



National Association of
State Energy Officials

NASEO Manufactured Housing Energy Efficiency and Affordability Initiative Meeting: *Statewide Heat Pump Installation and Incentive Programs for Manufactured Homes*

August 25, 2023

Photo Courtesy of RL Martin



Agenda

- Efficiency Maine: Whole Home Heat Pumps for Manufactured Homes
- Oregon Department of Energy (ODOE): Oregon Rental Home Heat Pump Program
- Florida Solar Energy Center (FSEC): Photovoltaic-Powered, Grid Enhanced Mechanical System (PV-GEMS)
- Q&A



Whole Home Heat Pumps for Manufactured Homes

Dan Mistro

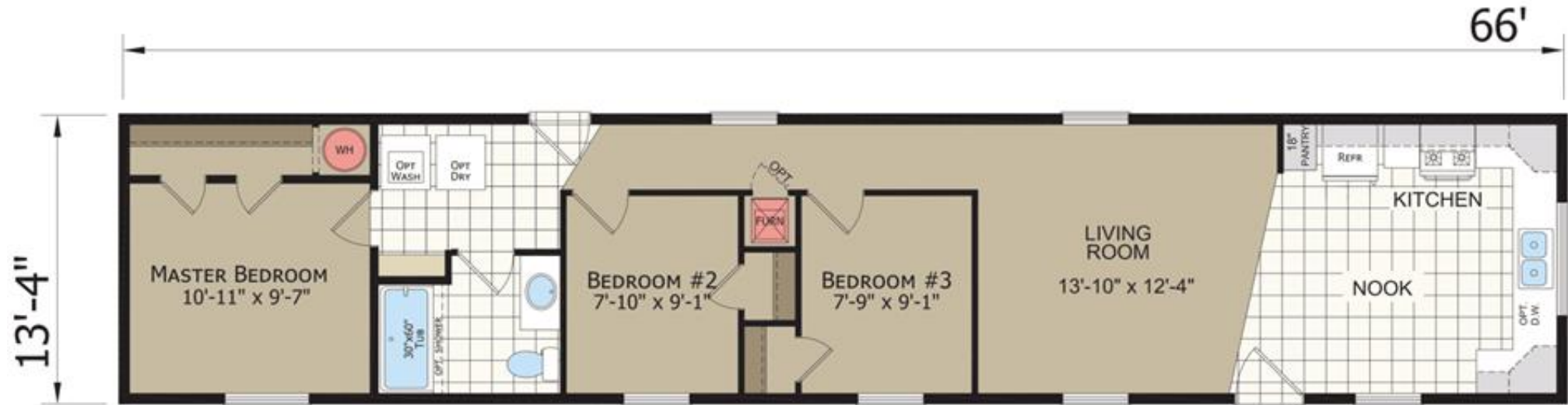
Efficiency Maine Trust

August 2023

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

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

Screening Criteria

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

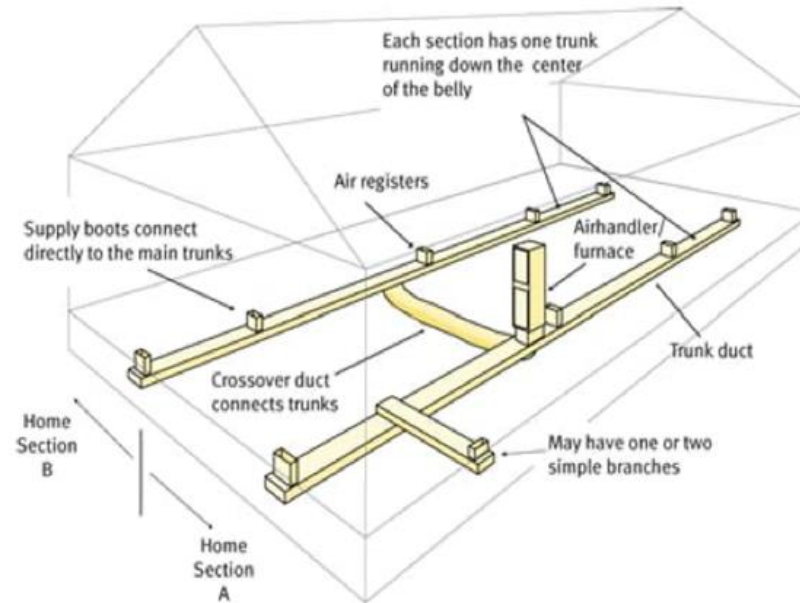
1. Manual J calculation was completed for all homes.
 - Homes with design loads > 37,000 BTU were generally referred to a weatherization program
2. Blower door and duct blaster tests conducted for homes older than 2005
3. HVAC closet width checked for unit compatibility
 - Older homes may be as narrow 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

