



Impact Evaluation of the Heat Pump Water Heater and Electronically Commutated Motor Circulator Pump Measures

Summary of Methods and Findings | June 2026

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BACKGROUND

WHY DO WE DO EVALUATIONS?

- Independent evaluation of Trust programs are required by Maine law
 - The Trust shall
 - arrange for an **independent evaluation**
 - of each **major program** implemented under this section
 - at least **once every 5 years**
 - include the results in the annual report submitted to the PUC and Legislature
 - The evaluation must
 - Include accounting audit of the program
 - Include evaluation of program effectiveness in meeting goals
 - Be conducted by a competent professional with expertise in energy efficiency matters
 - Chapter 35-A, Section 10104 of Maine Statutes
- Assess past program performance
- Inform future savings estimates and program design changes

EVALUATION OBJECTIVES

- Estimate the gross energy savings (kWh), summer and winter demand reduction (kW), and fossil fuel impacts (MMBtu) for heat pump water heaters and electronically commutated motor circulator pumps
 - Conduct detailed measurement and verification on a sample of projects
 - Calculate a “realization rate” equal to the ratio of evaluated savings to claimed savings
 - Extrapolate the findings from the sample to the population
- Recommend changes to the Technical Reference Manual (TRM) and factor schedule in effRT
- Estimate the net-to-gross ratio (NTGR)
- Conduct a benefit/cost analysis using the evaluated savings

EVALUATED MEASURES

Heat Pump Water Heater (HPWH)

- Evaluation period: January 2023 – June 2024
- Three program pathways: (1) Instant – Distributor, (2) Instant – Retail, and (3) Mail-in – Retail
- Rebates are only available for ENERGY STAR® certified HPWHs
- Baseline efficiency is a blend of pre-existing water heaters and new, code-minimum water heaters



Electronically Commutated Motor Circulator Pump (ECMCP)

- Evaluation period: FY2023 (July 2022 – June 2023)
- Contractors buy the ECMCPs at a discounted price and pass an instant discount to participants – no paperwork or rebate checks
- The baseline pump motor is a shaded pole motor



EVALUATION ACTIVITIES & FINDINGS

EVALUATION ACTIVITIES

- HPWH evaluation activities included:
 - **Web-based participant survey** with questions about the prior water heater (condition and fuel) and motivations behind installing a HPWH
 - **Pre/post AMI analysis** of a subset of survey participants
 - **Metering study** for a subset of survey participants
 - **Phone interviews** with five primary HPWH distributors
- ECMCP evaluation activities included:
 - **Price elasticity analysis** to understand how variations in incentive levels affect sales volume
 - **Metering study** including 41 program-supported ECMCPs in a sample of 22 households
 - **Phone interviews** with five ECMCP/HPWH distributors and fifteen participating contractors



EVALUATION TOPIC MATRIX

Evaluation Topic		Pre/Post AMI Analysis	Metering	Surveys / Interviews	Price Elasticity Modeling
Heat Pump Water Heaters	Annual energy impact	✓	✓	✓	
	Summer and winter peak impacts	✓	✓	✓	
	Energy period factors	✓	✓	✓	
	Peak coincidence factors	✓	✓	✓	
	Hourly load shape	✓	✓	✓	
	In-service rate			✓	
	Net-to-gross ratio			✓	
	Determine the appropriate baseline			✓	
ECM Circulator Pumps	Annual energy impact		✓		
	Summer and winter peak impacts		✓		
	Energy period factors		✓		
	Peak coincidence factors		✓		
	In-service rate			✓	
	Net-to-gross ratio			✓	✓

KEY FINDINGS – HPWH ANALYSIS

Topic	Findings
DHW baseline fuel	We found that 54% of participants had electric water heaters before installing the program-supported HPWH. Of the 46% with non-electric baselines, most used oil. Often, the replaced oil-fired system was integrated with the home's space heating.
Annual energy impact	Homes with electric baselines: 1,298 kWh of annual energy savings Homes with non-electric baselines: 862 kWh of additional annual electric use The average "all-in" MMBtu impact (inclusive of all energy saved or added regardless of fuel type) was 5.44 MMBtu/y.
Program impact on customer-level purchasing decisions	Overall, we estimate the freeridership rate is 15.8% and the NTGR is 84.2%.
Program impact on distributor-level stocking, sales, and awareness	Distributors were asked to rate how influential the incentive program has been in reaching the current level of awareness and adoption of HPWHs among Maine contractors. On a scale from 0 (not influential) to 10 (extremely influential), the average rating was 9.8.
Customer satisfaction	92% of survey respondents reported that they probably would, definitely would, or already have recommended a HPWH to family, friends, or neighbors.
Cost effectiveness	In the prospective gross scenario, we estimate the measure returns \$1.94 of benefits per \$1 of cost.



