CT R1982A – Residential HVAC/DHW Performance and Potential Assessment

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Kevin Price,
Evergreen Economics

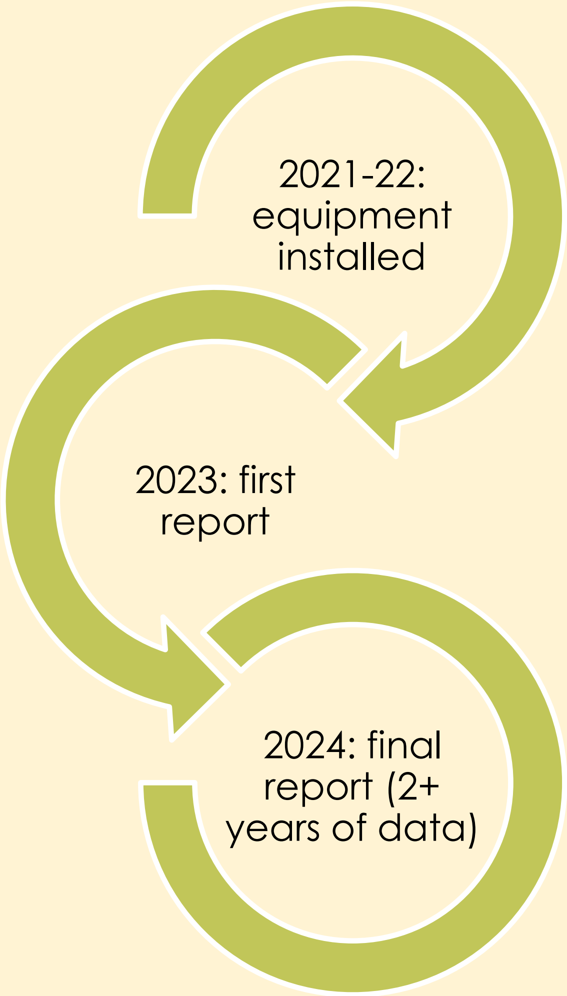
Agenda

1. Objectives and Approach
2. Findings
3. Methods

Objectives & Approach

Note About Project Scope

- Metering installations began in late 2021 and finished early 2022.
- Capturing electricity use.
- Today's presentation covers heat pump water heater savings and mini-split effective full load hours for heating.
- Additional analysis in 2024 will cover central air and ground source heat pumps.
- Coordinating with the R2246 Residential Heat Pump Study for additional analysis.



Objectives of This First Report

Support PSD updates for heat pump-based HVAC and DHW equipment

- Ductless mini-split effective full load hours
- Heat pump water heater kWh savings

Understand differences in usage / savings by inland and coastal climate zones

Assess how these technologies are used during extreme winter weather conditions

Energy Monitoring Approach

Monitored End Uses	Total			Included in Current Analysis*		
	Coastal	Inland	Overall	Coastal	Inland	Overall
HPWHs > 55 Gal	3	10	13	2	8	**10**
HPWHs 55 Gal and Below	27	53	80	19	45	**64**
Ductless Air Source Heat Pumps (only/primary heat source)	17	23	40	8	12	**20**
Ductless Air Source Heat Pumps (supplemental heat source)	24	23	47	16	20	36
Ducted Heat Pumps (ASHP and GSHP)	9	24	33	0	0	0

*End uses not included in the current analysis had insufficient months of data

Findings

PSD Assumption Updates

HPWH tank volume matters a lot (different baselines)

Objective	Parameter	Updated Estimates	Existing PSD Estimates*
Estimate HPWH energy savings (kWh)	kWh Savings for HPWHs > 55 Gal (n=10)	**731 kWh** (95% CI: 503-968)	197 kWh
	kWh Savings for 55 Gal or Below (n=64)	**1,723 kWh** (95% CI: 1,554-1,901)	1,818 kWh
Estimate ductless mini-split heating effective full load hours ($EFLH_h$) in full displacement, retrofit scenarios.	Ductless Heat Pump Heating EFLH (n=20)	**1,099** (95% CI: 836-1,350)	535**

*PSD does not provide a confidence interval for these estimates.
**Existing PSD estimate does not differentiate between full or partial displacement scenarios; updated PSD estimate is for full displacement scenarios.

