

DOCKETED	
Docket Number:	25-BSTD-03
Project Title:	2028 Energy Code Pre-Rulemaking.
TN #:	270347
Document Title:	Mike Little Comments - Comments for HPWH and PV exemption, additional information
Description:	N/A
Filer:	System
Organization:	Mike Little
Submitter Role:	Public
Submission Date:	5/29/2026 9:14:53 AM
Docketed Date:	5/29/2026

Comment Received From: Mike Little
Submitted On: 5/29/2026
Docket Number: 25-BSTD-03

Comments for HPWH and PV exemption, additional information

Additional submitted attachment is included below.

CEC DOCKET NO. 25-BSTD-03

COMMENT SUPPORT PACKAGE – FULL TECHNICAL ANALYSIS

Submitted by: Mike Little, California Energy Code Compliance / Michael Little HERS Rating

PART 1 – CORE ARGUMENT

1. The performance compliance pathway – EDR2/Total EDR under the 2022 standards
and Long-Term System Cost (LSC) under the 2025 standards –
interacts with the
PV exemption for small systems under 1.8 kWdc (Section 150.1(c)14,
Exception 2).
2. ADUs under approximately 700 sq ft commonly qualify for this
exemption
(Equation 150.1-C yields < 1.8 kWdc at small CFA in many climate
zones).
3. When the PV exemption is used, gas appliances cannot demonstrate
the
regenerative power contribution required for performance compliance
scoring.
This has been personally verified in CBEC-Res – there is no path
to
compliance using gas appliances when the PV exemption applies.
4. This creates a de facto HPWH mandate for small ADUs – not through
direct
requirement, but through compliance scoring mechanics.
5. ADU occupants skew lower income relative to regional medians (U.S.
Census
ACS; CA HCD; UC Berkeley Turner Center; UCLA Lewis Center for
Regional
Policy Studies).
6. The compliance model overstates HPWH efficiency and understates
operating
costs for ADU occupants.
7. Therefore lower-income ADU occupants bear utility costs materially
higher
than the compliance model predicts – an unintended equity
consequence.

PART 2 – WHY THE NBI STUDY DOES NOT ADDRESS THIS ARGUMENT

The CEC cited the NBI 2023 field study in response to the original comment.

The NBI study is a legitimate field validation study but does not address

the argument for the following reasons:

1. The NBI study explicitly excluded ADUs. All 32 monitored installations were in existing single-family homes, not ADUs.
2. The NBI study compared HPWHs only against storage gas (0.62 UEF) and propane – the least efficient gas options. Gas tankless at 0.95 UEF was never tested. This is the critical gap this analysis fills.
3. The NBI study did not test load-shifted operating conditions. Measurements reflect normal operation, not the off-peak/thermal battery configuration incentivized by JA13 and TECH Clean California.
4. NEEA efficiency ratings used in performance compliance modeling are derived from indoor lab conditions. The AO Smith HPTS-50 210 model plate states FOR INDOOR USE ONLY. Performance data from garage installations may not reflect rated performance; outdoor closet installations are further outside the rated operating envelope.
5. The NBI study was funded by PG&E, SCE, SMUD, DOE, and TECH Clean California – all parties with programmatic interest in HPWH adoption.
6. TECH Clean California is a retrofit program. It does not apply to new ADU construction under Title 24. These are separate policy contexts that should not be conflated.

PART 3 – HPWH PERFORMANCE IN ADU OUTDOOR CLOSET INSTALLATIONS

The dominant HPWH installation type That I have observed in new ADU construction is an outdoor utility closet. This is driven by spatial constraints intrinsic to ADU design. The following analysis estimates actual performance in this installation scenario using published manufacturer data, NEEA field data, and NBI measured consumption.

