Whole Home Heat Pumps for Manufactured Homes

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Overview

- Manufactured homes in Maine
  - Over 62,000 homes in the state, or roughly 8% of the housing stock
  - Primarily use low to moderate efficiency kerosene, oil, and propane furnaces for heating
    - Coefficient of Performance (COP) of existing units are roughly 0.8, or 80% efficient
  - Include economically stressed occupants
- Electrification of manufactured homes is a challenge due to:
  - Lack of industry experience
  - Water lines run under homes and are kept warm by air in the ducts
  - Small HVAC closets
  - 100A panel capacities

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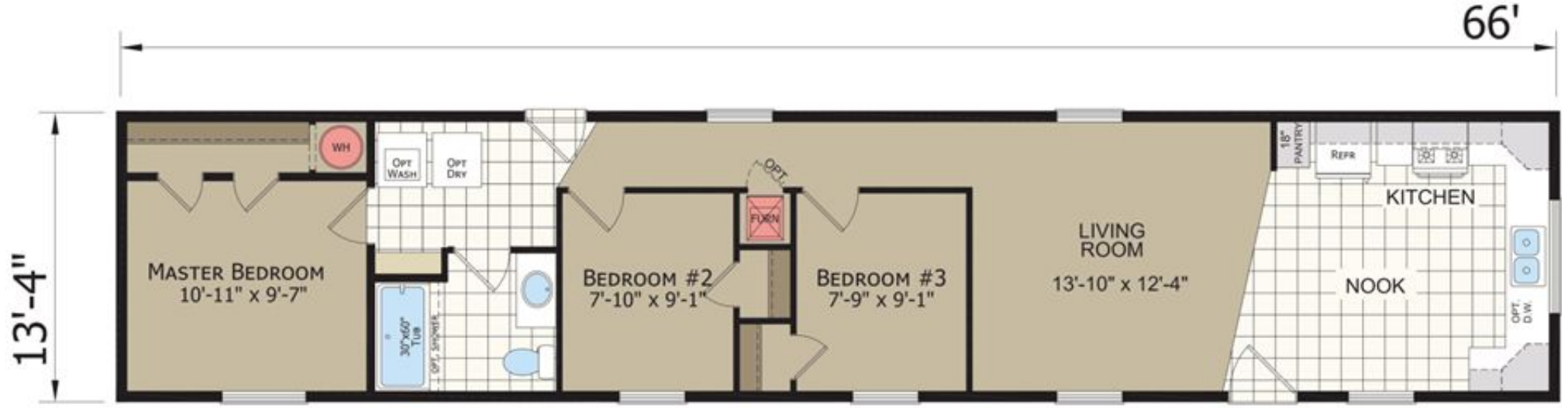
Target Homes to Date



Example "Single-Wide" Layout

- "Single-wide" manufactured homes
- Climate Zones 6a, 5b, and 5a
    - Kittery, ME to Bangor, ME
- Previously heated with kerosene, oil, or propane
- Underbelly insulation fully intact
- Owner Occupied
- Meet income screening requirements
- Ability to fit appropriately sized heat pump and any necessary supplemental electric resistance in both closet and electric panel

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Screening Criteria

Our partner in Ridgeline Energy Analytics has been completing the screening for our homes to date, which included:

1. Manual J calculation was completed for all homes.
    - Homes with design loads > 37,000 BTU were generally referred to a weatherization program
2. Blower door and duct blaster tests conducted for homes older than 2005
3. HVAC closet width checked for unit compatibility
    - Older homes may be as narrow as 18 inches, newer homes are generally wider
4. Electrical code calculations were completed for all homes
    - The heat pump and any supplemental electric resistance must fit within the NEC electrical capacity. Generally, heat pumps fit, but supplemental heating did not
5. Underbelly and duct boots were checked for signs of damage
    - Homes with missing or damaged vapor barriers were referred to a weatherization program or rejected