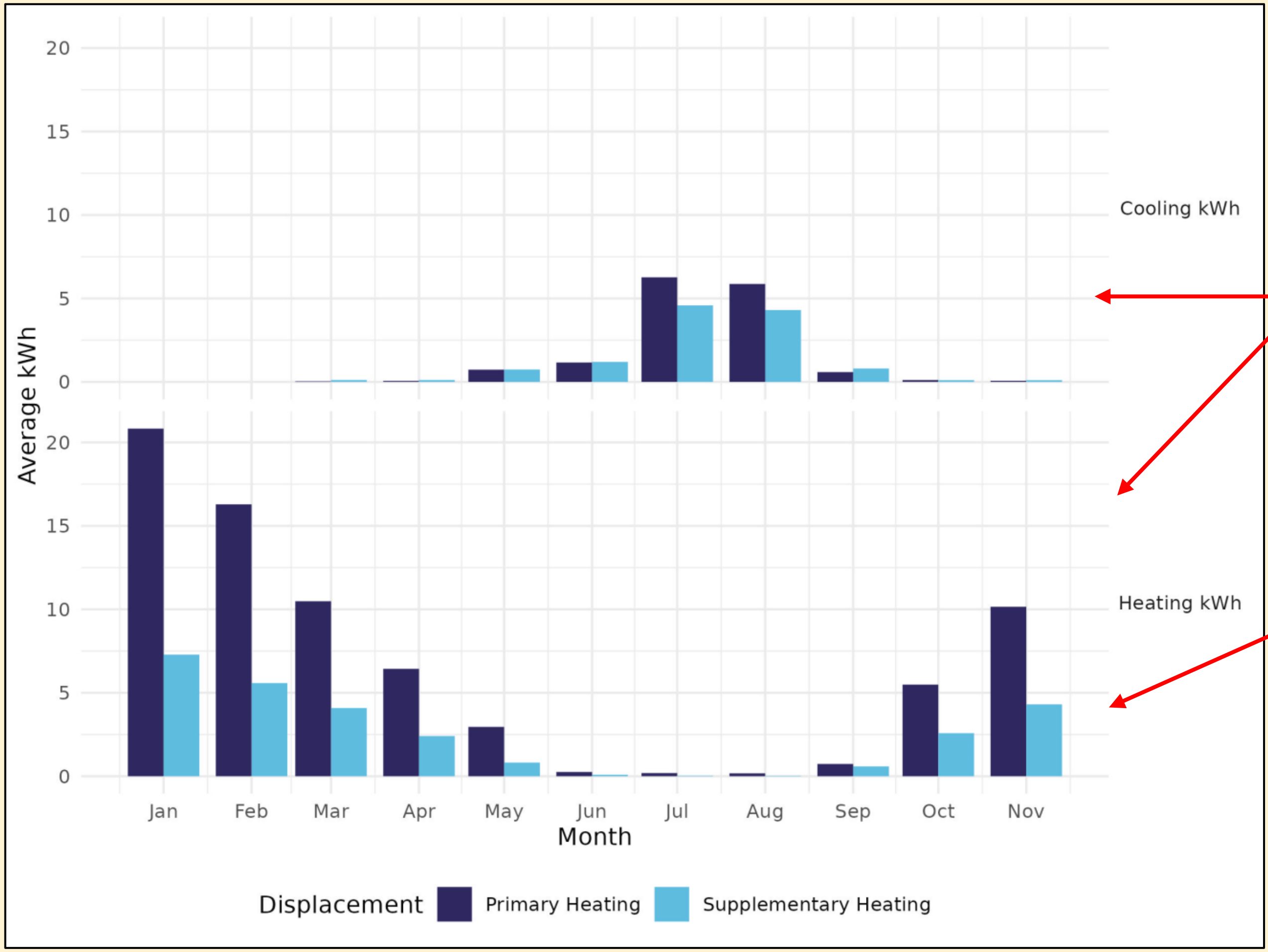
HPWH Savings by Tier and Climate Zone

HPWHs in inland areas tend to save slightly more energy.

Smaller HPWHs save more energy than larger HPWHs.