KEY FINDINGS – ECMCP ANALYSIS

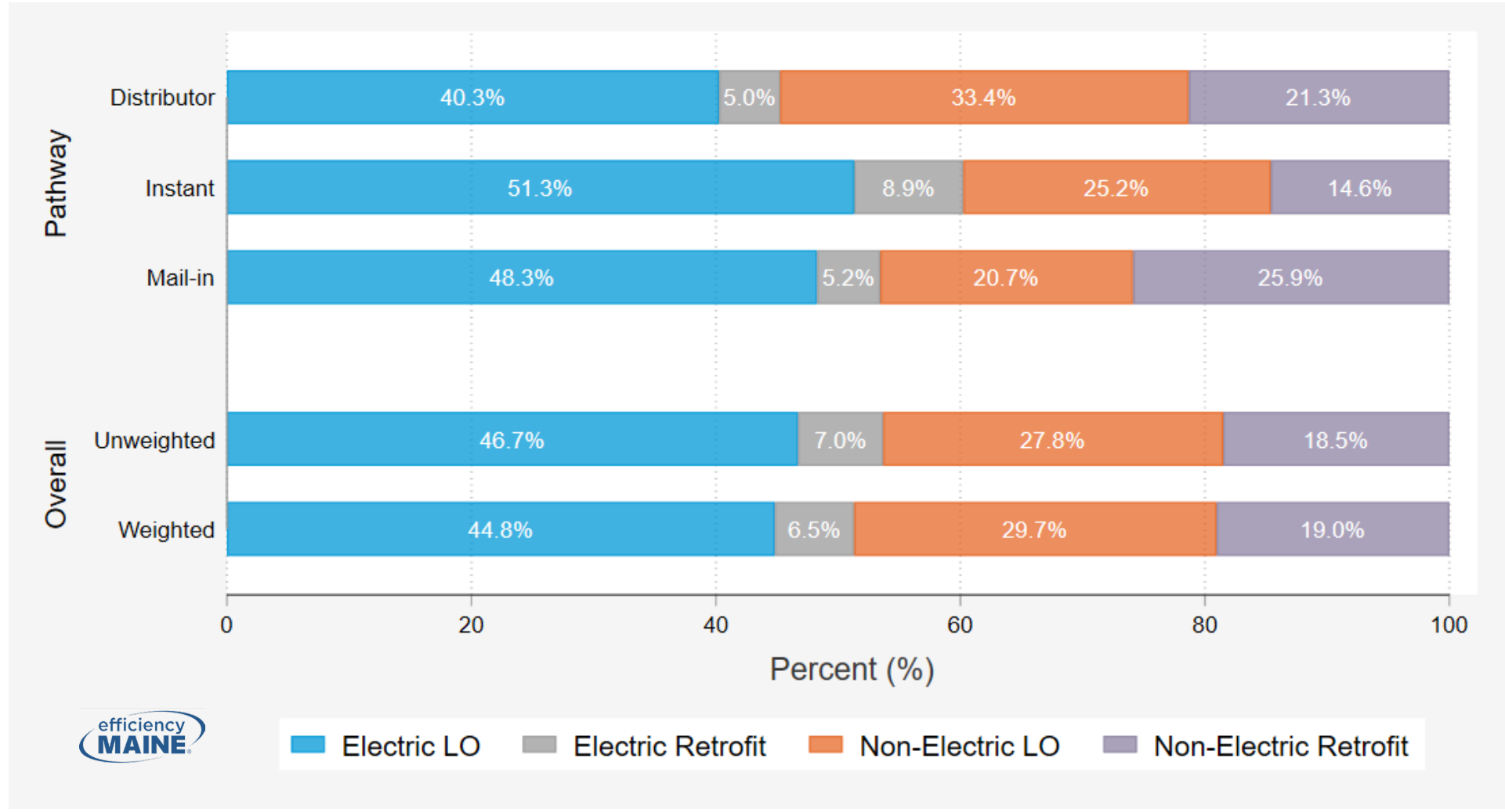
Topic	Findings
Annual energy impact of an ECMCP	In a residential application, ECMCPs save 47 kWh annually relative to a baseline circulation pump with a shaded pole motor
Typical application	Most ECMCPs serve as supply or return pumps in a hydronic heating system, but a few program-supported ECMCPs in our metering sample supplied heat exchangers in a DHW system or DHW in addition to space heating. As a result, we estimate non-zero summer peak demand savings.
Price elasticity / NTG	Based on our price elasticity analysis, our estimated NTGR for ECM circulator pumps is 79.5%.
Program impact on ECMCP stocking and sales	Four out of five interviewed distributors indicated stocking and sales of ECM pumps have increased because of the incentives. 60% of the interviewed contractors indicated that the incentives have influenced their stocking and sales of ECM pumps.
Program impact on ECMCP awareness and adoption	Distributors were asked to rate how influential the incentive program has been in reaching the current level of awareness and adoption of ECM pumps among Maine contractors. On a scale from 0 (not influential) to 10 (extremely influential), the average rating was 8.2.
Cost effectiveness	In the prospective gross scenario, we estimate the measure returns \$1.35 of benefits per \$1 of cost.



HPWH PARTICIPANT SURVEY

- Rebate recipients with valid email addresses were invited to take a web-based survey with questions about their prior domestic hot water system, their motivation to purchase a HPWH, and details about their HPWH (install location, operational setting, etc.)
 - Water heating baseline fuels collected through the survey informed the AMI analysis and TRM recommendations
 - 1,002 total responses
- Key findings:
 - Overall NTGR of 84.2%
 - 48% of the respondents also installed a heat pump within the last three years. The transition of space heating from oil to electric is correlated with HPWH adoption since the domestic hot water in many Maine homes is served by the boiler