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

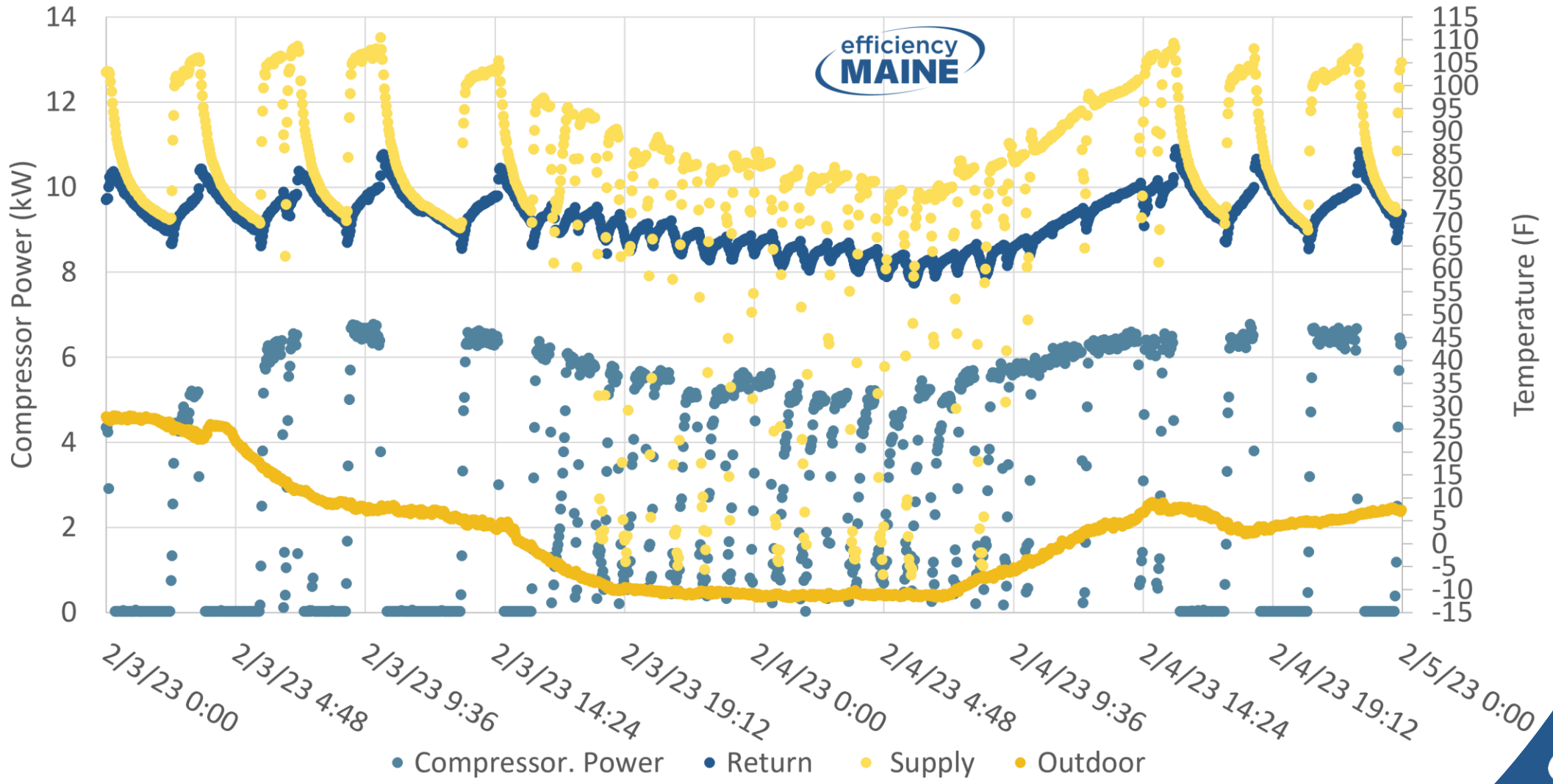
Pilot Progress

- 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 CLEARResult
 - Planning to mirror Phase 2 offering and test additional home sizes and climate zones