This is mainly due to baseline assumptions.

Ductless Mini-Split Usage



Mini-splits use more electricity for heating than cooling.

The primary heating systems use a lot more electricity for heating than the supplementary heating systems (as expected).

Ductless Mini-Split Heating EFLH

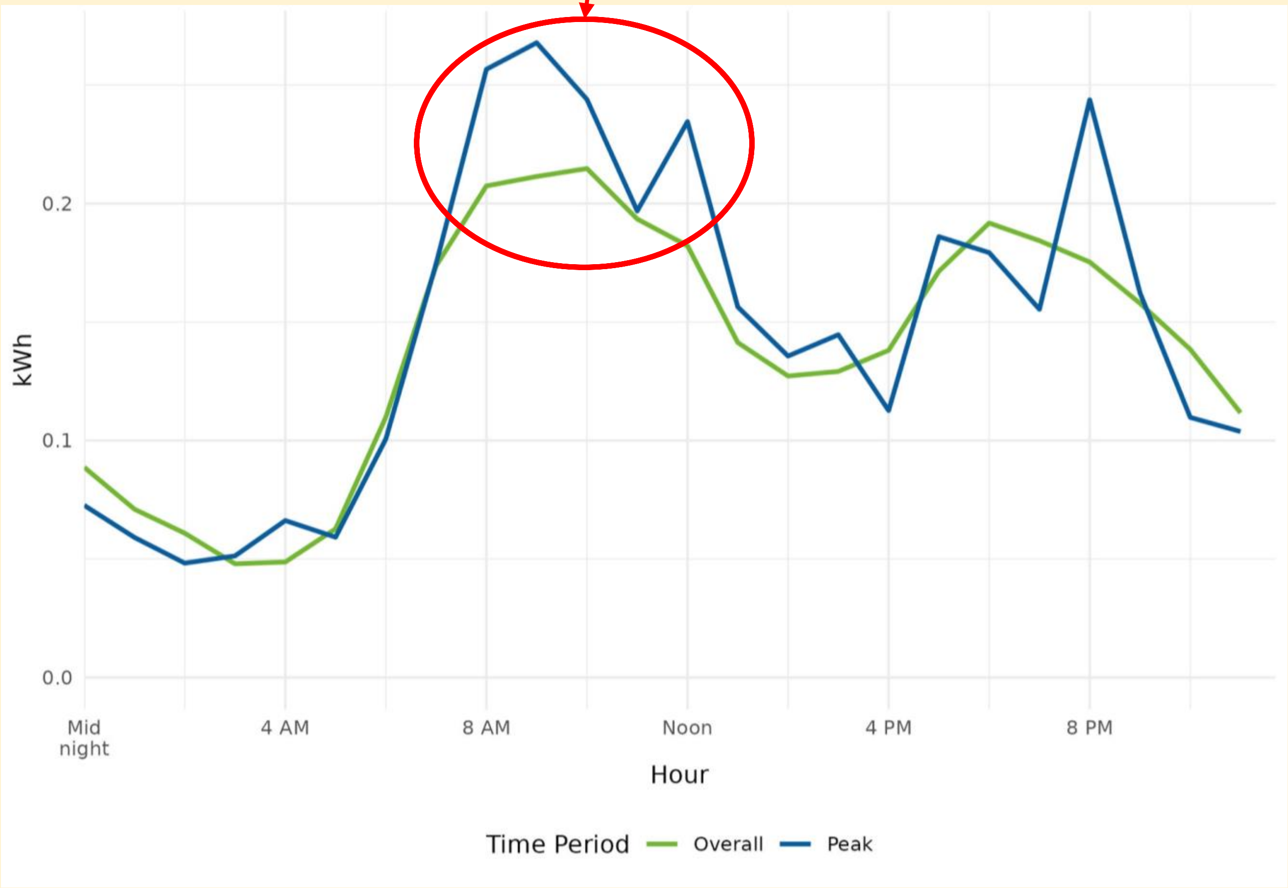
Important to differentiate primary vs supplemental in the PSD.