HPWH PARTICIPANT SURVEY – BASELINE ASSESSMENT

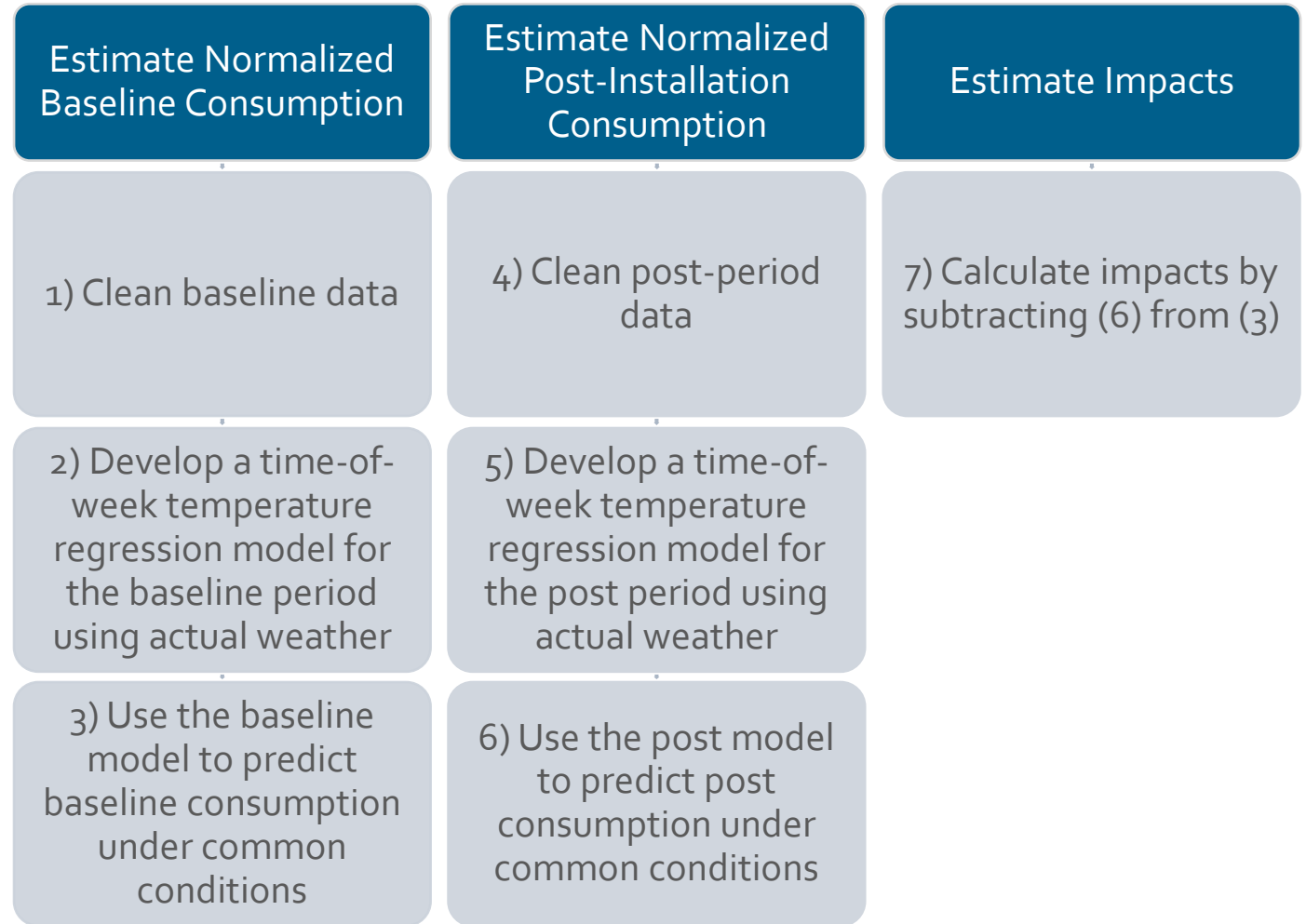


■ Electric LO
 ■ Electric Retrofit
 ■ Non-Electric LO
 ■ Non-Electric Retrofit



PRE/POST AMI ANALYSIS

- In a pre/post AMI analysis, electric consumption is compared across the pre-HPWH and post-HPWH periods
 - See steps to the right
- 252 homes were included in the analysis. We developed separate regression models for each home
 - Survey responses were used to identify the baseline water heating fuel for each home
- Key outputs: weather-normalized annual impacts and 8760 load profiles



PRE/POST AMI ANALYSIS RESULTS

- Pre-existing Electric and Non-Electric scenarios must be handled separately.
- Pre-existing Electric
 - Prior water heater used electricity
 - Impact of HPWH is a reduction (positive savings) in electricity use
 - Pre/Post AMI fully captures energy and demand impacts
- Pre-existing Non-Electric Baseline (and new construction)
 - Prior water heater used oil, kerosene, propane, or natural gas with negligible electricity use
 - Impact of HPWH is an increase (negative savings) in electricity use
 - Pre/Post AMI only captures energy and demand of the HPWH, fuel reduction is not captured