--- 3.1 Published Performance Ratings ---

DOE UEF (standard test at 67.5°F):	3.50
NEEA QPL Tier 3 weighted UEF:	2.90
Gap between DOE and NEEA weighted:	17% below DOE

DOE test conditions (10 CFR Appendix E):

Ambient dry-bulb: 67.5°F ± 1°F

Relative humidity: 50% ± 2%

These conditions are not representative of an outdoor closet during overnight load-shifted operation in California's coastal or mountain CZs.

--- 3.2 Manufacturer Performance Degradation (Rheem) ---

Rheem's published guidance states approximately 10% efficiency loss per 10°F drop in ambient temperature below rated conditions.

Applying this rule from the 67.5°F lab baseline:

60°F ambient: UEF ~3.15

50°F ambient: UEF ~2.45

40°F ambient: UEF ~1.75

37°F ambient: Compressor cutoff – resistance heating only (COP ~1.0)

Sources: Rheem Heat Pump Water Heater Space Requirements Planning Guide;

Rheem Cold Weather Operation Article; ENERGY STAR product record (compressor cutoff temperature: 37°F, PRO H40 T2 RH310BM, ID 2408561)

--- 3.3 NBI Measured EF by Climate Zone (Garage/Unconditioned Baseline) ---

Cold (CZ1, CZ16):	EF 2.60
Mild (CZ3-9):	EF 2.82
Warm (CZ10-14):	EF 2.82
Overall average:	EF 2.90

NBI installations were in garages and unconditioned spaces at approximately 55-65°F average ambient – already below DOE lab conditions.

--- 3.4 Estimated Outdoor Closet EF ---

Using NBI measured EF as baseline and Rheem's 10%/10°F degradation rule applied to approximate median overnight winter temperatures by climate zone:

Climate Zone	Overnight Winter Temp	NBI EF (garage)	Outdoor Closet Est. EF	Degradation
Cold (CZ1, CZ16)	32°F	2.60	1.00*	62%
Mild (CZ3-9)	46°F	2.82	2.48	12%
Warm (CZ10-14)	50°F	2.82	2.59	8%

* Below 37°F compressor cutoff – resistance heating only

--- 3.5 Estimated Monthly Consumption – Outdoor Closet ---

Scaled from NBI measured consumption (49 kWh/mo average) by EF ratio:

Climate Zone	Annual Avg kWh/month	Non-Summer kWh/month	Summer kWh/month

Cold (CZ1, CZ16)	127.4	161.5	75.7
Mild (CZ3-9)	55.7	70.6	33.1
Warm (CZ10-14)	53.3	67.5	31.6
NBI baseline (garage)	49.0	62.1	29.1

--- 3.6 Gap vs. Performance Compliance Model ---

The performance compliance model uses the rated UEF at DOE standard test conditions (67.5°F ambient, 50% relative humidity). For Tier 4 units, this value is 3.50 or higher depending on the specific product

entered. The modeled baseline used throughout this analysis is the DOE standard test value:

- Modeled consumption: ~39.5 kWh/month
- NBI measured (garage): 49.0 kWh/month (+24% vs. modeled)
- Outdoor closet est. (mild CZ): 55.7 kWh/month (+41% vs. modeled)
- Outdoor closet (cold CZ): 127.4 kWh/month (+222% vs. modeled)

The compliance model understates actual energy consumption by 24-222% depending on climate zone and installation type.

CBECC-RES "TANK OUTSIDE OR IN EXTERIOR CLOSET" CHECKBOX

CBECC-Res includes a "Tank Outside or in Exterior Closet" checkbox in the water heater configuration dialog. The Commission has indicated this feature accounts for outdoor installation in the compliance model.

When this option is selected, the compliance engine removes the HPWH's thermal interaction with the conditioned zone – the unit's air exchange no longer affects the zone heating and cooling load calculation. This is an appropriate adjustment for the building envelope model.