Displacement	Coastal (n=24)	Inland (n=32)	Average	Existing PSD Estimate
Only/Primary Heating System (n=20)	**1,124** (95% CI: 796-1,400)	**1,081** (95% CI: 758-1,464)	**1,099** (95% CI: 863-1,350)	
Supplemental Heating System (n=36)	555 (95% CI: 287-857)	773 (95% CI: 459-1,110)	676 (95% CI: 459-911)	
Overall (n=56)	745 (95% CI: 508-989)	889 (95% CI: 652-1,139)	827 (95% CI: 654-1,008)	535*

*PSD does not provide a confidence interval for this estimate.

HPWH Usage on Very Cold Days

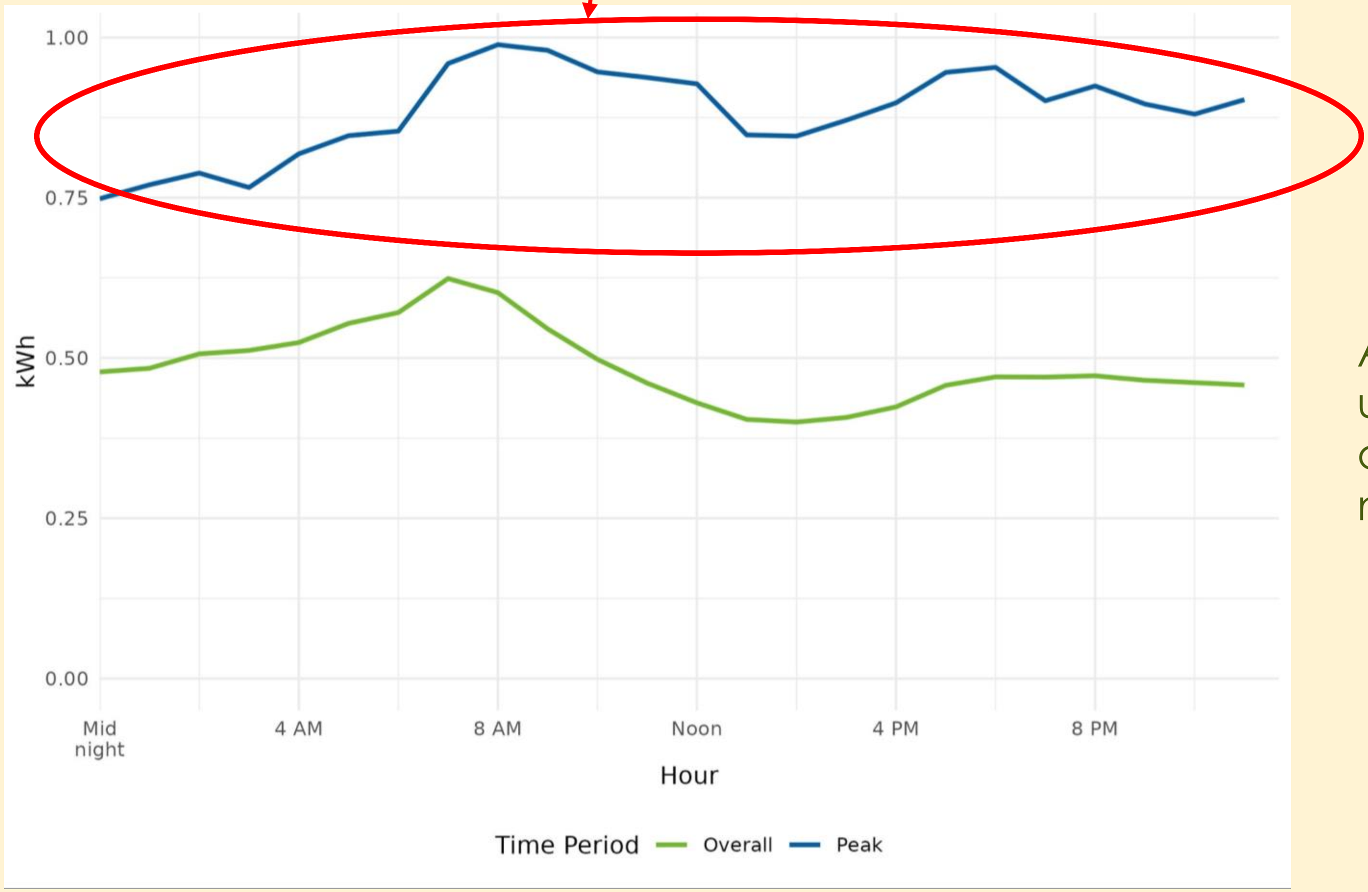
Slightly higher usage in the morning peak.



