Residential Heat Pump Water Heating Market Transformation Initiative

Appendix B: Market Forecasting & Cost-Effectiveness Modeling Approach

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List of Abbreviations

Abbreviation	Definition
ACC	Avoided Cost Calculator
ACS	American Community Survey
BAAQMD	Bay Area Air Quality Management District
BMA	Baseline Market Adoption
CalMTA	California Market Transformation Administrator
CARB	California Air Resources Board
CARE	California Alternate Rates for Energy
CE	Cost-Effectiveness
CEC	California Energy Commission
CEDARS	California Energy Data and Reporting System
CE	Cost-Effectiveness
CET	Cost Effectiveness Tool
CPUC	California Public Utilities Commission
CZ	Climate Zone
DEER	Database for Energy Efficient Resources
DER	Distributed Energy Resources
DOE	Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
EOL	End of Life
EV	Electric Vehicle
eTRM	electronic Technical Reference Manual
EUL	Effective Useful Life
FERA	Family Electric Rate Assistance
GHG	Greenhouse Gas
GWP	Global Warming Potential
HPWH	Heat Pump Water Heater
HVAC	Heating Ventilation and Air Conditioning
IMC	Incremental Measure Cost
IOU	Investor-Owned Utility
MF	Multifamily
MTI	Market Transformation Initiative
NPV	Net Present Value
PA	Program Administrator
PAC	Program Administrator Cost
PG&E	Pacific Gas and Electric
RECS	Residential Energy Consumption Survey
RACC	Refrigerant Avoided Cost Calculator
RASS	Residential Appliance Saturation Survey
SCE	Southern California Edison
SCT	Societal Cost Test
SDG&E	San Diego Gas and Electric
SF	Single Family
TECH	TECH Clean California

TMA	Total Market Adoption
TRC	Total Resource Cost
TSB	Total System Benefit
UEF	Uniform Energy Factor
UEI	Unit Energy Impact
UES	Unit Energy Savings

1 Purpose

Market Transformation Initiatives (MTIs) generate energy savings and related benefits by accelerating and increasing market adoption of energy-efficient technologies and practices. Estimating the energy impacts and cost-effectiveness of MTIs requires developing a market adoption forecasting model and using model outputs to estimate incremental system benefits and cost-effectiveness.

This appendix documents the approach, methods, assumptions, and data sources CalMTA used to estimate incremental impacts resulting from the Residential Heat Pump Water Heating (HPWH) MTI and summarizes findings from the analysis. These methods are consistent with the approach described in the CalMTA MTI Evaluation Framework.[1]

2 Executive summary

To estimate incremental impacts for the HPWH MTI, CalMTA developed forecasts of Baseline Market Adoption (BMA) and Total Market Adoption (TMA) and, ultimately, the net incremental market adoption achieved by the MTI. Forecasted units of adoption are a key input to the calculation of Total System Benefit (TSB) and cost-effectiveness ratios: Total Resource Cost (TRC), Program Administrator Cost (PAC), and Societal Cost Test (SCT).

This appendix focuses on the existing home replacement market and does not include new-construction water-heater installations in the modeled adoption forecast.[2] The adoption forecast treats new construction as an important market context, but focuses on the existing home replacement segment, which represents the greatest market transformation potential.

California's existing residential market for dedicated water heating is large and still dominated by natural gas equipment. CalMTA estimates that approximately 11.5 million California households are served by dedicated water-heating systems, of which approximately 76% use gas water

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[1] To learn more about the CalMTA MTI Evaluation Framework, please see https://calmta.org/wp-content/uploads/2025/04/Market-Transformation-Evaluation-Framework-FINAL.pdf. Further information is also available in Appendix F: Evaluation Plan.

[2] CalMTA excluded new construction from this forecast due to both market size and policy context. New construction represents approximately 11% of annual dedicated water-heater sales and equipment decisions are increasingly shaped by building-code compliance rather than the customer-economics and installer-confidence dynamics that are central to CalMTA's adoption forecasting model. Beginning January 1, 2026, California's 2025 Title 24 Energy Code makes HPWHs or solar water heating with electric backup the core prescriptive pathway for low-rise residential new construction, while existing-home water-heater change-outs remain more permissive statewide. For more information about the 2025 Title 24 code, see CalMTA (2026), *Residential Heat Pump Water Heating Market Characterization Report*, Section 3.2.3.

heaters and approximately 23% use electric water heaters. HPWHs currently represent an estimated 5&-6% of annual sales and less than 2% of installed stock, indicating substantial remaining market opportunity.[3] Of the approximately 753,052 annual dedicated, non-central water-heater sales in California, CalMTA estimates that about 669,432 occur in retrofit or replacement applications in existing buildings, compared with about 83,620 in new construction.[4]