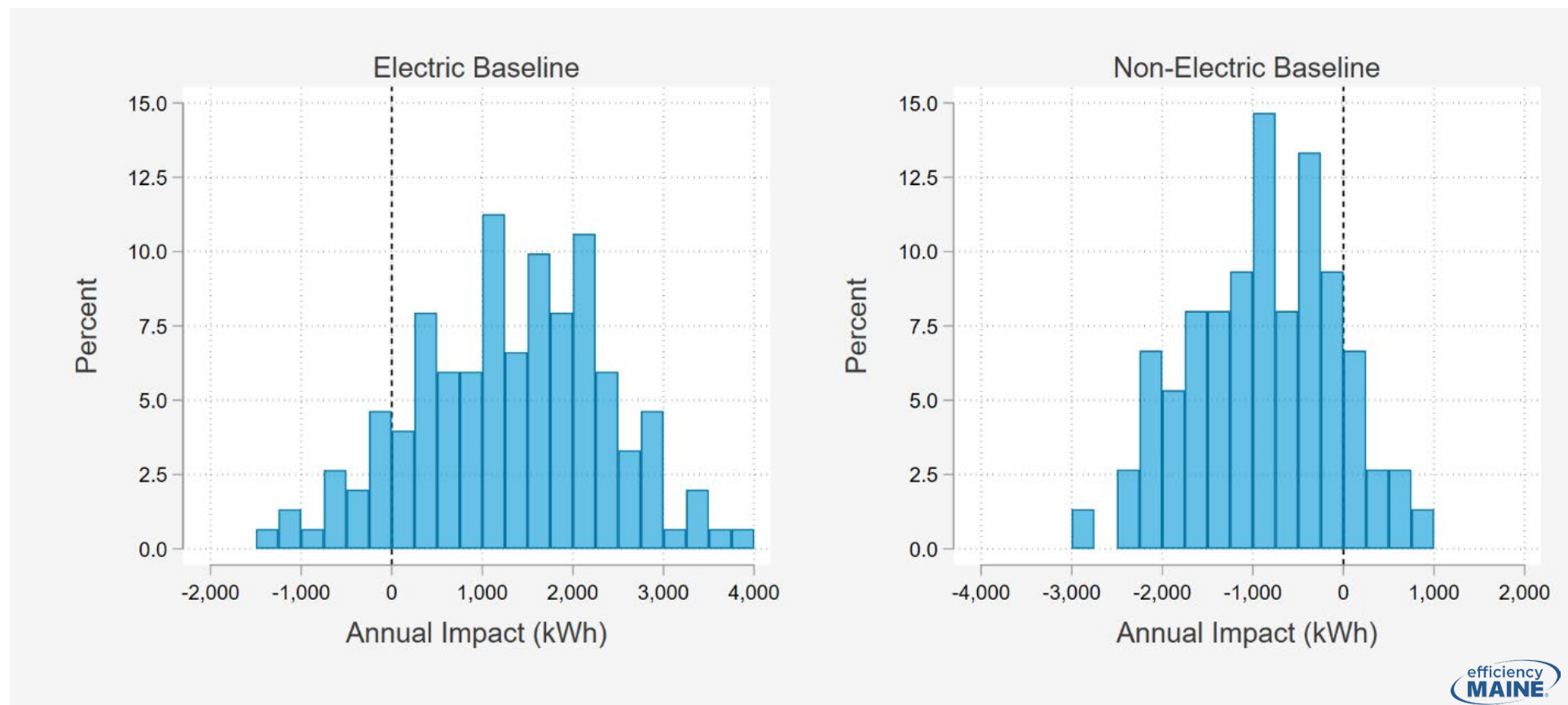
PRE/POST AMI ANALYSIS RESULTS

■ Distribution of annual impacts across homes in our sample

➤ Differences are driven by

- Domestic hot water use
 - volume
 - draw pattern
- HPWH mode of operation
- Ambient conditions
- Confounding factors
 - Occupancy changes
 - Unscreened electric load modifiers

Impact = Pre HPWH Electric Use –
Post HPWH Electric Use



PRE/POST AMI ANALYSIS RESULTS – BLENDING BASELINES

■ Electric Energy and Demand Impacts

- 54% Electric Baseline
- 46% Non-Electric Baseline

Baseline Fuel	Impact Estimate (kWh/yr)	Relative Precision at 80% Confidence	Share of Blended Baseline
Electric	1,298	8.4%	53.6%
Non-Electric	-862	13.6%	46.4%
Blended Baseline	297	10.8%	---

Season	Baseline Fuel	Peak Demand Impact (kW)
Summer	Electric	0.118
	Non-Electric	-0.040
	Blended Baseline	0.045
Winter	Electric	0.269
	Non-Electric	-0.130
	Blended Baseline	0.084