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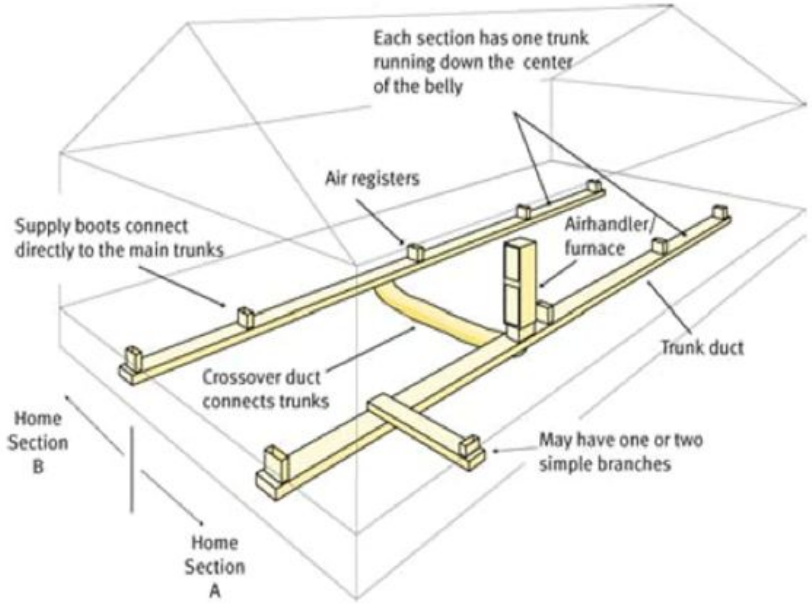
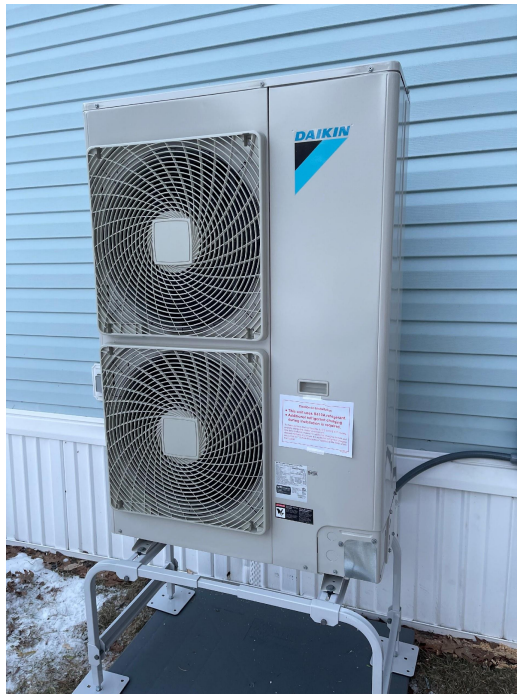
Ducted Mobile Home Solution

Indoor Unit

- Heat pumps replace the Miller furnace and use the existing closet and ductwork to warm every part of the home.
  - Keeps warm air flowing through the ducts which prevents frozen pipes.



Duct Work Layout



Outdoor Unit

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Pilot Progress

- Phase 1: Winter 2021 – 2022 in Collaboration with Ridgeline Energy Analytics
  - 10 manufactured homes participated in first year
    - No participant co-pay for initial pilot testing
    - Allowed us to meter their homes throughout the winter
    - Offering included an opt-out clause after 1 year to go back to previous heating system (no participants took this offering)
- Phase 2: Winter 2022 – 2023 in Collaboration with Ridgeline Energy Analytics
  - 19 additional manufactured homes participated in second year
    - Received unit for no money down, but participants agreed to a co-pay of $50 / month for 50 months
    - Includes full 5-year labor warranty through the installers, in addition to manufacturer parts warranty
    - Allowed us to meter their homes throughout the winter
- Phase 3: Winter 2023 – 2024 in Collaboration with Ridgeline Energy Analytics and CLEAResult
  - Planning to mirror Phase 2 offering and test additional home sizes and climate zones