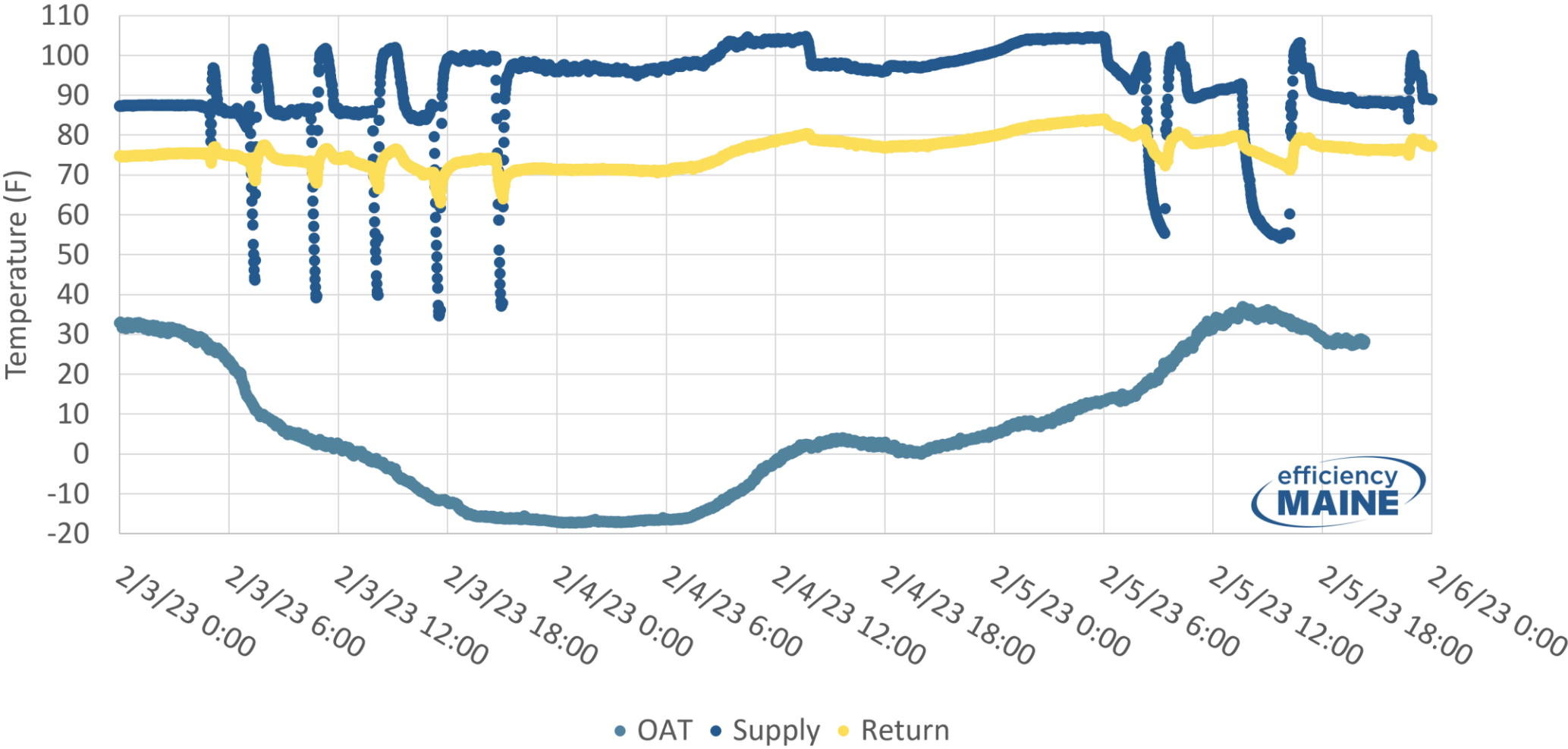
Heat Pump Metering

- 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)

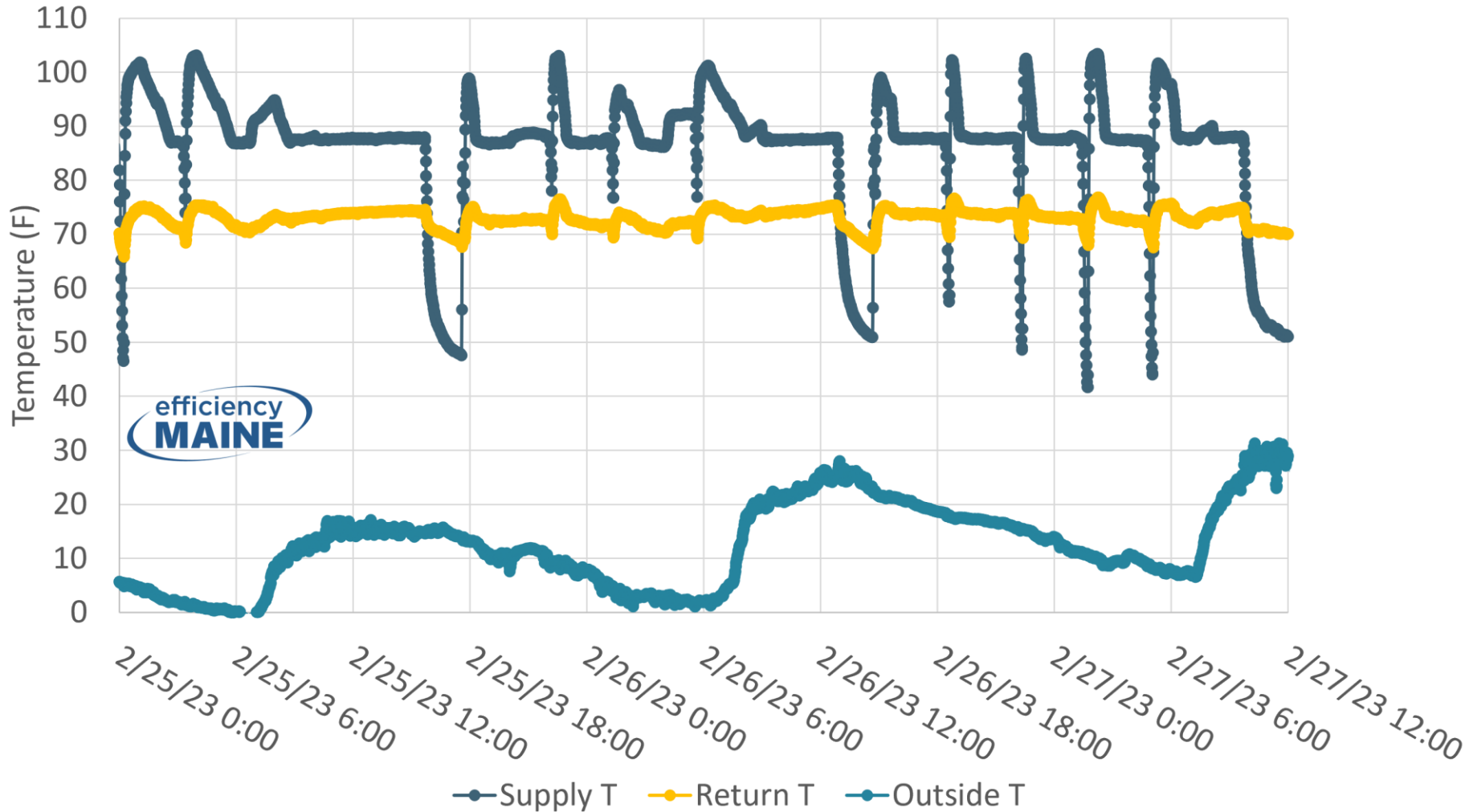
Very Cold Temperature Performance: Freeport, Maine, at -10F