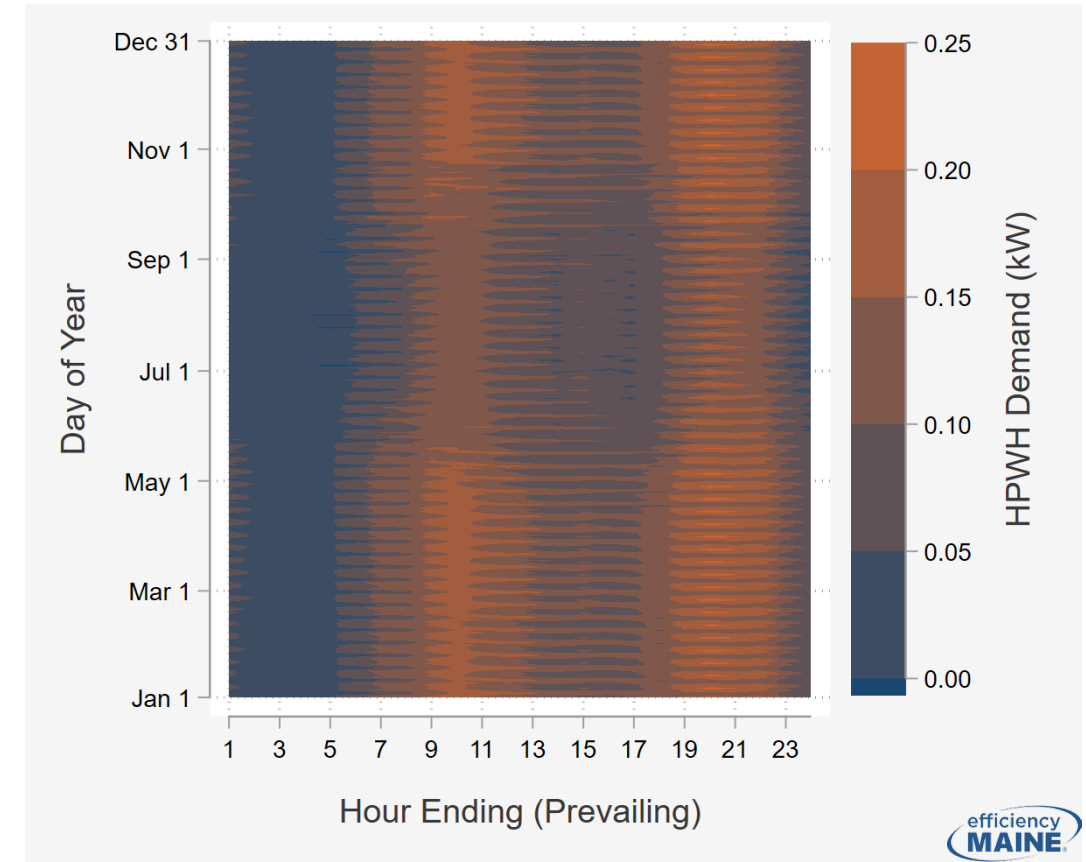
HPWH METERING STUDY

- A sample of 20 program-supported HPWHs were metered over a 9-month period spanning February 2025 to October 2025. The combined metering system covered:
 - Water flow
 - Water temperature (supply and return)
 - Electric use
- Used regression modeling to develop weather-normalized estimates of annual electric use, annual gallons of water used, and annual heat delivered
- Key outputs: coefficient of performance (COP) and expected annual water heating load for a theoretical electric water heater with a COP of 1.0 (denoted $\text{kWh}/y_{\text{HWL}}$)



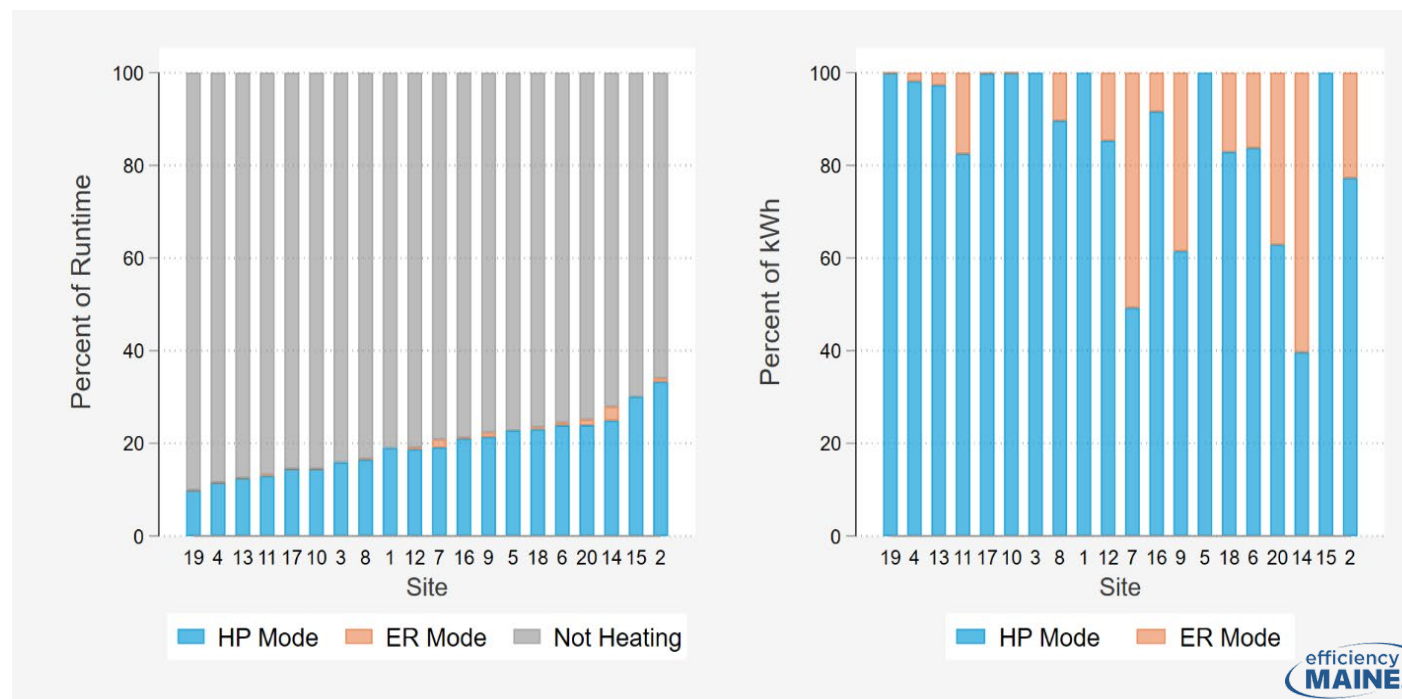
HPWH METERING STUDY RESULTS

- 855 kWh/year, on average
- 28 gallons/day, on average
- Figure to the right shows an 8760 heat map
 - Pockets of orange indicate times of the year with higher HPWH loads
- Summer loads are slightly smaller than non-summer loads. This is likely a function of:
 - Cooler inlet water temperatures outside of the summer
 - Greater standby losses when indoor temperatures are lower
 - The heat pump water heater runs more efficiently in a warm space