2.1 Market adoption forecast

To estimate HPWH adoption in BMA and TMA, CalMTA developed a constrained discrete-choice model in which annual HPWH adoption is driven by relative customer economics and constrained by installer confidence and acceptance. In this framework, customer economics capture the combined effect of upfront cost and lifetime utility-bill impacts, while the installer-confidence constraint captures important non-price barriers such as uncertainty around household fit, installation complexity, and willingness to recommend HPWHs in the field. The adoption model segments the replacement market into three groups of household installation scenarios:

1) Existing gas water heaters in homes that are not assumed to be 240-volt (240V) ready
2) Existing gas water heaters in homes that are assumed to be 240V ready
3) Existing electric-resistance water heaters

BMA reflects expected market adoption under current and emerging market, policy, and technology trends, including Title 24, the recently adopted Bay Area Air Quality Management District (BAAQMD) residential water-heater rule,[5] and the 2029 federal water-heater efficiency standard. TMA reflects the additional acceleration expected from the strategic interventions described in the MTI Plan. Relative to BMA, TMA assumes faster improvement in installer confidence and acceptance and faster decline in HPWH costs as a result of coordinated market transformation activities.[6] Figure 1 compares forecasted HPWH adoption under the BMA and TMA scenarios. In both cases, adoption increases over time as the market responds to changing policy, technology, and market conditions; however, TMA rises more quickly because it reflects the expected effect of coordinated market transformation interventions that improve installer

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[3] For more information on market segmentation calculations, please refer to Appendix D: Market Characterization.
[4] For more information on HPWH sales, please refer to Section 4.3 and Attachment G in Appendix D: Market Characterization. The team is estimating approximately 753,052 annual dedicated, non-central water-heater sales in California, of which approximately 83,620 occur in new construction and 669,432 occur in retrofit or replacement applications in existing buildings.
[5] BAAQMD, Regulation 9, Rule 6.
[6] For more information, please refer to Appendix A: Logic Model and the Residential HPWH MTI Plan's Executive Summary and Strategic Interventions sections, identifying increased installer confidence and acceptance as a short-term market outcome and linking TMA to coordinated market transformation activities that reduce non-price barriers and accelerate adoption.

confidence and acceptance and accelerate cost reductions. The gap between the two curves therefore represents the statewide incremental adoption associated with the MTI.