However, the Uniform Energy Factor applied to the water heating energy

calculation is not adjusted. The rated UEF – whatever value is entered, based on the product's DOE test rating at 67.5°F – remains the basis for calculating water heating energy consumption regardless of outdoor ambient temperature. The checkbox does not instruct the model to apply a lower efficiency for cold outdoor conditions, reduced compressor performance, or resistance heating fallback below 37°F.

The practical result: a unit installed in an outdoor closet in CZ9 and a unit installed in a conditioned mechanical room are modeled at identical water heating efficiency. The outdoor closet checkbox accounts for where the heat goes – it does not account for how well the compressor performs in that location.

The performance degradation documented in Sections 3.2 through 3.5 – approximately 12% efficiency loss in mild CZ outdoor closets and 100% loss (resistance only) in cold CZ conditions – is not reflected in the compliance calculation regardless of how the installation location is configured in CBECC-Res.

--- 3.7 Resistance Heating Fallback and 120V Performance Penalty ---

WHEN RESISTANCE HEATING ACTIVATES

When ambient temperature falls below the compressor cutoff (37°F for the Rheem PRO H40 T2 RH310BM and comparable units), the heat pump compressor shuts off and the unit operates on the resistance element only, at COP ~1.0 – no efficiency advantage over a standard electric resistance water heater.

Compressor cutoff:	37°F (ENERGY STAR ID 2408561)
Cold CZ1/CZ16 overnight winter temp:	~32°F – below cutoff
Result:	Resistance-only operation for duration of cold overnight

hours

In the cooler end of the "mild" classification (CZ3–6: Bay Area, coastal ranges, Sacramento foothills), overnight temperatures intermittently drop below 37°F in winter months, triggering resistance fallback even in zones the compliance model treats as temperate. JA13 load-shifted overnight operation increases exposure to these threshold events precisely because it pushes operation into the coldest hours.

120V RESISTANCE ELEMENT PERFORMANCE PENALTY

The NBI 2023 field study tested 120V plug-in HPWH units. The

performance difference between 120V and standard 240V hardwired units is significant in resistance heating mode.

The 120V efficiency penalty in resistance mode is as follows:
A 120V element (1,000–1,500W) takes 4.5 to 6.8 hours to recover 40 gallons that a 240V element (4,500W) recovers in approximately 1.5 hours. Throughout that extended recovery cycle, the tank loses heat to the surrounding ambient – standby heat loss that must be replaced by additional element run time.

Heat energy to recover 40 gallons (50°F → 120°F):
 $40 \text{ gal} \times 8.34 \text{ lb/gal} \times 70^\circ\text{F} = 23,352 \text{ BTU} \approx 6.84 \text{ kWh}$

Recovery time by element type:
120V element (1,000–1,500W): 4.5 to 6.8 hours per recovery cycle
240V element (4,500W): approximately 1.5 hours per recovery
Ratio: 3x to 4.5x longer for 120V

Standby heat lost during recovery (0.02–0.04 kWh/hr tank loss rate):
240V (1.5 hours): 0.03–0.06 kWh per cycle
120V (4.5–6.8 hours): 0.09–0.27 kWh per cycle

In an outdoor closet at cold ambient temperatures, the standby loss rate from the hot tank to the surrounding cold enclosure is higher than standard indoor test conditions assume. The extended 120V recovery cycle compounds with the cold ambient: more time losing heat at a higher-than-rated rate. The NBI study's viability finding was based on 120V operation in garages at moderate temperatures. In outdoor closet resistance-only operation, both penalties apply simultaneously.

The cold CZ resistance cost estimates below reflect the 127.4 kWh/mo figure from Section 3.5, which is itself a conservative lower bound

– the NBI 120V standby penalty in cold outdoor closet conditions would push actual consumption higher.