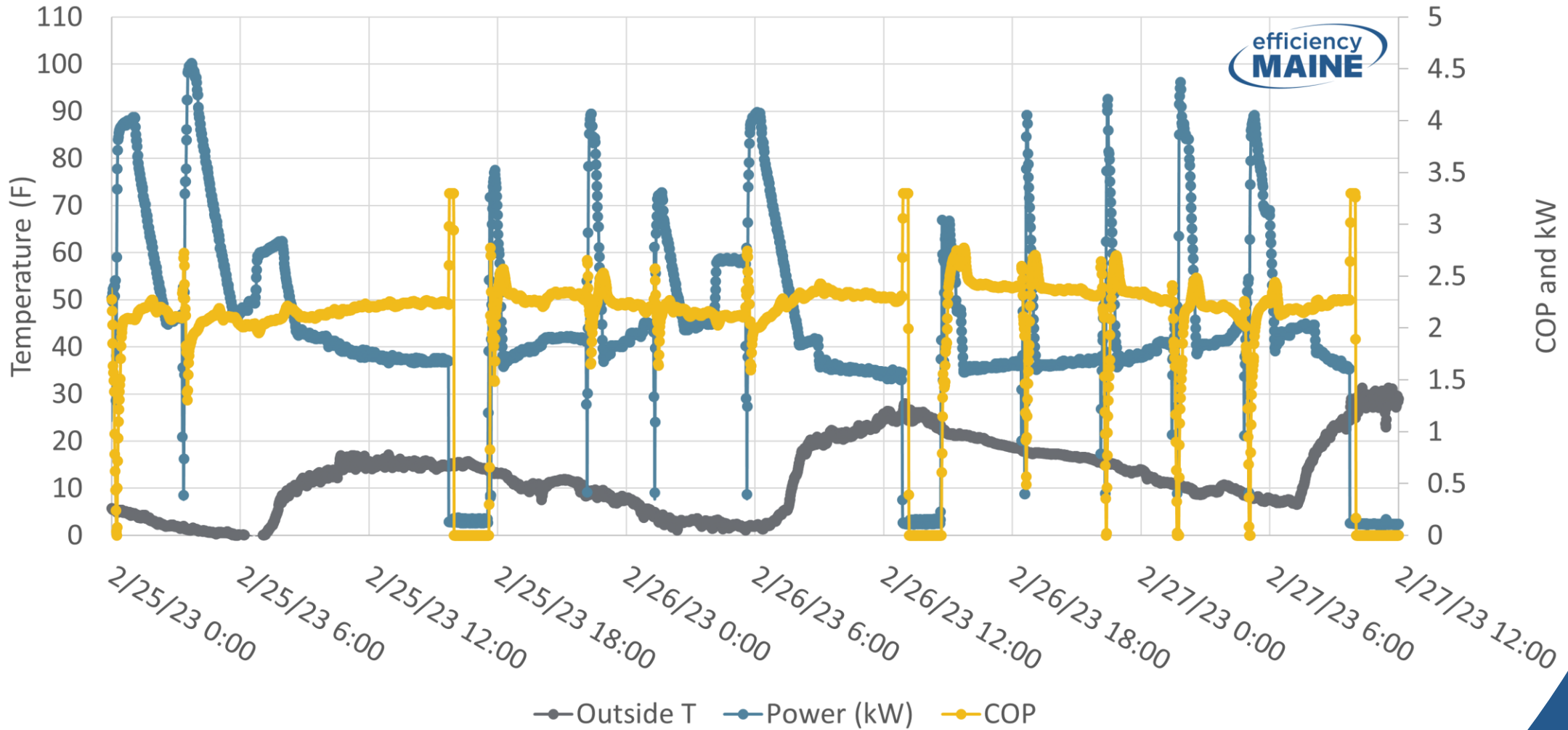
Very Cold Temperature Performance: Hancock, Maine, Down to -16F



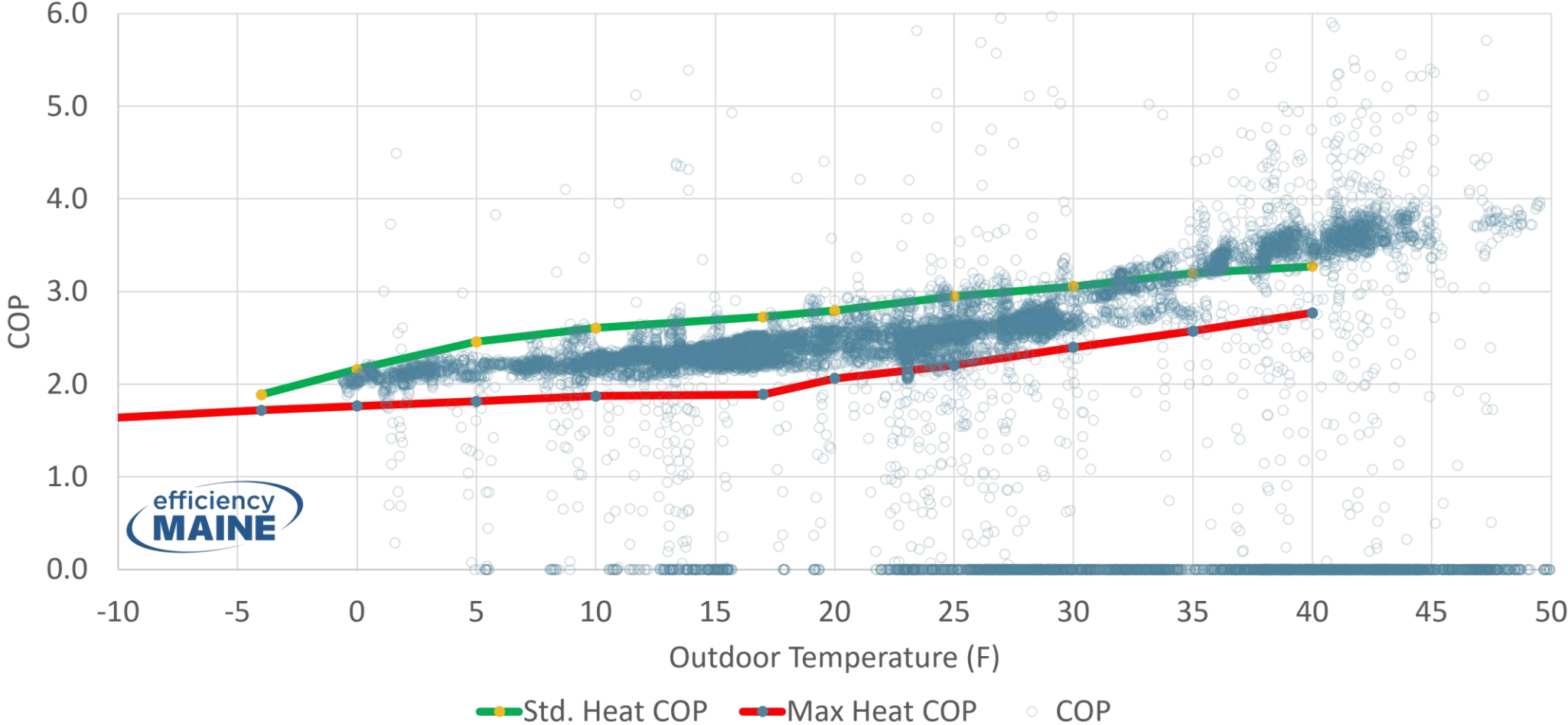
Cold Weather Air Performance: Hancock, Maine