Figure 1. HPWH market adoption – annual market share, BMA vs. TMA

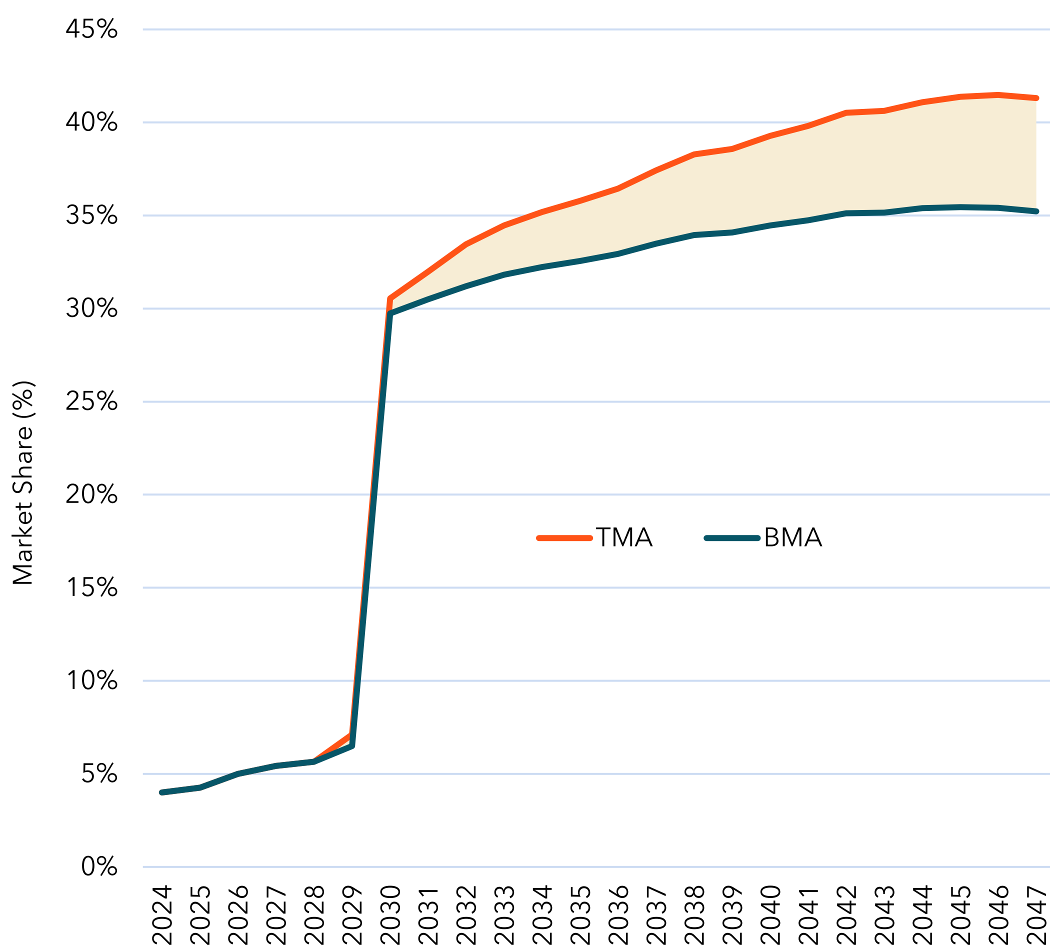

Table 1 summarizes cumulative HPWH adoption outcomes across the 2028–2047 forecast period. Under the TMA scenario, CalMTA forecasts approximately 4.36 million HPWH adoptions, compared with 3.89 million under BMA, for a statewide incremental difference of about 474,000 units.

Consistent with the CalMTA MTI Evaluation Framework, CalMTA is required to make two adjustments to the MTI's statewide incremental market adoption forecast, for purposes of calculating cost-effectiveness:

1) CalMTA excludes the portion of incremental adoption attributed to households outside Investor Owned Utility (IOU) service territories from IOU-level TSB and cost-effectiveness estimates.
2) CalMTA also subtracts Program Administrator (PA)-verified units associated with incremental adoption to avoid double counting with PA-claimed program activity.

After adjusting for PA-verified units and adoption outside IOU territories, the *net* incremental adoption used for TSB and cost-effectiveness estimation is lower – approximately 196,000 units. The approach to estimating units outside IOU territory and PA-verified units is detailed in Section 2.5 of this appendix. This document also provides context and discussion for why the estimated net incremental adoption shown in Table 1 should be regarded as conservative. Results of various sensitivity analyses are provided in Section 8.

Table 1. Forecast of HPWH adoption, 2028-2047

TMA	BMA	Statewide incremental adoption	PA-verified units	Adoption attributed to non-IOU territory	Net incremental adoption for TSB and CE estimation
4,622,263	4,121,252	501,011	183,671	110,222	207,118

Source: CalMTA estimates. PA-verified units include adoption associated with PA programs statewide.

2.2 Total system benefit and cost-effectiveness forecast

After developing the BMA and TMA forecasts, CalMTA estimated net incremental adoption for use in TSB and cost-effectiveness by adjusting statewide incremental adoption for forecasted PA-verified units and for adoption outside IOU territories, consistent with the MTI Evaluation Framework.

In addition to the adoption forecast, the TSB and cost-effectiveness analysis incorporates initiative costs, incremental measure costs, avoided costs, load shapes, and unit energy impacts. CalMTA estimated TSB and cost-effectiveness for the HPWH MTI using the TRC, PAC, and SCT frameworks. The initiative is expected to deliver significant long-term benefits, driven primarily by avoided greenhouse gas emissions from fuel substitution and by electricity savings in replacement of electric resistance water heaters. Table 2 and

Table 3 summarize TSB and cost- effectiveness results for 2028–2047.

Table 2. HPWH estimated TSB, 2028-2047

TSB ($M)	Energy ($M)	Grid ($M)	GHG ($M)	GHG Refrigerant ($M)
618.68	70.53	10.08	557.41	-19.35

Source: CalMTA estimates. PA-verified units include adoption associated with PA programs statewide.

Table 3. HPWH cost-effectiveness estimate, 2028-2047

TRC	PAC	Base SCT	High SCT
1.67	16.8	2.70	2.69

3 Market adoption forecast

This section details CalMTA's approach to forecasting the adoption of HPWHs by California households over the forecast period (2028-2047), along with the forecast results.