RESISTANCE HEATING COST SCENARIOS – SCE/SoCalGas TERRITORY

Cold CZ outdoor closet at resistance only (127.4 kWh/mo annual avg, 161.5 kWh/mo non-summer – see Section 3.5):



	Annual Avg	Non-Summer
	127.4 kWh/mo	161.5 kWh/mo
Gas Tankless (avg rate)	\$4.34/mo	\$4.34/mo
HPWH – Tier 1 (\$0.29)	\$36.95/mo	\$46.84/mo
HPWH – TOU off-pk (\$0.23)	\$29.30/mo	\$37.15/mo
Premium vs gas (Tier 1)	+\$32.61/mo	+\$42.50/mo
	+\$391/yr	
Premium vs gas (TOU)	+\$24.96/mo	+\$32.81/mo
	+\$300/yr	

COMPLIANCE MODEL – EFFICIENCY SHORTFALL IN RESISTANCE MODE

Performance compliance credits HPWH at DOE UEF 3.50.

An electric resistance water heater has a UEF of approximately 0.93 (accounting for standby losses). In resistance-only mode the HPWH achieves roughly 27% of its credited DOE UEF ($0.93 \div 3.50$).

The compliance model assigns efficiency credit for a device that, in cold outdoor closet conditions during load-shifted overnight operation, performs at approximately one-quarter of its credited efficiency.

PART 4 – MONTHLY OPERATING COST COMPARISON

Gas Tankless (0.95 UEF) vs. HPWH Outdoor Closet
Using NBI Measured Data + Outdoor Closet Degradation

Gas tankless at 0.95 UEF: 7.24 therms/month to deliver equivalent hot water
(NBI baseline: 6.88 therms useful energy delivered; gas storage UEF 0.62)

NOTE: NBI never tested gas tankless at 0.95 UEF. This comparison fills

that gap using NBI's own measured data. Gas tankless at 0.95 UEF uses 35% less gas than the storage baseline used in the NBI study.

--- SCE/SoCalGas Territory (Southern California – most ADUs) ---

Gas tankless: \$4.34/mo (avg \$0.60/therm) | \$7.24/mo (max \$1.00/therm)

Climate Zone	HPWH	HPWH	vs Gas	vs Gas
	Tier 1	TOU	Tier 1	TOU off-peak
peak	avg/mo	off-peak	(avg gas)	(avg gas)
Mild (CZ3-9)	\$16.15	\$12.81	+\$11.80	+\$8.46/mo
			+\$142/yr	+\$102/yr
Warm (CZ10-14)	\$15.45	\$12.25	+\$11.10	+\$7.91/mo
			+\$133/yr	+\$95/yr
Cold (CZ1,16)	\$36.95	\$29.30	+\$32.61	+\$24.96/mo
RESISTANCE ONLY*			+\$391/yr	+\$300/yr

* Below 37°F compressor cutoff – resistance element only, COP ~1.0. 120V element (NBI-tested configuration) compounds cost further via extended recovery cycles and elevated standby losses (see Sec. 3.7).

HPWH is \$95-\$142/year more expensive than gas tankless in Southern California outdoor closet installations at mild/warm climate zones – even at best available TOU off-peak rates. In cold climate zones where

resistance heating is the only available operating mode, the premium reaches \$300-\$391/year.

--- PG&E Territory ---

Gas tankless: \$14.48/mo (avg \$2.00/therm) | \$18.10/mo (max \$2.50/therm)

At PG&E average gas rates, HPWH Tier 1 (\$15.68/mo) costs slightly MORE.

At PG&E maximum gas rates, HPWH Tier 1 saves \$2.42/mo (\$29/yr).

TOU off-peak operation (\$21.07/mo) costs MORE than gas at both rate levels.

PG&E is the only territory where HPWH approaches cost parity with gas

tankless – and only at maximum gas rates, not average rates.