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.

Participant Quotes

- “The heat seems more even with the HP.”
- “We are very happy. The heat pumps worked so well we didn’t turn on the furnace at 0 F. Our pipes [under the home] did not freeze.”
- “We are happily enjoying our heat pump. It is keeping us toasty warm.”

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.

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

Oregon Rental Home Heat Pump Program

NASEO Manufactured Housing Task
Force Meeting
August 25, 2023



OREGON
DEPARTMENT OF
ENERGY

Senate Bill 1536

- Heat dome event of 2021
- Legislature passes Senate Bill 1536 (2022)
- Creation of two heat pump incentive programs:
 - Community Heat Pump Deployment Program
 - Oregon Rental Home Heat Pump Program

Oregon's heat wave death toll grows to 116

Updated: Dec. 01, 2021, 12:18 p.m. | Published: Jul. 07, 2021, 12:42 p.m.



Salem Fire Department paramedics and employees of Falck Northwest ambulances respond to a heat exposure call during a heat wave, Saturday, June 26, 2021, in Salem, Oregon. Nathan Howard | AP Photo

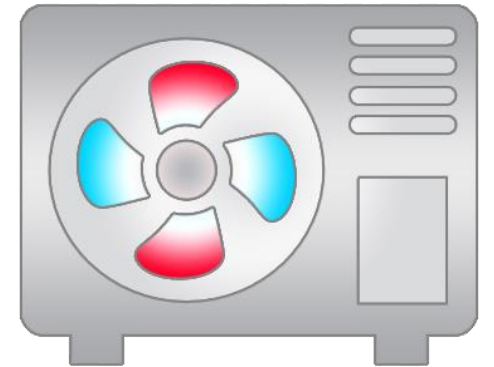
TARGETING BENEFITS TO MANUFACTURED HOMES

- Roughly 8% of Oregon's housing is manufactured homes and RVs
- Less insulated and sealed leading to worse exposure and higher energy use intensity
- Efficiency opportunities by replacing furnaces or electric resistance heaters
- Eligibility carve out for both state heat pump programs

PROGRAM OVERVIEW

Financial assistance for the purchase and installation of heat pumps and related upgrades.

- ▶ \$15 million allocated for program administration and incentives
- ▶ Assistance available to owners of:
 - Rental units – does not include vacation occupancy or transient occupancy in hotel or motel.
 - Manufactured dwellings or recreational vehicles that rent a space in a manufactured dwelling or RV park.
- ▶ Eligible contractors apply to ODOE online to reserve and request funds. The full rebate amount is passed on to the customer.



AVAILABLE INCENTIVES



Rebate Amounts

Owner of a rental unit

\$2,000 - \$5,000 or
60% of purchase and installation costs
of the heat pump

**Owner of manufactured dwelling or
RV that rents a space in a
manufactured dwelling or RV park**

\$2,000 - \$7,000 or
80% of purchase and installation costs
of the heat pump

- ▶ Rebate amount dependent on costs, heat pump efficiency, and tenant income level
- ▶ Grants for related upgrades may range from \$2,000 – \$4,000, depending on tenant income level

PROGRAM PROGRESS UPDATE

- Program opened for rebate reservations in July 2023
- Program results to date
 - Number of approved contractors: **83**
 - Number of reservation requests: **483**
 - Number of requests submitted for manufactured homes: **33**
 - Amount of funds reserved to date: **\$982,421**



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Thank You!

Any questions?

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Presenter Email: Patrick.T.DePriest@energy.Oregon.gov

<https://www.oregon.gov/energy/Incentives/Pages/ORHHPP.aspx>



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PV-GEMS: Photovoltaic Powered, Grid Enhanced Mechanical Solution

NASEO Manufactured Housing Initiative Meeting

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US DOE Advanced Building Construction Initiative

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Advanced Building Construction

The U.S. Department of Energy's (DOE's) *Building Technologies Office* (BTO) is carrying out R&D and market transformation efforts to integrate energy efficiency solutions into an evolving U.S. construction industry to deliver affordable, appealing, high-performance, low-carbon new buildings and retrofits at scale.



Zero energy retrofits can be completed quickly and without disruption to occupants by incorporating most of the improvements into the façade of the building. *Photo credit Energiesprong.*

Innovation Across the Supply Chain + Streamlined Delivery



<https://www.energy.gov/eere/buildings/articles/advanced-building-construction-fact-sheet>

Challenge: Deep EUI Reduction w/ Minimal Enclosure Upgrades

Manufactured Housing:

- Frequent deferral of WAP and other services due to need for high-cost repairs.
- Limited HVACWH equipment replacement options due to space constraints.
- Some success with shallow retrofits at scale via close proximity weatherization.