But mainly very similar load shapes during very cold days compared to other winter days.

Ductless Mini-Split Usage on Very Cold Days

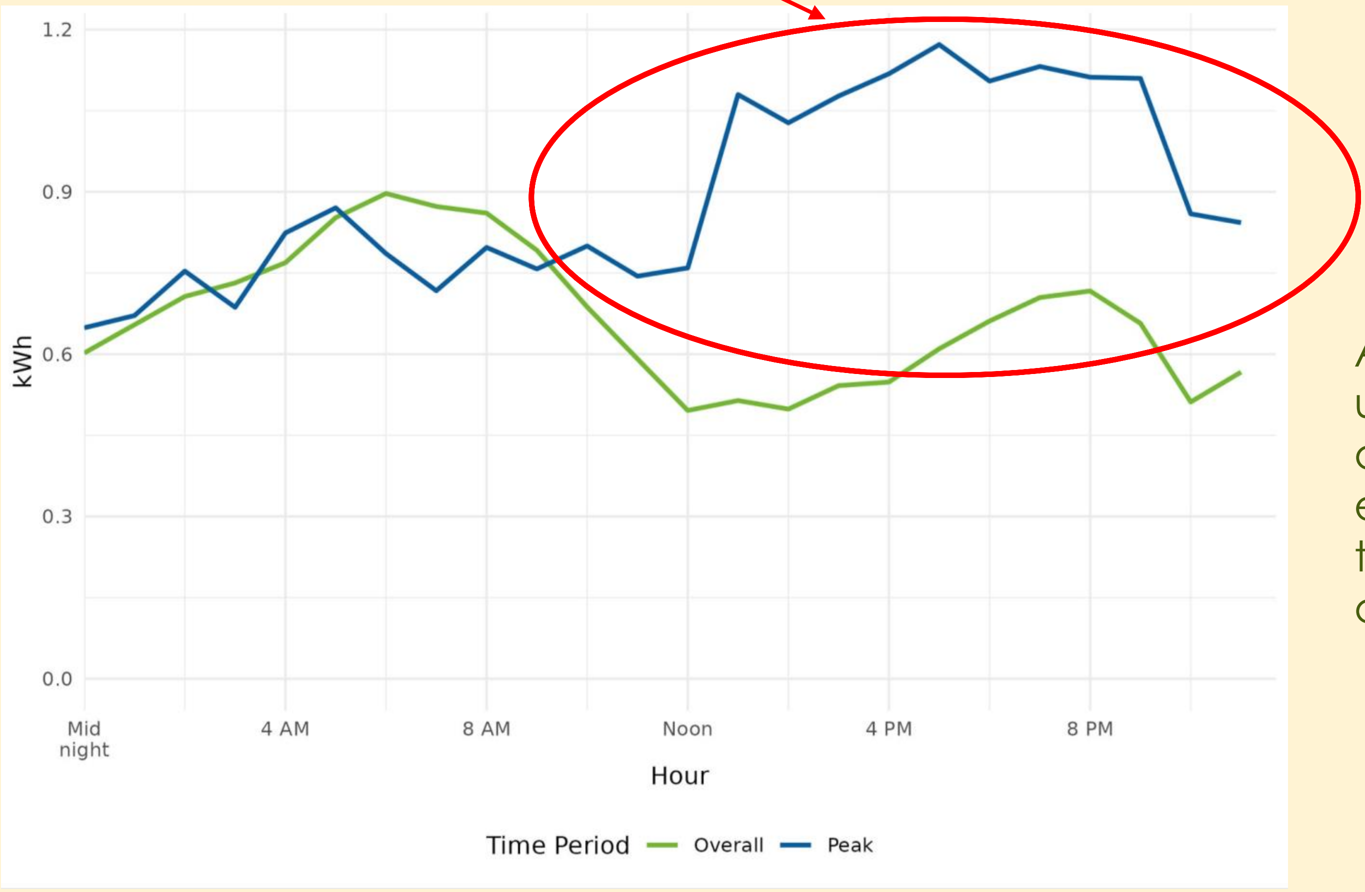
Increased usage at all hours of the day.