--- Non-Summer (Peak Hot Water Demand) ---

Hot water demand peaks in non-summer months (36-38 gal/day vs. 23-26 summer). This is also when outdoor closet ambient temperatures are coldest

and HPWH efficiency is lowest. The adverse conditions compound:

Mild CZ (non-summer, outdoor closet): 70.6 kWh/mo × \$0.29 = \$20.46/mo

vs. gas tankless: \$4.34/mo

Monthly difference: \$16.12 more for HPWH in peak demand month

PART 4A – CEC UTILITY ALLOWANCE TOOL: UTILITY TERRITORY AND CZ9

The CEC's Utility Allowance Calculation Tool (UAT) was used to model a 600 sq ft, 2-bedroom ADU with heat pump space heating, comparing HPWH against gas tankless water heating under CARE rates in two climate zones

(January 30, 2026 runs).

yr	Scenario	HPWH Total/yr	Gas Tankless Total/yr
	CZ5 (San Jose/Bay Area)	\$1,193.40	\$1,220.16

CZ9 (Riverside/San Bern) \$1,186.08	\$1,284.72
---------------------------------------	------------

These runs suggest HPWH saves \$27/yr in CZ5 and \$99/yr in CZ9. The CZ5 result reflects PG&E territory and is internally consistent. The CZ9 result warrants closer examination of the utility configuration.

UTILITY TERRITORY NOTE – CZ9

Both runs were configured using:
 Electric utility: PG&E (E-ELEC CARE 2026)
 Gas utility: PG&E (RES G1 CARE)

CZ9 encompasses Riverside, San Bernardino, and surrounding Inland Southern California communities. This territory is served by SCE (electric) and SoCalGas (gas), not PG&E. The Commission is of course aware of these service territory boundaries; this note is intended to flag that the comparison as run may not reflect the utility cost structure applicable to CZ9 ADU occupants.

The distinction materially affects the result because gas rates differ significantly between the two territories:

- PG&E gas (as configured in UAT run): ~\$2.00/therm average
- SoCalGas (actual CZ9 utility): ~\$0.60/therm average

At PG&E gas rates, gas tankless at 7.24 therms/month costs \$14.48/mo. At SoCalGas rates, the same unit costs \$4.34/mo. This difference – not HPWH performance – accounts for the apparent HPWH advantage in the CZ9 run. When the comparison is run with SCE electric and SoCalGas gas rates, the result aligns with the analysis in Part 4: HPWH costs \$95–\$142/yr more than gas tankless in Southern California outdoor closet installations.

CZ9 AND THE TERRITORY OF GREATEST CONCERN

Riverside and San Bernardino counties represent the geographic core of new ADU construction in California. The cost impact documented in this analysis falls primarily on SCE/SoCalGas customers. A UAT comparison using the correct utility rates for this territory is the relevant benchmark for evaluating the equity concern raised in Part 7.

SPACE HEATING AND COOLING – INDOOR INSTALLATION MODELING

The UAT runs also reflect a modeling condition worth noting for outdoor closet installations. Space heating consumption differs between scenarios:

CZ9 HPWH scenario: 138.8 kWh/yr space heating
CZ9 Gas tankless scenario: 57.9 kWh/yr space heating
Additional heating load: 80.9 kWh/yr (+139%)

The HPWH scenario requires 2.4x more space heating electricity – consistent with the model capturing cold air exhaust from an indoor HPWH increasing the space heating burden of the conditioned space.

The model simultaneously reflects reduced summer cooling with HPWH:

CZ9 HPWH scenario: 225.7 kWh/yr cooling
CZ9 Gas tankless scenario: 346.2 kWh/yr cooling
Difference: 120.5 kWh/yr less cooling with HPWH

Both effects – the increased heating load and the reduced cooling load – are consistent with indoor installation, where the HPWH exchanges heat with the conditioned living space. In an outdoor closet, the unit operates outside the conditioned envelope. The cooling benefit does not apply; the heating penalty is reduced; and the ambient temperature performance degradation documented in Part 3 applies in its place. The net effect of outdoor closet installation is not captured in the UAT modeling as currently configured.

PART 5 – THE THERMAL BATTERY / JA13 CONTRADICTION

California incentivizes HPWHs as thermal batteries for grid management.