Mild Climate Single Family Homes:

- Costly enclosure retrofits such as windows and wall insulation indirectly addressing HVACWH energy use through load reduction have low energy savings potential (<10% whole house savings).
- Some success with equipment retrofits directly addressing HVACWH energy making a big impact (>30% savings) though often require >1 contractor.

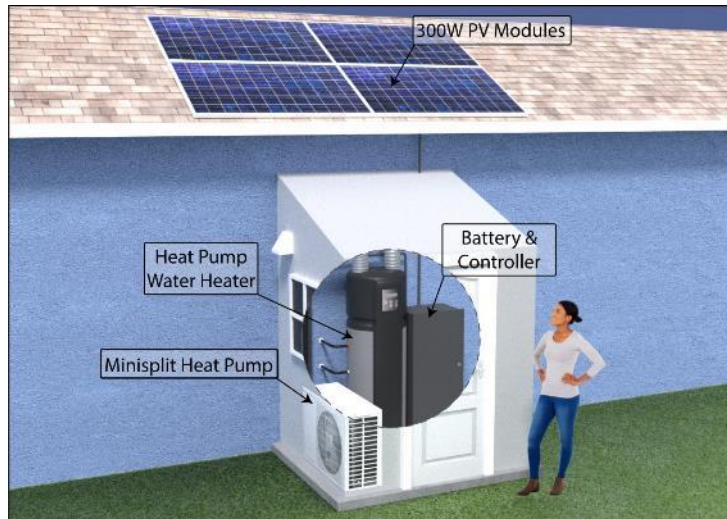
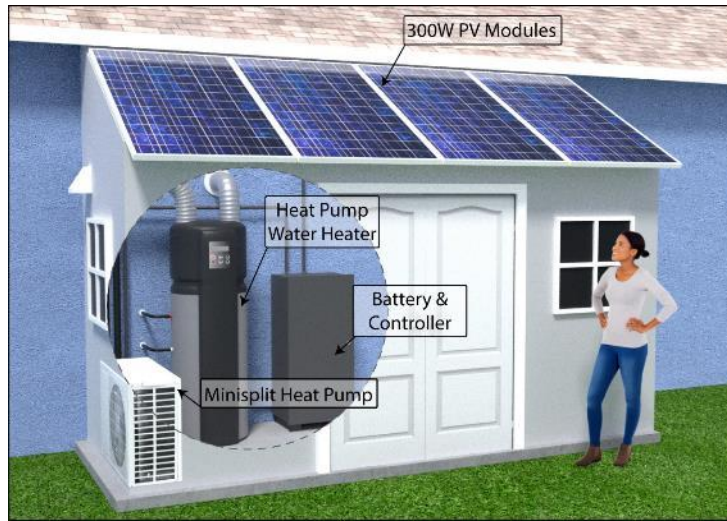


Energy Trust of Oregon Study: HPWH installation \$300-\$700 more than site built garage install due to space constraints.



NH Community Loan Fund Study: Pilot program improved 70% of homes (382) in 38 ROC's.

PV-GEMS: Pre-packaged, high efficiency, heating/cooling/water heating retrofit solution



Bundle PV-GEMS with Shallow Retrofit Improvements

- Deploy with cost effective, minimally-disruptive retrofit measures that will improve control of airflow, pressures, and comfort while reducing heating and cooling energy use.