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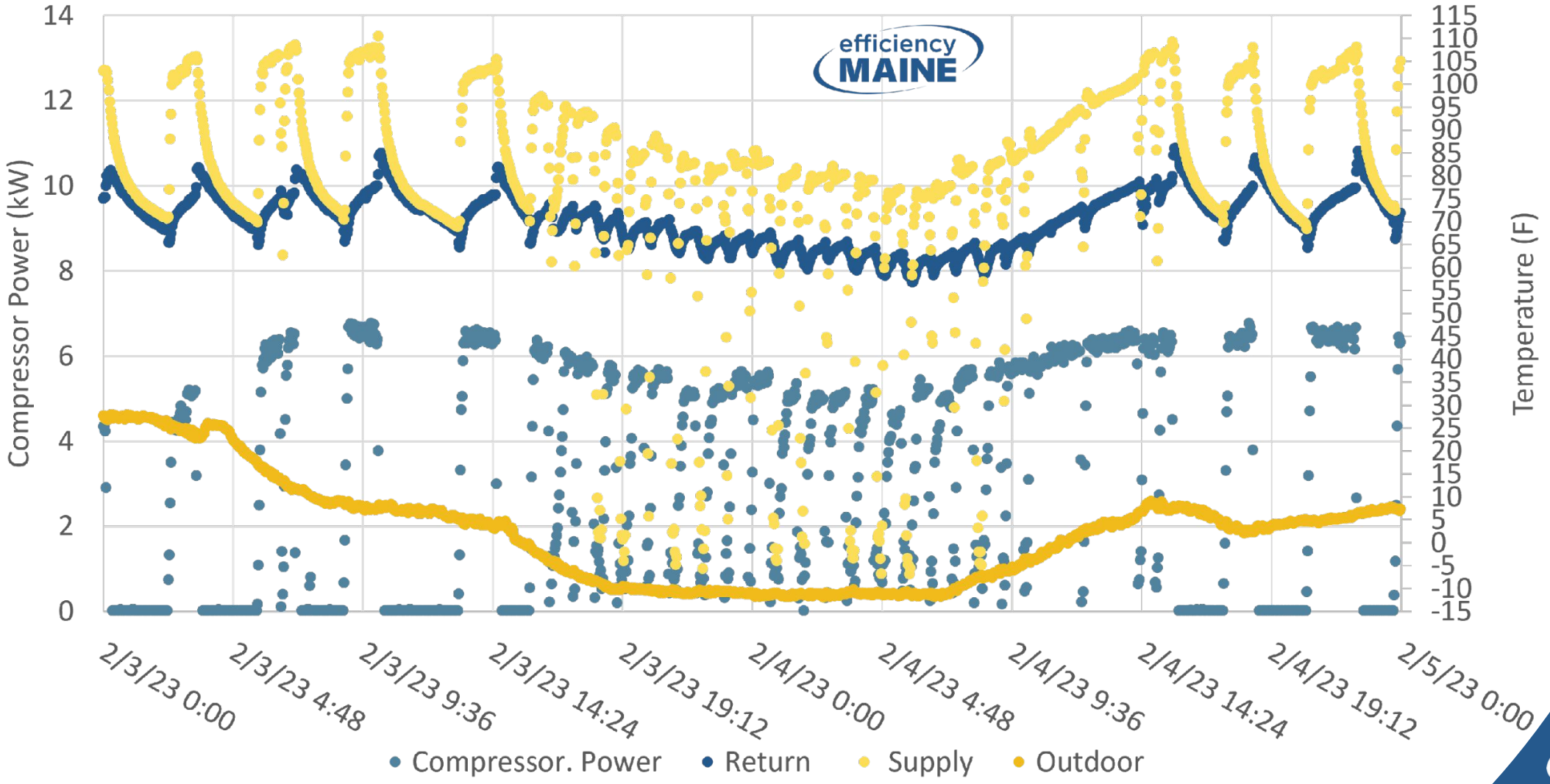