Almost DOUBLE the usage on very cold days compared to normal winter day.s

Central ASHP Usage on Very Cold Days

Increased afternoon and evening usage.



Almost DOUBLE the usage in the afternoons and evenings compared to on normal winter days.

Methods

HPWH Savings Method

Step 1: Determine HPWH operation mode for every minute observation

Step 2: Calculate annual kWh in each mode

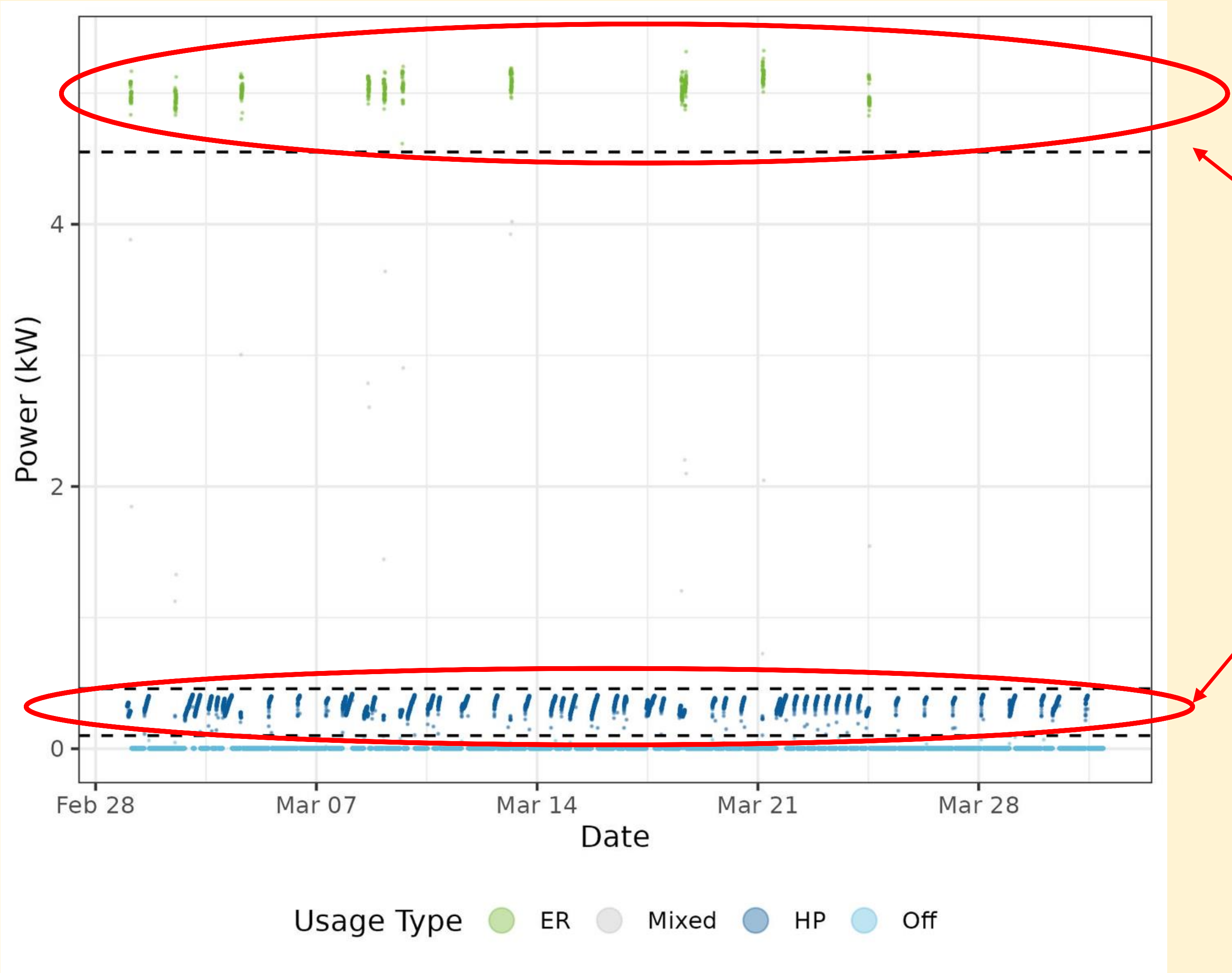
Step 3: Calculate an efficiency factor based on observed and baseline UEFs