JA13 (CEC-adopted Title 24 appendix) creates compliance credits for load-shifted HPWH operation. JA13 specifies load shifting as default opt-out behavior. TECH Clean California requires installer-configured grid connectivity and off-peak capability for rebate qualification.

The CEC has stated that off-peak operation is not specifically required for compliance credit. This creates an irreconcilable internal contradiction:

IF off-peak operation IS required for the thermal battery compliance credit:

- Load-shifted operation = overnight = coldest outdoor ambient temperatures
- HPWH efficiency degrades precisely when the policy succeeds at its grid management objective
- The compliance model credits grid-beneficial performance but does not account for the efficiency cost of achieving it

- Actual operating costs are higher than modeled

IF off-peak operation is NOT required:

- The grid benefit that justified the compliance credit does not materialize
- The thermal battery classification is a compliance fiction
- The homeowner receives higher HPWH operating costs without the utility bill benefit of off-peak rates

Either outcome results in actual operating costs exceeding modeled costs.

PEER-REVIEWED CONFIRMATION – NRDC/ACEEE 2018

This finding is confirmed by independent peer-reviewed simulation research.

Delforge and Vukovich (Natural Resources Defense Council, ACEEE Summer Study

on Energy Efficiency in Buildings, 2018) simulated HPWH load-shifting strategies across all 16 California climate zones using HPWHSim – the same

simulation engine embedded in CBECC-Res. Their findings directly address

the thermal battery compliance credit assumed by JA13:

1. On/off load-shifting (simplest, most deployable strategy):
Median customer savings: 0%.
Range: -8% to +7% across models and climate zones.
The paper states: "price gains from load shifting were offset by efficiency losses from operating at a higher temperature."
2. Optimizing for grid marginal costs (utility/societal benefit):
Customer bill change: \$0 to +\$10/year.
Customers pay the same or MORE when the HPWH is operated to maximize grid benefit. The authors note this would require compensating customers through mechanisms other than TOU rates.
3. Electric resistance heating represents 14% of hybrid HPWH energy use even under the most sophisticated "optimal price" control strategy. The authors state: "A modest use of electric resistance appears necessary for optimal consumer economic outcomes in many cases." This confirms resistance heating fallback (Section 3.7) is not an edge case – it is a predictable operating reality acknowledged by the researchers who advocate for HPWH flexibility.
4. The study modeled 50, 65, and 80-gallon tanks in 1-5 bedroom homes.
No ADU-scale analysis was performed. The study's positive

findings

do not transfer to 40-gallon units in small ADU installations.

5. The study used a hypothetical "NRDC Flexible Water Heating Rate" with a 3:1 peak/off-peak price differential – a rate designed by the authors specifically to make load shifting pencil out. No such rate is available to ADU occupants in SCE territory. Actual SCE TOU differentials are smaller, reducing customer savings further.

6. In cold CZ16, load-up/shed strategy failed to meet customer demand even with larger tank sizes – confirming the cold climate performance limitations documented in Part 3.

The thermal battery compliance credit embedded in JA13 and California's performance compliance pathway is premised on customer savings that independent peer-reviewed simulation finds to be, at best, zero – and potentially negative when the system is operated for grid benefit rather than customer benefit.

Source: Delforge, P. and Vukovich, J. 2018. "Can Heat Pump Water Heaters Teach the California Duck to Fly?" ACEEE Summer Study on Energy Efficiency in Buildings. Natural Resources Defense Council.

PART 6 – THE DUCK CURVE COMPLICATION

The traditional off-peak load-shifting assumption placed HPWH operation overnight during low-demand hours. California's solar overproduction has shifted this assumption materially.