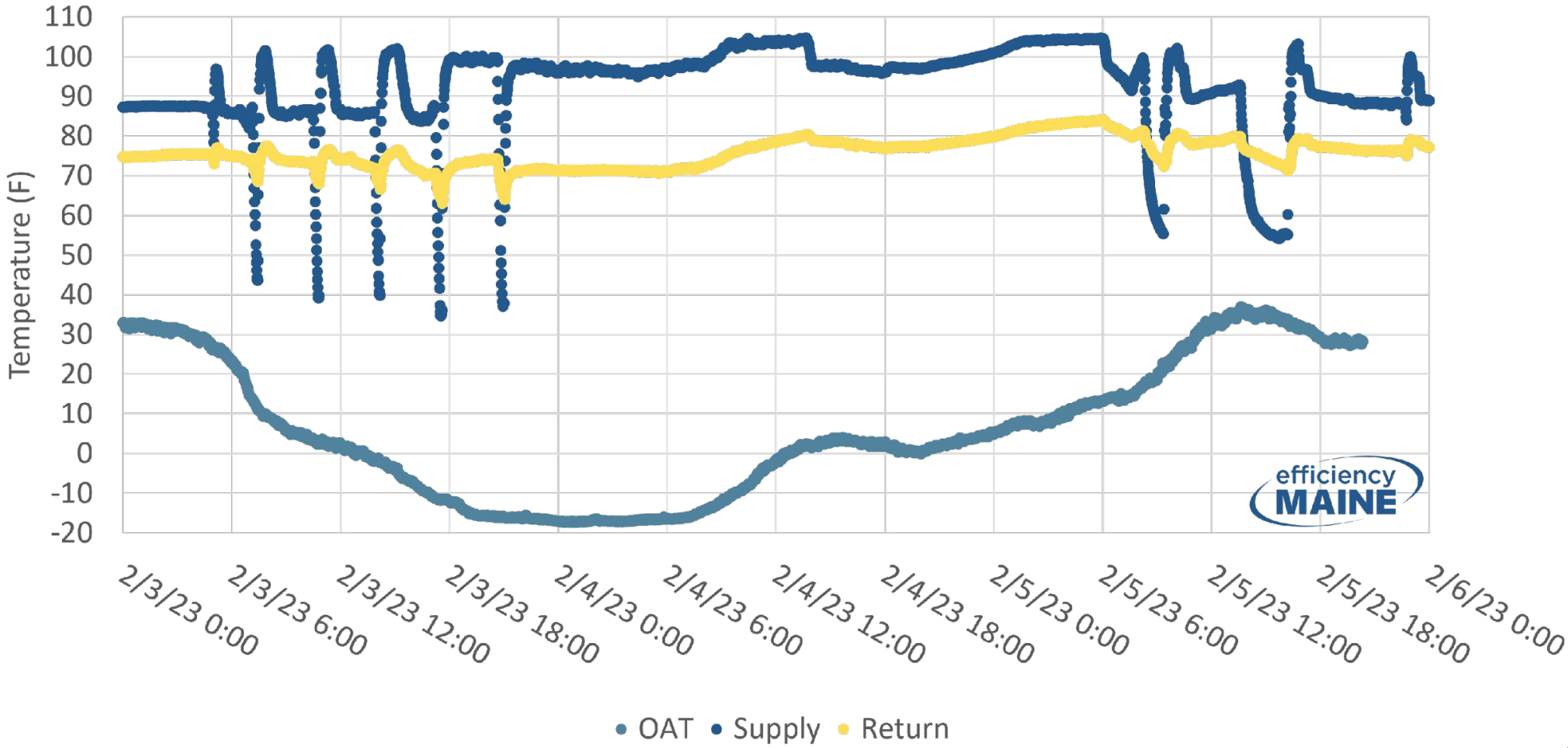
Heat Pump Metering