Step 4: Apply the efficiency factor to observations in heat pump mode to recalculate heat pump mode usage with baseline efficiencies

Step 5: Calculate baseline kWh by combining recalculated heat pump mode usage and electric resistance mode usage

Step 6: Calculate annual savings by subtracting observed kWh from estimated baseline kWh

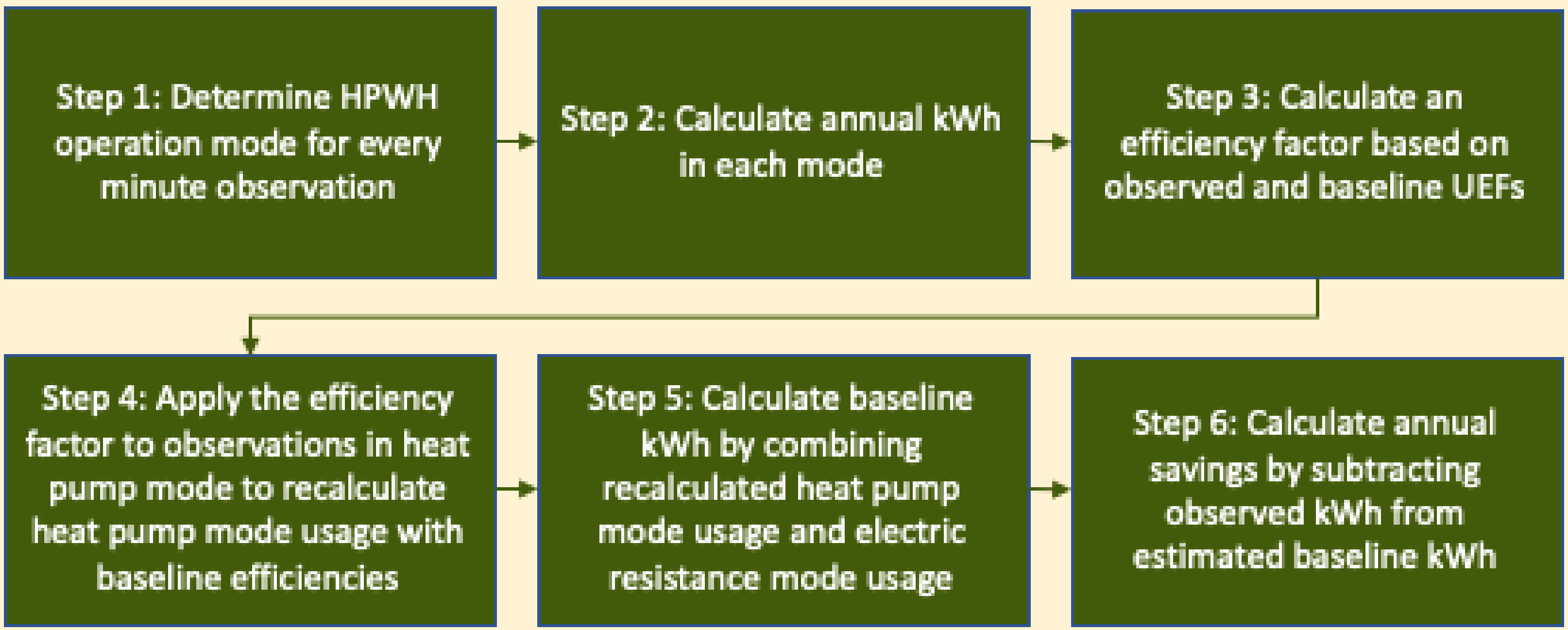
Step 1. HPWH Operation Mode



Electric Resistance Element is "On".

Heat Pump Compressor is "On".

HPWH Savings Method (step 2-6)



Ductless Mini-Split EFLH Method

- Electricity usage and manufacturer specs, utilizing method from the PSD.