HPWH METERING STUDY RESULTS

- The average COP was 1.8 compared to an average UEF of 3.6
- The delta between the two factors is attributable to:
 - **Operational mode.** Most of the HPWHs operated in a hybrid mode that blends HP mode and electric resistance mode. Efficiency is poor in ER mode.
 - **Low usage.** HPWHs in homes with lower hot water loads have greater standby losses relative to useful work performed than HPWHs in homes with higher hot water loads. These losses reduce the overall efficiency of the HPWH





HPWH METERING STUDY RESULTS

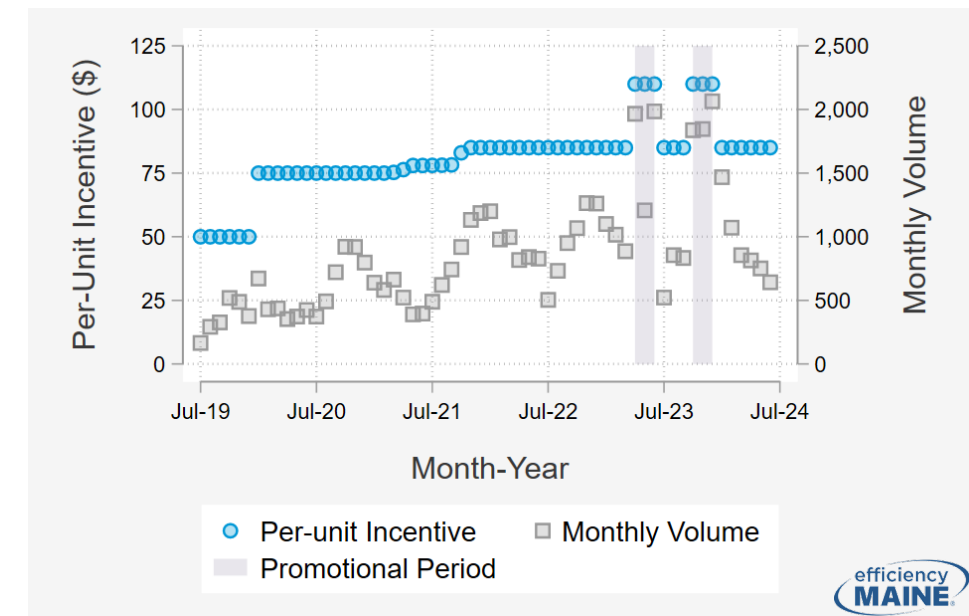
Impact Factor	Definition	Discussion
 kWh/y_{HWL}	Annual hot water load	Prior HPWH evaluation + 2015 Residential Energy Consumption Survey = 2,821 kWh. Results from this metering study = 1,534 kWh
 EAF_{EE}	Ratio of field-based measurements of HPWH efficiency to rated HPWH efficiency	Prior evaluation = 0.88 Current evaluation = 0.50 Drivers: hybrid mode and low water use (higher standby losses)
 EAF_{Base}	Ratio of in-situ efficiency and rated efficiency	Prior evaluation = 1 (de facto) Current evaluation = 0.75 Driver: low water use (higher standby losses)
 Decision type	“Decision type” refers to whether the HPWH replaced a functioning water heater (“retrofit”) or not (“lost opportunity”)	Prior evaluation = 19% retrofit and 81% lost opportunity Results from this customer survey = 13/87 electric baseline (increased savings); 40/60 non-electric baseline (increased electrification loads/negative savings)

HPWH METERING STUDY RESULTS

- Realized in-situ efficiency and hot water load were primary realization rate drivers for the HPWH evaluation
- The efficiency adjustment factor for HPWHs (EAF_{EE}) is the ratio of field-based measurements of HPWH efficiency to rated HPWH efficiency. The prior evaluation found an EAF of 0.88, while we found an EAF of 0.50.
 - The prior slide covered the drivers of the low EAF
 - Baseline storage water heaters experience standby losses just like HPWHs do, so we recommend adding an EAF_{Base} term to the TRM algorithms
- kWh/y_{HWL} represents the energy required to serve the annual hot water load (HWL). The current TRM assumption of 2,821 kWh is drawn from the prior HPWH evaluation and based on the 2015 Residential Energy Consumption Survey. Our evaluated value of 1,534 kWh is based on metering study results.