- We metered the following parameters:
  - Power at unit
  - Amperage of indoor fan (helped determine fan setting)
  - Supply air temperature
  - Return air temperature (analog for temperature of home)

Very Cold Temperature Performance: Freeport, Maine, at -10F



Very Cold Temperature Performance: Hancock, Maine, Down to -16F



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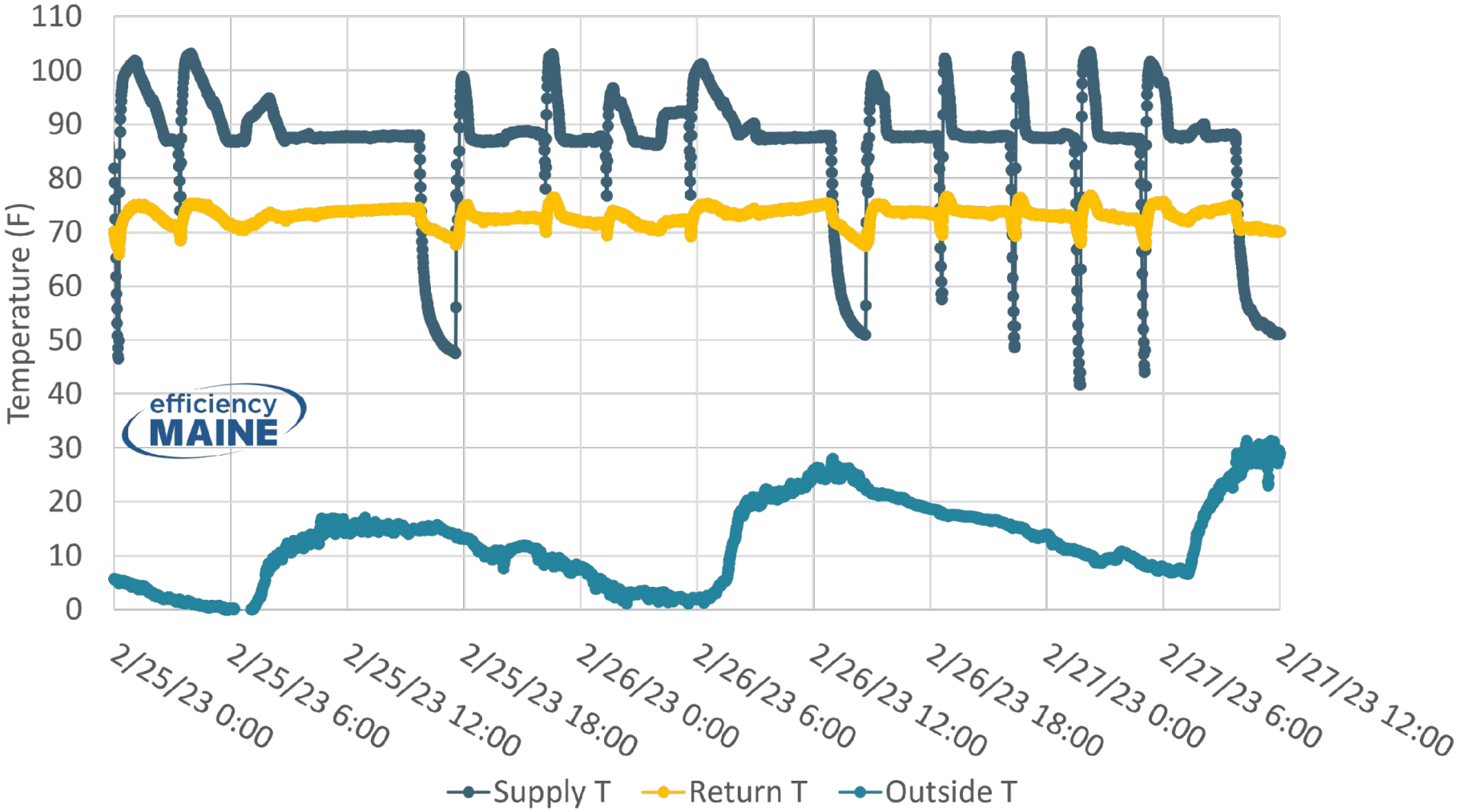
Cold Weather Air Performance: Hancock, Maine