Equation 4: Ductless Air Source Heat Pump Energy Usage Calculations

$$kWh\ Heating_{observed} = Heating\ Capacity_{BTUs} \times \left(\frac{1}{HSPF}\right) \times EFLH_h \times \frac{1\ kW}{1{,}000\ W}$$

$$kWh\ Cooling_{observed} = Cooling\ Capacity_{BTUs} \times \left(\frac{1}{SEER}\right) \times EFLH_c \times \frac{1\ kW}{1{,}000\ W}$$

- Heating and cooling **kWh** were observed for each ductless mini-split, so we reordered the equations.

Ductless Mini-Split EFLH Method

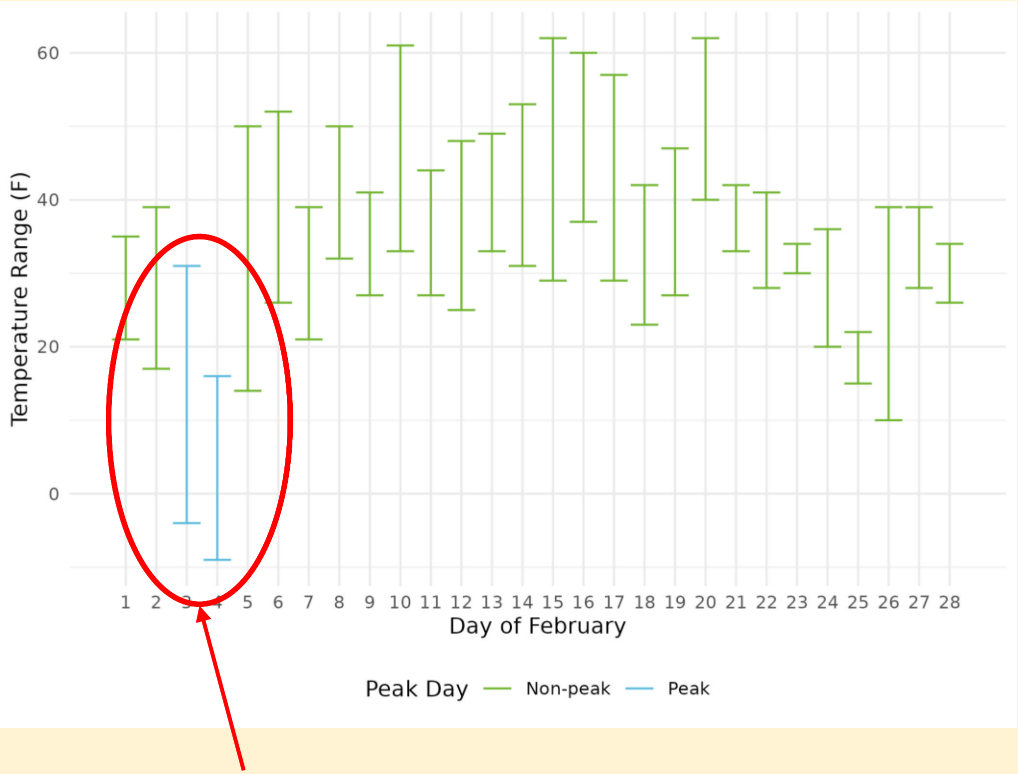
- EFLH calculated by reordering the equations and inputting the metered kWh and HSPF or SEER.
- kWh values were normalized to typical weather (TMY3).

Equation 5: Calculation of Heating EFLH and Cooling EFLH

$$EFLH_h = \left(kWh\ Heating_{observed} \times 1{,}000 \frac{W}{kW} \times HSPF\right) \div Heating\ Capacity_{BTUs}$$

$$EFLH_c = \left(kWh\ Cooling_{observed} \times 1{,}000 \frac{W}{kW} \times SEER\right) \div Cooling\ Capacity_{BTUs}$$

Extreme Cold Day Usage Method



Step 1. Selected two very cold days in February to compare to the entire month.

Step 2. Calculated the weighted average load shapes based on average hourly kWh for each end use, once for the cold days and again for the entire month.

Q&A

Kevin Price, Evergreen Economics

price@evergreenecon.com