Duct Sealing



Envelope Sealing

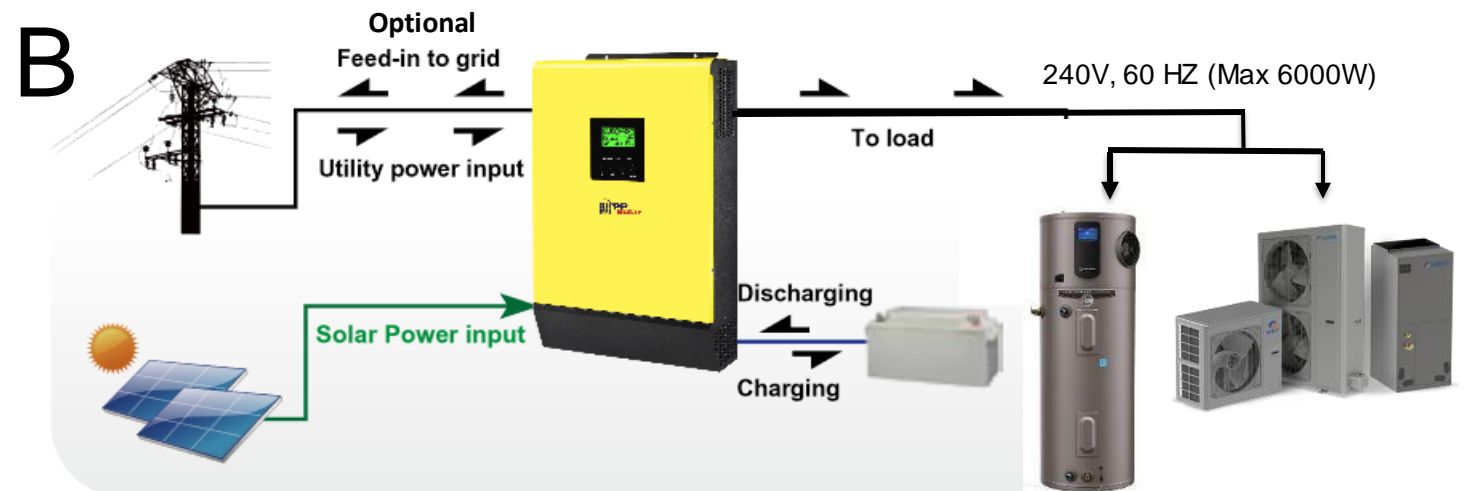
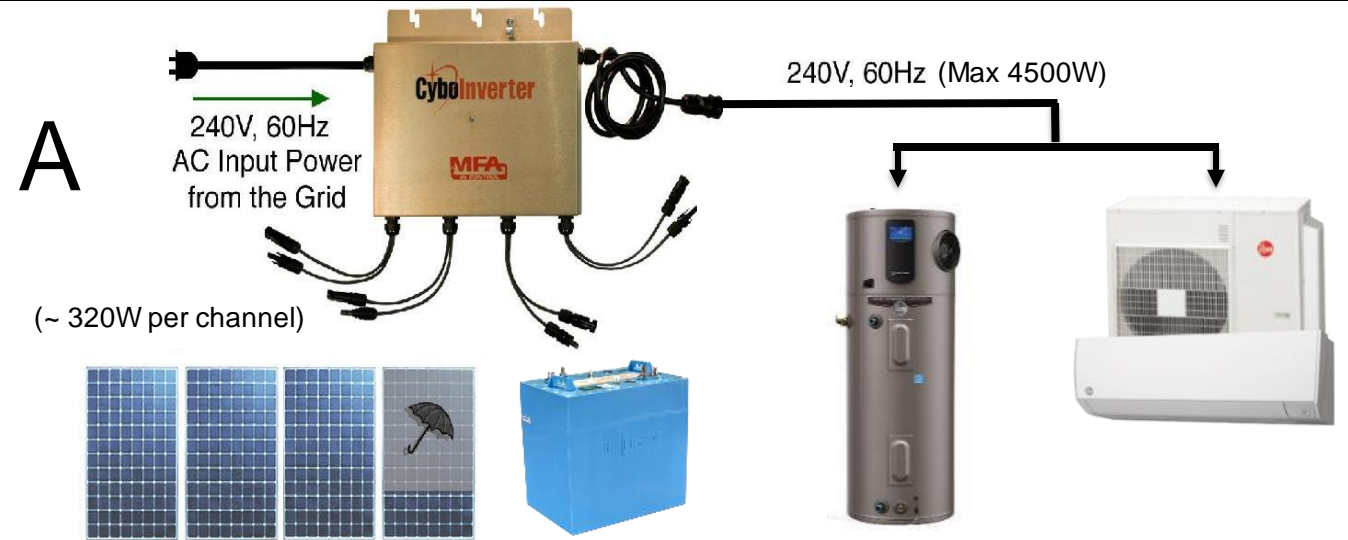


Ceiling Insulation



PV-GEMS: Pre-packaged, high efficiency, heating/cooling/water heating retrofit solution

- Retrofit involves heat pumps for water heating and space conditioning, utilizing existing space conditioning system as backup.
 - Option A: Ductless heat pump
 - Option B: Central heat pump
- PV, batteries, and Grid assisted inverters enhance the resource-use efficiency of the components by minimizing use of energy from grid.
- Can be configured so no excess energy sent to grid.
- System designed to reduce energy use, demand, and carbon; provide renewable electrification; and enable elements of resilience and grid-interactivity.