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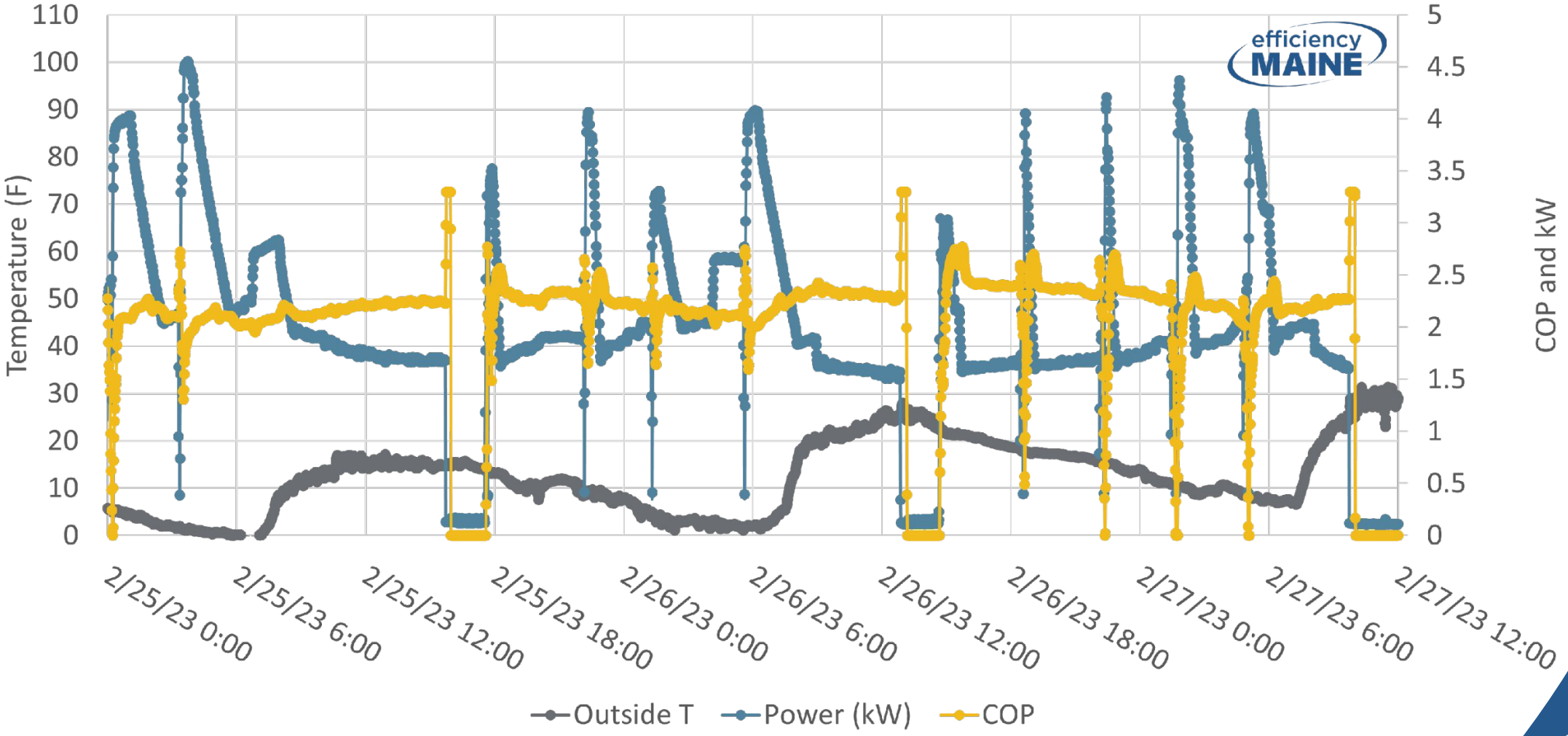
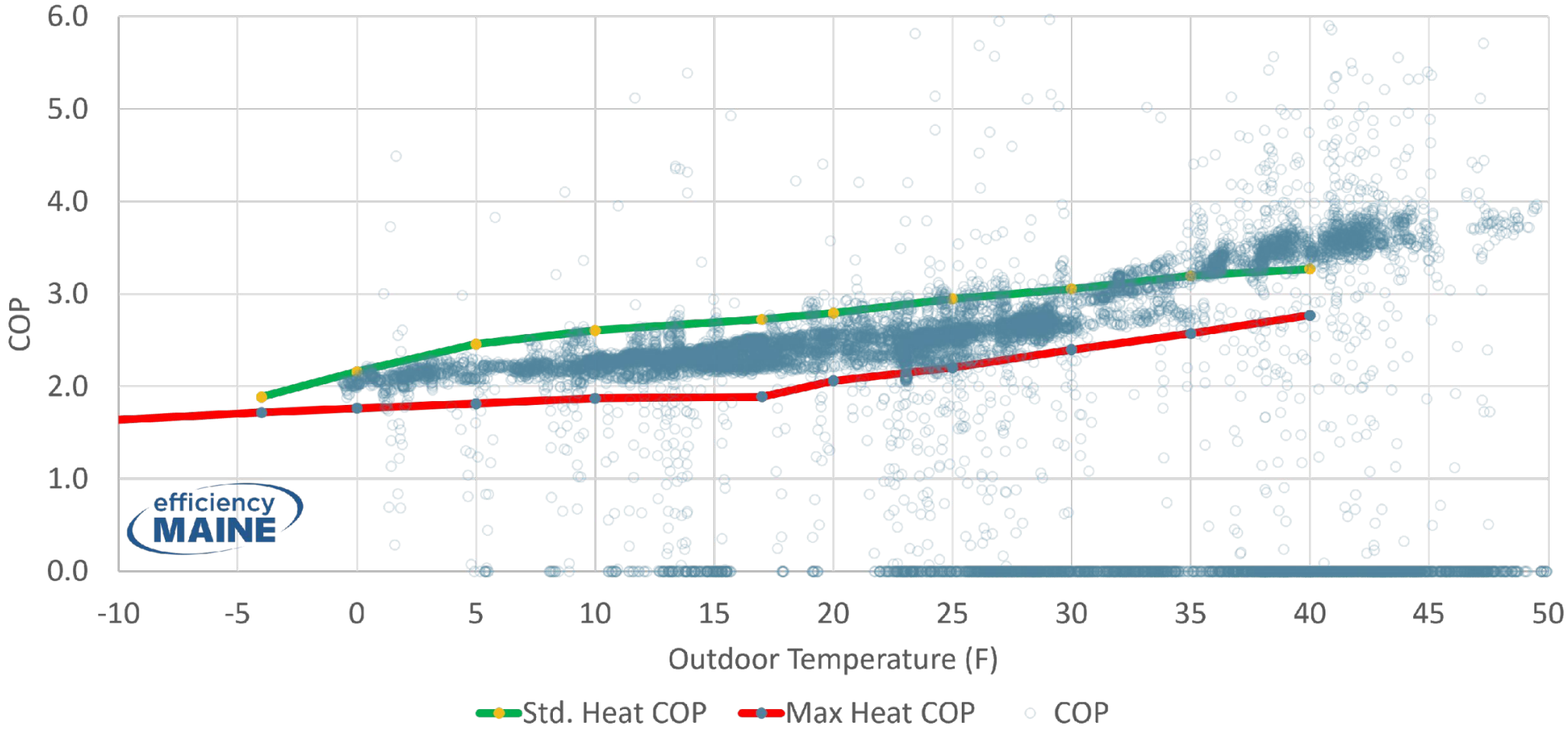
Cold Weather COP: Hancock, Maine



