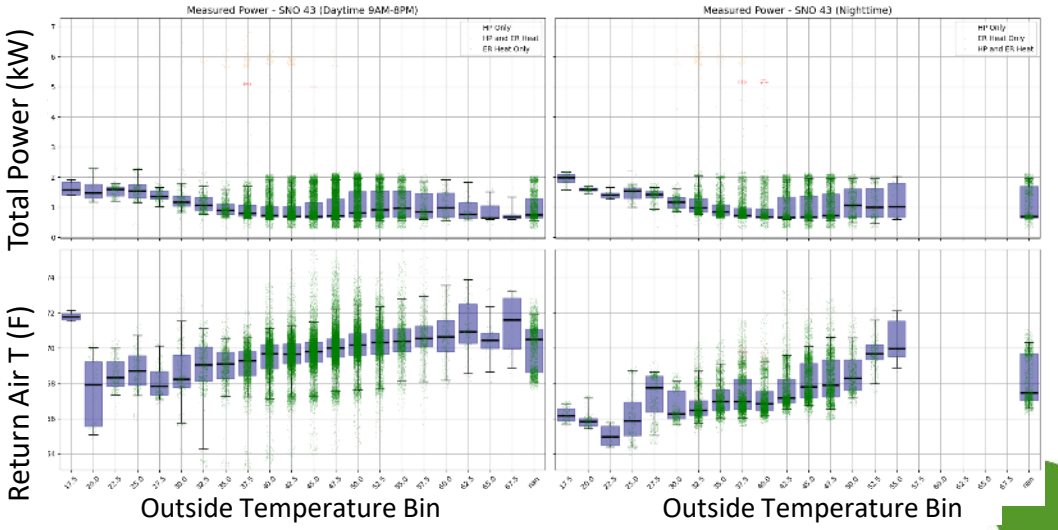


Some overnight drift downwards in temp but not consistent

SNO 43 – HZ1, ER installed, looks like could have gotten away without it







ID Temp appears to stay in a steady range and the system does cycle down/off at times; ER heat runs briefly in the early morning one of the days, but return temperature had not dipped. Arguably this system may have been OK without.

Site does have a thermostat setback, hence lower overnight temperatures

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What Predicts ER Use?

Does Not

- Duct leakage
- Whole home infiltration (ACH50)
- Square footage
- Brand differences: not enough data to say
- Heat loss survey derived heating load and balance point

Does Too

- Observed/Measured Balance Point
- Thermostat setback
  - Combined with lack of ER lockout

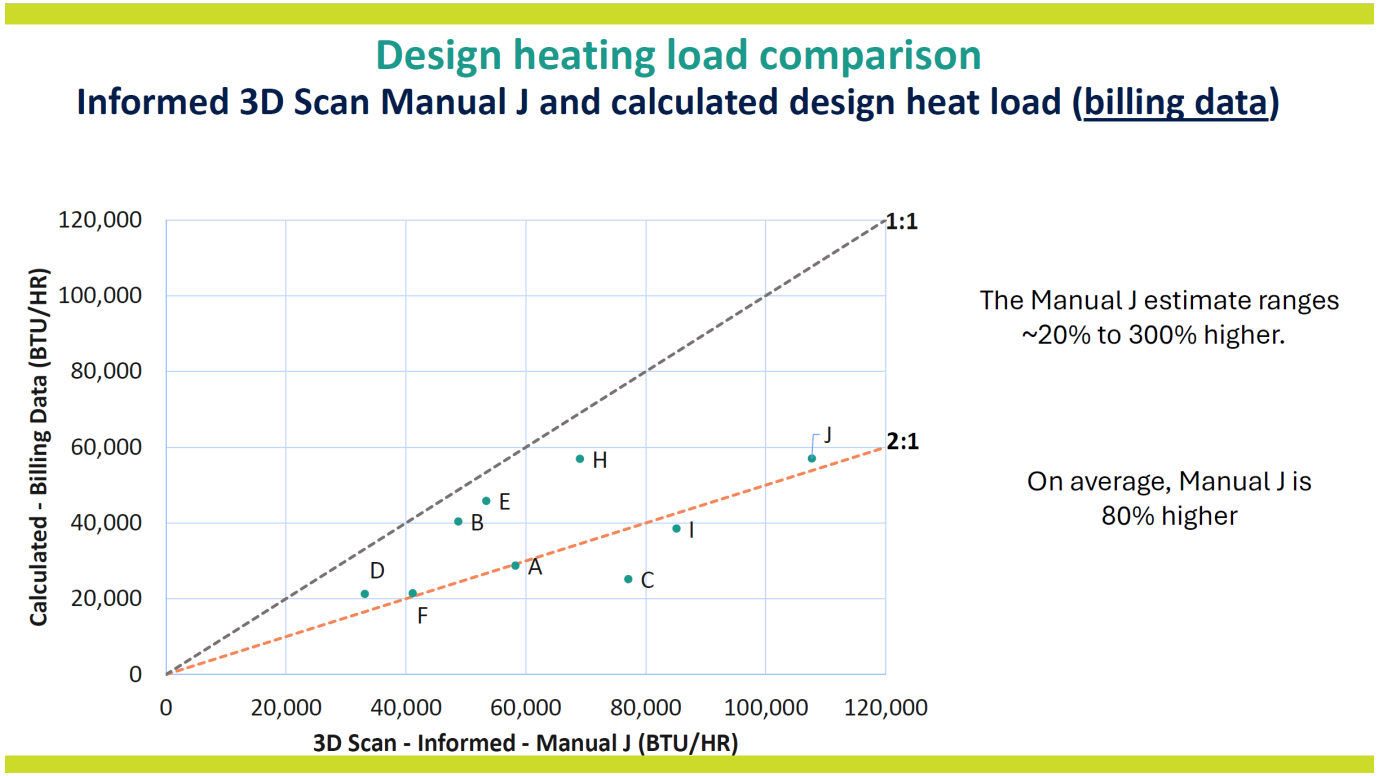
ER Use Driver Takeaways

- Proxies for “true” home heating load didn’t cleanly line up
- Some houses that looked “bad” from the pre-install survey data actually used no ER heat, and vice versa
- If we had accurate load prediction pre-install, THAT along with heat pump capacity, would probably predict “No ER needed”
- Accurate load calc and balance point sizing to design temperature are necessary conditions to achieve no ER use
  - But not entirely sufficient. We also need the controls to not use the ER unnecessarily.