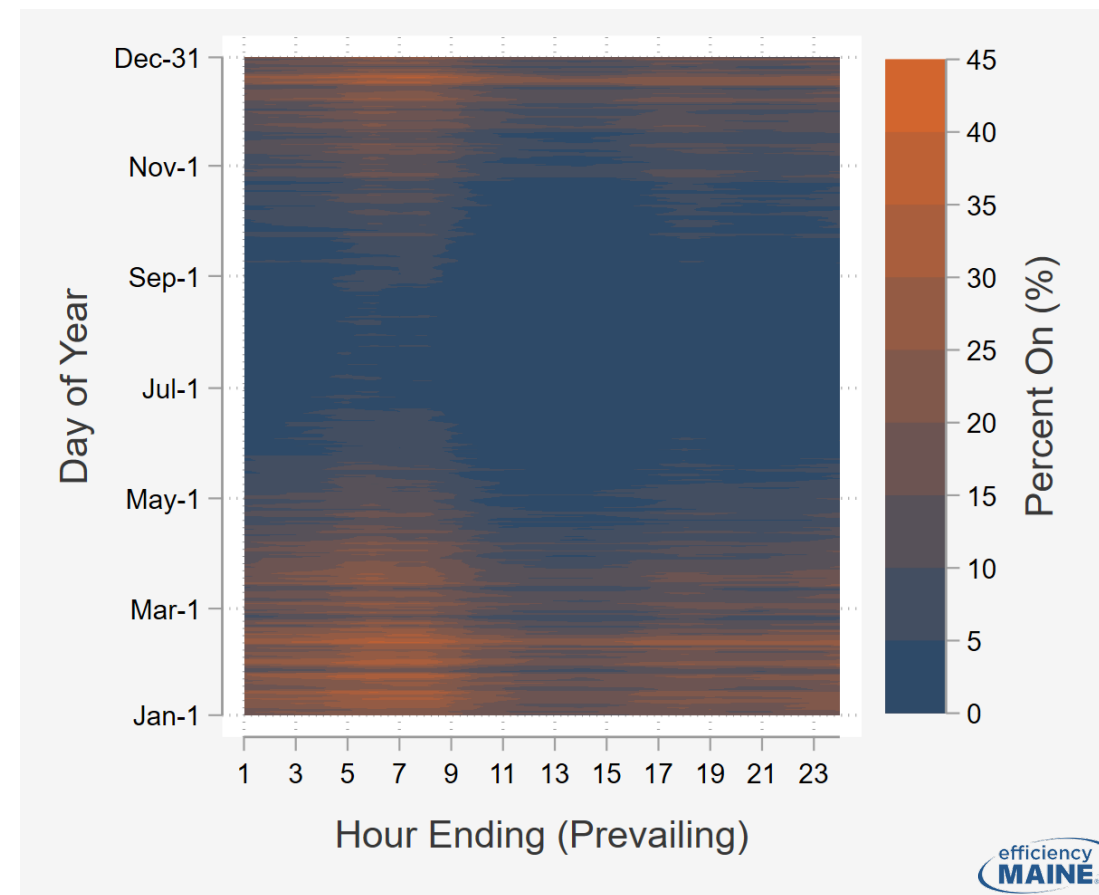
ECMCP PRICE ELASTICITY ANALYSIS

- The goal of a price elasticity analysis is to understand how variations in incentive level affect sales volume. Outputs from this analysis established the net-to-gross ratio for ECMCPs
- We used five years of rebate data for the analysis
 - Figure to the right shows the number of pumps sold and the average incentive level during each month in the analysis window
 - Our analysis controlled for retail prices rising over time due to inflation, seasonal effects on ECMCP purchases, the dollar value of the paperwork stipend fee over time, and increasing ECMCP adoption over time
- Key findings:
 - ECMCP sales are highly responsive to discounts, and sales volume spikes when the ECMCP has a lower upfront cost than the standard efficiency alternative
 - Approximately 80% of circulator pump purchases would have been the lower cost standard efficiency option absent program discounts



ECMCP METERING STUDY

- We metered a sample of 41 program-supported ECM circulator pumps in 22 Maine homes
- The metering period varied by house but generally ran from November 2024 through March 2025
- Most of the metered pumps served as supply or return pumps in a hydronic heating system, but a few served a DHW system or DHW in addition to space heating
- Figure to the right shows an 8760 heat map of ECMCP runtime



ECMCP METERING STUDY RESULTS

- Key realization rate drivers include:
 - **Hours of use.** We calculated an average annual hours of use value of 812. The prior TRM assumption of 1,374 hours was adapted from the 2016 Efficiency Vermont TRM
 - **ΔkW_{max} .** Prior assumptions regarding efficient and baseline wattage were drawn from the 2016 Efficiency Vermont TRM (14.4 Watts and 87.7 Watts, respectively). Evaluated values were based on ECMCP metering data and spot amp and power readings taken from non-ECM pumps while in the field
 - **CF_w .** Our weather-normalized estimate of 17.9% is based on predicted pump runtime during the ISO-NE winter peak period. The prior TRM assumption of 49.5% was a ratio of the average heating degrees during winter on peak hours to maximum heating degrees using a population-weighted TMY weather profile

Impact Factor	Evaluated Value
Watts _{Base}	78.2
Watts _{EE}	20.1
CF_w	17.9%
CF_s	0.6%
ΔkW_{max}	0.0581
ΔkW_{wp}	0.0104
ΔkW_{sp}	0.0003
Annual Hours	812
ΔkWh	47.2
EPF – Winter Off	51.7%
EPF – Winter On	39.7%
EPF – Summer Off	5.1%
EPF – Summer On	3.5%