COP of LG 3T Ducted HP in Hancock (2/14/23 - 3/10/23)



Winter Observations

- Heat pumps successfully heated homes with no back up down to -16F with few issues.
- One home was encased in ice due to ice sliding off metal roof. The heat pump did not provide capacity until ice was cleared, then returned to normal.
- Heat pumps appeared to operate at or near rated efficiency (COP) and provided heat near capacity.
- Actual heat loss appeared to be lower than heat loss modeled using Cool Calc, a Manual J-based vended software.

Installation Related Best Practices

- Ice sliding off metal roofs ice can encase or damage units.
  - A best practice could be to install heat pumps on the gable end of the home, but consider other environmental factors and air flow.
- Install on a ground stand rather than mounted to the siding for this building type.
  - This will reduce noise inside the building.
- Consider piping condensation outside of the skirting of the home and checking routinely for blockages.
  - Condensation pumped beyond the underbelly, but within the skirting, may result in pools forming and increased humidity under the home.
- Consider the appropriate power cabling for the environment.
  - A best practice may be to use Underground Feeder (UF) rated cable over Romex (NM) due to the damp environments under a home.

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Have Sites Included Supplemental Electric Resistance?

- Some have, but not all.
- The ability to add electric supplemental heat is limited by the electrical panel capacity as calculated by code requirements.
- All the homes were limited to 100 Amps. Where panels were larger, the meter breaker was limiting at 100 Amps.
- Where home have gas appliances, supplemental heaters of 3kW – 5kW will usually fit. Where homes are all electric adding supplemental heat is a challenge.
- Heat pump and any supplemental heat should be adequately sized to heat the home below design temperature. If this cannot be achieved within the limits of the panel capacity, the upgrade should not be completed until the electric capacity is addressed.

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Heat Pump Units

Brand	Outdoor Unit Model #	Indoor Unit Model #	Output (kBTUh) @ temp	Width (inches)
Daikin	RZQ36TAVJUA	FTQ36TAVJUD	40.3@ -4F Rated to -13F	17.5
Daikin	RZQ42TAVJUA	FTQ42TAVJUD	40.5@ -4F Rated to -13F	21
Fujitsu	AOUH36LMAH1	AMUG36LMAS	38.0@ -5F 32.0@ -15F	21
Fujitsu	AOUH48LMAH1	AMUG48LMAS	45.5@ -5F 39.0@ -15F	21
LG	LUU360HHV	LVN361HV4	33.8@ -4F 28.4@ -13F	18.5
LG	LUU420HHV	LVN420HV	38.2@ -4F 28.8@ -13F	25

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