Load Estimation Accuracy

- HPHCHP Study surveyed heat load and measured heat load disagreed (a lot)
  - Industry best practices used and practitioners carried out the calculations
- Disagreement not unique to BPA study
  - See graph at right

Source: Margolies, Justin. Cold-climate ASHP sizing -estimating loads and matching duct capacity. 2026 ACEEE Hot Air Forum. https://drive.google.com/file/d/1Oc6TJPRaX1svRdNilzpSEGdz4AJs5rtT/view



Conclusions

- Important project finding from report:
  - The stated equipment output capacity at 17 °F matched what we observed in the field.
    - You can use the 17 °F data to size equipment and trust it.
- It appears that the attempt to size to a 20 °F balance point was good enough to get heat pump sized to the 20 °F point.
  - This happened even though we had inaccuracies in heating load calculations
- Using no ER heating is possible if
  - Adequate heat pump output capacity
  - Setback recovery managed intelligently
  - Defrost schemes avoid running ER
  - Any other controls avoid ER

Questions and Discussion

Contact Info

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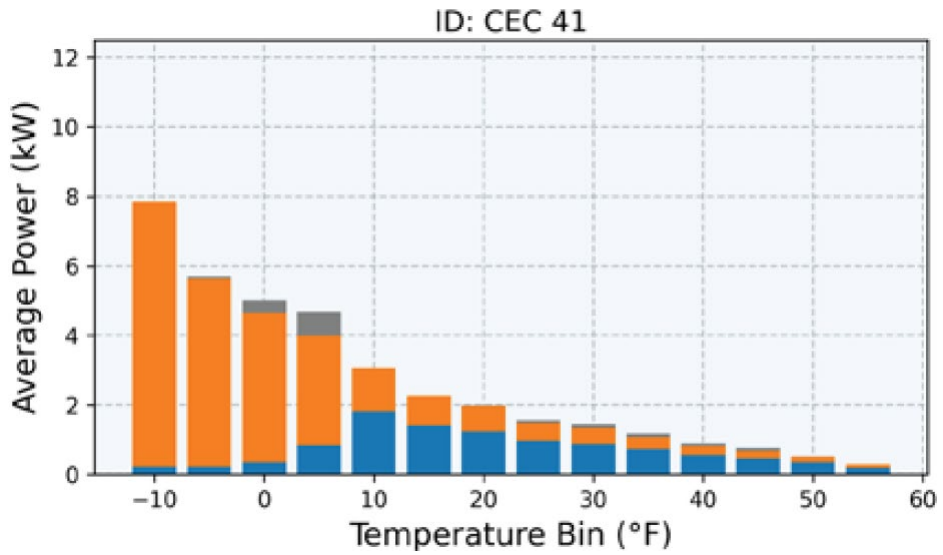
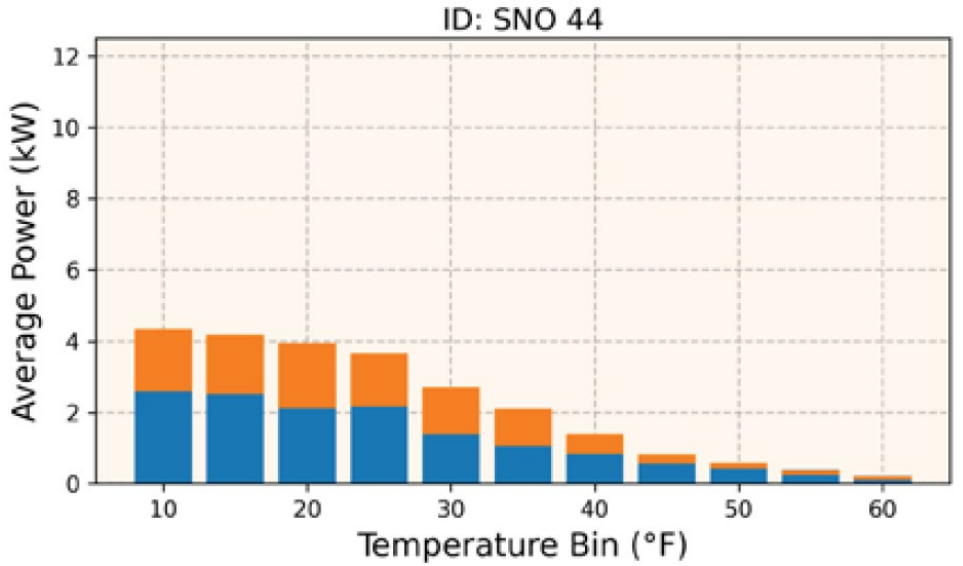
More Site Examples

HZ2 – Load Activated ER



- HP balance point ~10 °F
- Below 10 ° F, ER needed to maintain house temperature

HZ1 – Controls Activated ER



- HP balance point ~ 5 °F
- Controls opt to run ER