Phase 1 – Pilot System Development

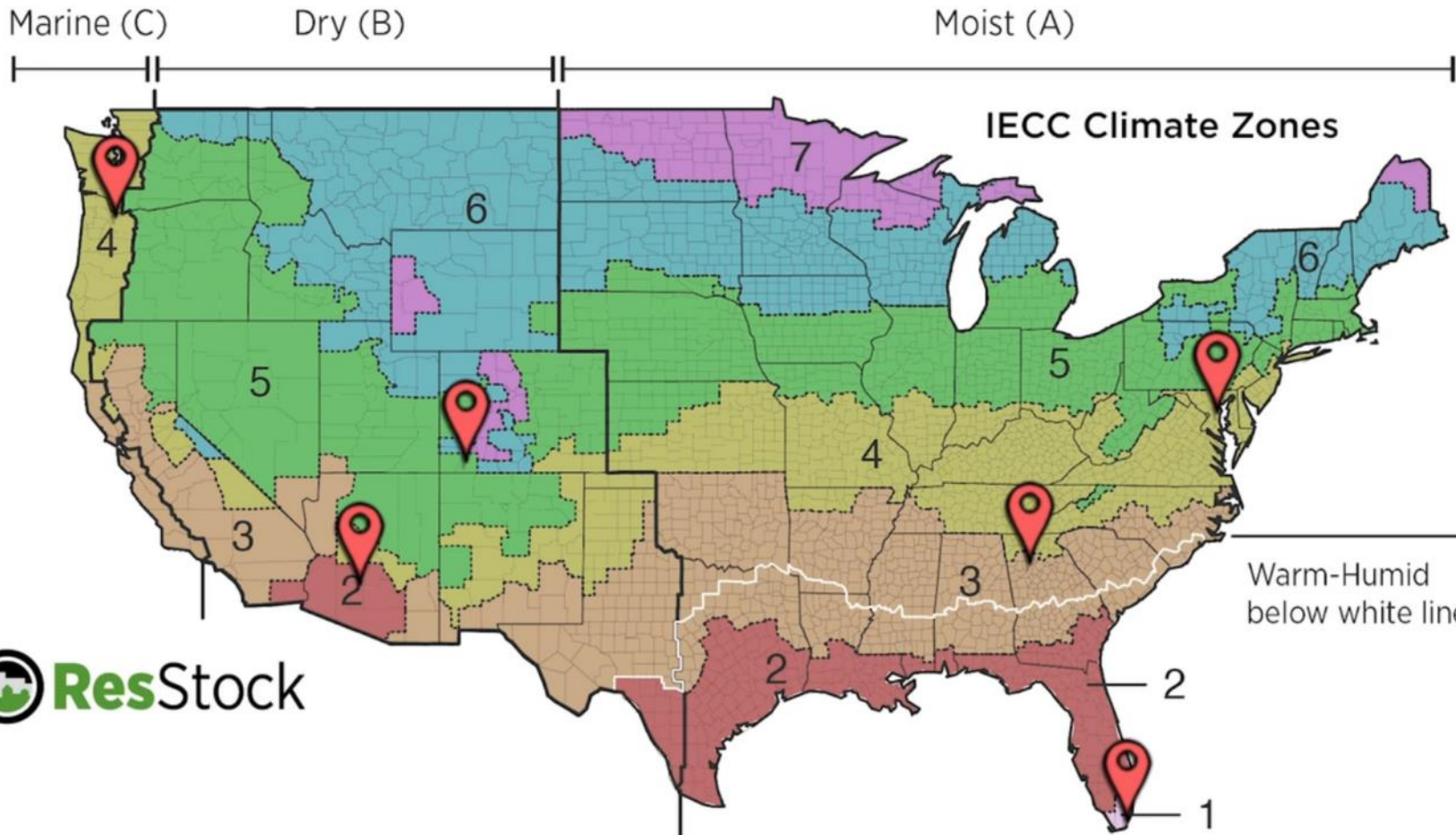
Building Science Lab



Manufactured Housing Lab



Savings Estimates - EnergyPlus Simulations Calibrated with Monitored Lab Data from Phase 1 Pilot Systems



Created multiple single-family home baselines for six cities representing CZ 1-5:

Vintage

- Pre-1990 (80s)
- Post-1990 (90s)

Central Heating System

- Electric resistance
- Heat pump
- Natural gas

Heating/Cooling/Water Heating EUI Savings Range from 50-90%

Planned Demonstration Sites (12 Total)

Climate Zone	Location	Community Name	Building Type	PV-GEMS Installation
5B, Cold/Dry	Durango, CO	Animas View	Manufactured Homes	Site Assembled
5A, Cold/Humid	Hudson, MA	Meadowbrook	Manufactured Homes	Site Assembled
2A, Hot/Humid	Pasadena, TX	Pasadena Trails	Manufactured Homes	Site Assembled
4C, Marine	Oregon	TBD	Manufactured Homes	Site Assembled
4A, Mixed/Humid	North Carolina	TBD	Single-Family Homes	Site Assembled
3A, Mixed/Humid	Georgia / South Car.	TBD	Single-Family Homes	Pre-Packaged

Two homes per location, all with 60 gal HPWH.

Ten systems with 1.5 ton MSHP supplements, 4 PV modules, 3kWh battery

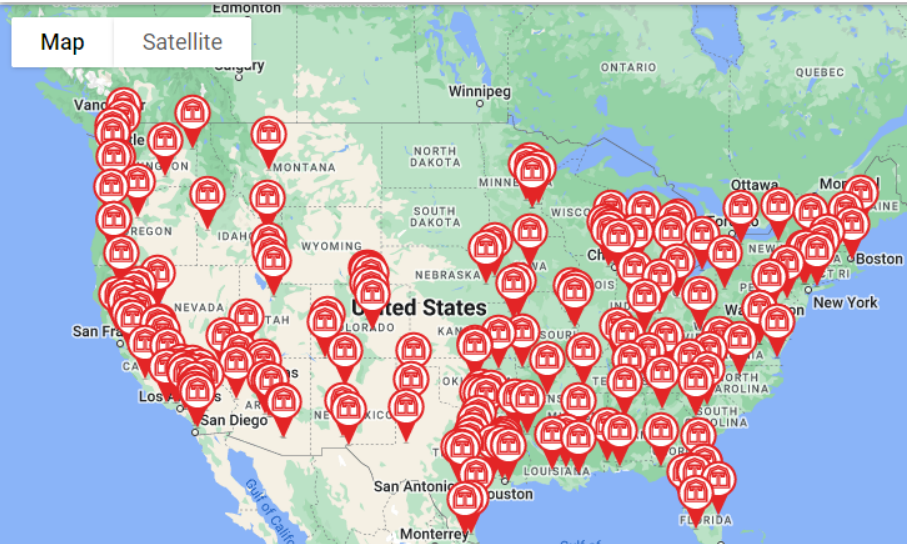
Two systems with central system upgrades, 4-8 PV modules, 3kWh battery

Current Activity – Designing Prototypes



special OFFERS Free Upgrades + 6 Months Same as Cash Financing

Premier Lean-To - 6' wide by 10' long



Additional Activities Towards Deployment at Scale

Further Technical Development

- System enclosure design.
- System controller design to maximize PV utilization and optimize battery charging/discharging.
- Optimize inverter design for targeted loads.



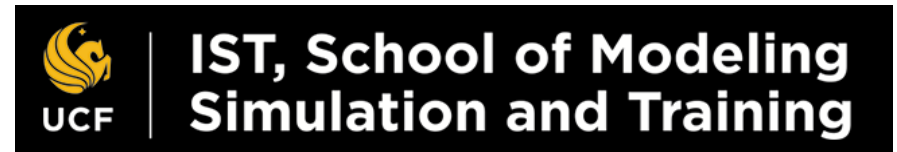
Tech to Market Planning

- Considerations: financing/incentives, manufacturing, distribution/installation, marketing/sales, etc.
- Task Force: state and local government, regional efficiency organizations, financing institutions, utilities, etc.



Sales and Installation Training

- PV-GEMS is unique and cuts across traditional silos including HVAC, solar, electrical, structural, and plumbing.
- Installation curriculum to feature video content and simulated, interactive installation scenarios.





FSEC Energy Research Center

UNIVERSITY OF CENTRAL FLORIDA

Thank You

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Link to PV-GEMS Video

<https://vimeo.com/655024096>