The optimal thermal battery operating window has moved toward 10am–2pm solar surplus hours, when grid electricity is cheapest and cleanest. Midday operation in an occupied ADU means:

- Cold discharge air (~50°F) exhausted into occupied living space
- Increased space heating demand during occupied hours
- Occupant comfort impacts not captured in compliance modeling
- Secondary heating energy not reflected in performance compliance efficiency assumptions

Performance compliance modeling has not been updated to reflect duck curve operating realities. The compliance credit assumes grid benefit at times when actual operation creates a competing residential energy burden.

PART 7 – EQUITY ARGUMENT

The CEC has argued that lower-income electricity customers receive subsidized rates through CARE and FERA programs.

Counter-argument: Lower-income gas customers also receive subsidized rates (SoCalGas CARE discount: approximately 20%). The subsidy argument cancels out – it does not justify compelling lower-income occupants onto a more expensive fuel source. The relative cost differential between gas tankless and HPWH persists after low-income subsidies are applied to both.

The smallest ADUs – under 700 sq ft – are the most affordable units and the most likely to house lower-income occupants. These are precisely the units most affected by the performance compliance/PV exemption interaction that creates the de facto HPWH mandate.

PART 8 – REQUESTED OUTCOME

The Commission should consider exempting new ADU construction under approximately 700 sq ft that qualifies for the small PV exemption (Section 150.1(c)14, Exception 2) from the de facto HPWH mandate created by the performance compliance/PV exemption interaction – until a water heating technology is developed that is specifically designed for ADU-scale applications, installation constraints, and real-world operating conditions.

SOURCES

Delforge, P. and Vukovich, J. 2018. "Can Heat Pump Water Heaters Teach the California Duck to Fly?" ACEEE Summer Study on Energy Efficiency in Buildings. Natural Resources Defense Council.

NBI (New Buildings Institute). Plug-In Heat Pump Water Heater Field Study Findings & Market Commercialization Recommendations. July 2023. Prepared for PG&E, SCE, SMUD, TECH Clean California, and DOE.

NEEA. Laboratory Assessment of Rheem Generation 5 Series HPWH. Report E21-318. January 2021.

NEEA. Heat Pump Water Heaters in Small Spaces Lab Testing. Report E22-334.

NEEA. Heat Pump Water Heater Field Study Report. Report E13-266.

NEEA. Advanced Water Heating Specification v8.1.

Rheem. Heat Pump Water Heater Space Requirements Planning Guide. rheem.com/water-heating/articles/heat-pump-water-heater-space-requirements

Rheem. Cold Weather Operation Article. rheem.com/water-heating/articles/do-heat-pump-water-heaters-work-in-cold-weather

Rheem. Understanding Operating Modes. rheem.com/water-heating/articles/understanding-rheem-hybrid-electric-heat-pump-water-heater-operating-modes

ENERGY STAR. PRO H40 T2 RH310BM Product Record. ID 2408561. energystar.gov/productfinder/product/certified-heat-pump-water-heaters/details/2408561

Slipstream / Cautley. Installed Performance of Heat Pump Water Heaters in a Cold Climate. slipstreaminc.org

ETCC. Code Readiness: Laboratory Testing of HPWH Performance – Impact of Airflow and Space Configurations. etcc-ca.com/reports/code-readiness-laboratory-testing-heat-pump-water-heater-performance-impact-airflow-and

GreenBuildingAdvisor. Water Heaters Get a New Performance Standard.
greenbuildingadvisor.com/article/water-heaters-get-a-new-performance-standard

10 CFR Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters. [law.cornell.edu/cfr/text/10/appendix-E_to_subpart_B_of_part_430](https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B)

CEC. 2022 Reference Appendix B – Water Heating Calculation Method.

CEC. 2025 Building Energy Efficiency Standards – What's New for Single Family. [energy.ca.gov](https://www.energy.ca.gov)

U.S. Census Bureau. American Community Survey.
CA Department of Housing and Community Development.
UC Berkeley Turner Center for Housing Innovation.
UCLA Lewis Center for Regional Policy Studies.