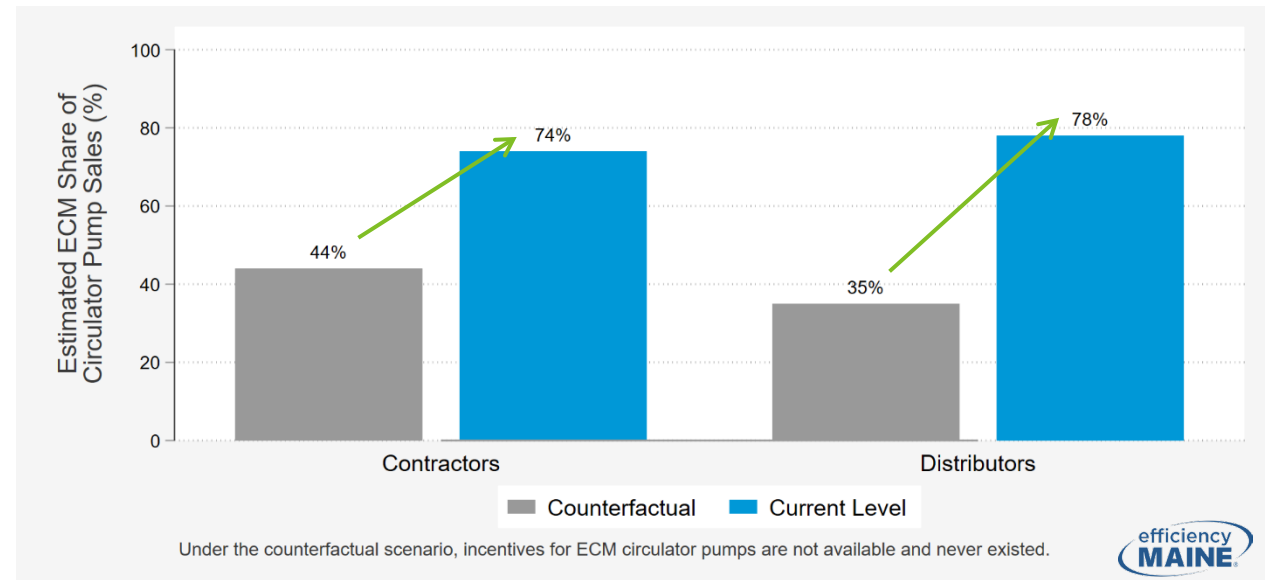
DISTRIBUTOR INTERVIEWS

- We conducted phone interviews with five distributors representing 91% of HPWHs rebated through the Instant – Distributor pathway and 90% of ECMCP rebates over the respective evaluation periods

Topic	HPWH Findings	ECMCP Findings
Program impact on HPWH/ECMCP stocking and sales Overall direction:	All five distributors indicated they have seen a significant increase in sales of HPWHs since they began participating in the program.	Four of five distributors indicated stocking and sales of ECM pumps have increased because of the incentives. Distributors thought the share of circulator pump sales that are ECM would drop by more than 50% in a counterfactual scenario where the incentive program never existed.
Program impact on HPWH/ECMCP awareness and adoption Overall direction:	On a scale from 0 (incentive program has no influence on current levels of HPWH awareness/adoption) to 10 (incentive program is extremely influential), the average rating was 9.8.	On a scale from 0 (incentive program has no influence on current levels of ECMCP awareness/adoption) to 10 (incentive program is extremely influential), the average rating was 8.2.

CONTRACTOR INTERVIEWS

- We conducted phone interviews with fifteen ECMCP contractors and recorded their responses to questions about stocking practices and the circulator pump market. Key findings include:
 - 60% of the contractors interviewed indicated that the discounts have influenced their selection of circulator pumps
 - When scoping a project, 60% of the contractors interviewed typically propose just the ECM model. Another 27% present both ECM and non-ECM options
 - Overall, contractors thought the share of circulator pump installations that are ECM would drop from 74% to 44% in a counterfactual scenario, where the incentive program never existed





BENEFIT-COST ANALYSIS AND RESULTS

- We used the results of the gross and net impact evaluations in combination with two different sets of avoided costs to compute benefit-cost (BC) ratios for 15 different HPWH BC scenarios and 11 different ECM circulator pump BC scenarios
 - All BC analysis utilized the Efficiency Maine primary BC test, which takes the perspective of all utility customers (participants and non-participants)
- In all scenarios, both measures screened as cost effective. Primary prospective results are shown below

Technology	Scenario	Perspective	Costs	BC Ratio
HPWH	2024 Gross Evaluated	Prospective	AESC 2024	1.94
ECMCP	2024 Gross Evaluated	Prospective	AESC 2024	1.35

TRM RECOMMENDATIONS

TRM CHANGE SUMMARY

- For the HPWH measure, we recommend modifying select algorithms, introducing new impact factors, updating impact factors, and updating per-unit savings values. The full set of recommendations is included in the evaluation report. Key impact factor changes include:
 - $\text{kWh/y}_{\text{HWL}} = 1,534$ (previously 2,821)
 - $\text{EAF}_{\text{EE}} = 0.50$ (previously 0.88)
 - $\text{EAF}_{\text{Base}} = 0.75$ (new term to account for standby losses in baseline water heaters)
- For the ECMCP measure, we recommend updating the impact factors but not modifying the algorithms or introducing new terms.
 - The table on slide 21 shows the updated factors from metering.
 - The price elasticity analysis on slide 19 provides the net-to-gross ratio of 79.5%.



Questions?