3.1 Model structure

CalMTA used a constrained discrete-choice framework to estimate annual HPWH adoption under baseline and MTI conditions. The model forecasts annual market shares across competing baseline and HPWH options as a function of relative customer economics, including upfront cost and lifetime utility-bill cost. The resulting market shares are then constrained by a forecasted installer confidence and acceptance factor.

$$s_i = \frac{\alpha_j * e^{(c_j) * \gamma}}{\sum_{j=1}^{J} \alpha_j * e^{(c_j) * \gamma}}$$

Where:

s_j = market share for product j

α_j = constraint weight of product j

c_j = relative cost of ownership of HPWH option j compared to a baseline option

γ = logit exponent parameter, which defines the sensitivity of product market share to the relative cost of ownership

J = total number of water heater options in the choice set

The logit exponent, γ, determines the magnitude of cost difference needed to produce a given change in market share. CalMTA used a value of -4 for the logit exponent. This value is in the range of common values in energy research when modeling energy technology choices.[7] Holding α constant, the difference in market share depends only on cost variation between product alternatives. The logit coefficient defines the sensitivity of market share to changes in relative costs.

The relative cost of ownership between HPWHs and a baseline water heater is a key driver of adoption in this modeling framework. The total cost of ownership of a water-heating unit is

[7] Clarke, J.F. and Edmonds, J.A. (1993). "Modelling energy technologies in a competitive market." Energy Economics, Volume 15, Issue 2, 1993, Pages 123-129. https://doi.org/10.1016/0140-9883(93)90031-L.

calculated as the sum of upfront costs and discounted lifetime utility-bill costs. Upfront costs include equipment and installation labor. Annual utility-bill costs are calculated from hourly consumption load shapes multiplied by weighted-average hourly utility rates. The calculated annual utility bills are summed over the full effective useful lifetime of the unit and discounted to determine the net present value (NPV) of the lifetime utility-bill costs.

In addition to the relative costs of ownership, the model includes a constraint factor represented by the constraint-weight parameter α. This constraint reflects installer confidence, acceptance, and recommendation of HPWHs and takes values between zero and one. Lower values reduce realized market share relative to unconstrained demand, even when customer economics improve.

3.2 Inputs and assumptions

CalMTA developed model assumptions using market research data, policy and program review, MTI intervention planning materials, the California Electronic Technical Reference Manual (eTRM), and other sources, which are cited throughout this document. Major input categories include annual product flow for each of the three household installation scenarios, equipment and installation costs, utility bill impacts, historical HPWH sales and program data, and installer confidence and acceptance assumptions used in BMA and TMA.

The adoption model uses a common set of inputs and assumptions for both the BMA and TMA scenarios unless otherwise noted. The shared inputs include market size and annual product flow, policy assumptions, upfront equipment and installation costs, utility bill assumptions, and consumption and savings shapes. This section provides details on the inputs and assumptions that do not vary from the BMA to TMA scenario. The following Sections (3.3 and 3.4) focus only on the inputs and assumptions that differ between the BMA and TMA scenarios: forecasted cost declines and the installer confidence and acceptance constraint.

3.2.1 Market size and segmentation

Existing water heater stock

California's existing residential market for dedicated water heating is large and still dominated by gas equipment. The HPWH Market Characterization Report estimates that approximately 11.5 million California households are served by dedicated water-heating systems, of which approximately 76% use natural gas or propane water heaters and approximately 23% use electric water heaters.[8] HPWHs currently represent a relatively small share of both annual sales and installed stock, indicating substantial remaining market opportunity.

[8] For more information, please refer to Appendix D: Market Characterization, Executive Summary at 9–10 and Section 4.2 at 43–45 (estimating approximately 11.5 million California households with dedicated water heating, of which 76% are served by gas water heaters and 23% by electric water heaters).

For the purposes of the adoption model, propane water heaters are included in the natural gas baseline segment and are not modeled as a separate competition group. This is a simplifying assumption. In practice, homes with propane water heating are often strong candidates for HPWH upgrades from a customer-economics perspective, so grouping propane with natural gas is a conservative modeling choice.

CalMTA segmented the adoption forecast model, which comprises the existing-home replacement market, into three household installation scenario groups: (1) existing gas water heaters in homes that are not assumed to be 240V ready without major electrical work, (2) existing gas water heaters in homes that are assumed to be 240V ready without major electrical work, and (3) existing electric resistance water heaters. These groups reflect major differences in customer economics, installation feasibility, and market readiness across replacement pathways. For modeling purposes, the split between the two gas-baseline groups is represented as a statewide planning assumption of 70% of gas-baseline homes treated as 240V ready and 30% treated as not 240V ready.[9] This 70/30 segmentation is informed by two recent CPUC-supported studies of residential electrification infrastructure:

- A 2024 Guidehouse fuel-substitution infrastructure study that isolates residential water-heating electrification estimates that approximately 14% of single-family homes and 13% of multifamily units would require a panel upgrade, while panel optimization would be needed for 30% of single-family homes and 41% of multifamily units.[10]
- A related 2024 CPUC stakeholder presentation summarizing broader residential electrification infrastructure needs reports that, depending on scenario, 27% to 41% of residential units are likely to require a panel upgrade and an additional 19% to 27% are likely to require panel optimization services.[11]

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[9] CalMTA assumption informed by recent California electrification-infrastructure research, including Guidehouse Inc. and Opinion Dynamics Corporation (2024). *Fuel Substitution Behind the Meter Infrastructure Market Study*, Final Report, Table 25; Opinion Dynamics (2024). *Fuel Substitution Infrastructure Market Study Stakeholder Presentation,* Key Takeaways; and CalMTA (2026). *Residential Heat Pump Water Heating Market Characterization Report*, Section 5.1.6. These sources indicate that a meaningful share of gas-baseline homes face electrical constraints that may complicate standard 240V HPWH replacement, but they do not provide a single statewide "240V ready" estimate for the HPWH adoption model. CalMTA therefore applies a simplified 70/30 segmentation assumption for modeling purposes.

[10] Guidehouse Inc. and Opinion Dynamics Corporation (2024). *Fuel Substitution Behind the Meter Infrastructure Market Study*, Final Report, Table 25, reporting that for residential gas water-heating electrification, approximately 14% of single-family homes and 13% of multifamily units would require a panel upgrade, while panel optimization would be needed for 30% of single-family homes and 41% of multifamily units.

[11] Opinion Dynamics (2024). *Fuel Substitution Infrastructure Market Study Stakeholder Presentation*, "Key Takeaways," reporting that statewide residential results indicate 27% to 41% of housing units are likely to receive a panel upgrade to accommodate fuel-substitution measures and another 19% to 27% are likely to receive panel optimization services, depending on scenario.

Taken together, these studies indicate that a meaningful share of gas-baseline homes are not straightforward 240V retrofit candidates. CalMTA therefore uses a simplified statewide assumption that 30% of gas-baseline homes are not 240V ready for purposes of the adoption model. This assumption is intended to represent homes where a standard 240V HPWH replacement would face substantial electrical feasibility barriers; it does not imply that the remaining 70% require no electrical work at all.

CalMTA models a dedicated 120-volt (120V) HPWH pathway for gas-baseline homes that are assumed not to be 240V ready without major electrical work. This pathway reflects the emerging role of 120V HPWHs as a lower-power retrofit option that can reduce the need for panel upgrades, rewiring, or other substantial electrical interventions in electrically constrained homes.[12] Although 120V HPWHs generally offer lower performance than higher-efficiency 240V models, they may play an important role in retrofit and emergency-replacement applications where installation feasibility is a primary barrier. In the model, the 120V pathway is not intended to imply that all electrically constrained homes will adopt 120V equipment. Rather, it serves as a representative lower-power HPWH option for homes where a standard 240V HPWH retrofit is less feasible or materially more costly.

Table 4 summarizes the estimated 2024 statewide market context used to frame the adoption forecast.[13] These values show both the scale of the existing market and why the replacement segment matters: California has roughly 11.5 million households with dedicated water heating, most of which still use gas equipment, while a meaningful minority of homes face electrical-readiness constraints that may complicate straightforward 240V HPWH replacement. At the same time, the broader policy landscape is moving in a direction that should gradually support HPWH growth over time, including stronger new-construction requirements under the 2025 Title 24 code, the BAAQMD zero-NOx rule beginning in 2027, and the 2029 federal standard for water-heater efficiency.

Table 4. California residential water-heating market context, 2024

Metric	Value (2024 Estimates)
Existing CA Households with dedicated water heating	11.5 million
Gas water-heating households	8.7 million

[12] For more information, please refer to Appendix D: Market Characterization, Section 5.1.6 and Attachment E, which synthesizes stakeholder research and installer survey data pointing to approximately 30% of California households requiring electrical upgrades prior to HPWH installation; other sources reviewed in Attachment E suggest higher shares, ranging up to 44% of single-family homes when panel optimization is included alongside full panel upgrades. Using 30% is therefore conservative in the model: a lower share of electrically constrained homes means a greater share fall into the higher-adoption 240V fuel-substitution pathway, yielding higher incremental adoption and TSB.

[13] For more information, please refer to Appendix D: Market Characterization, Executive Summary, Section 5.1.6.

Metric	Value (2024 Estimates)
Electric water-heating households	2.6 million
Gas homes 240V capable	70%
Gas homes not 240V capable	30%
Estimated installed HPWHs	182,911
Estimated installed HPWH saturation	1.6%
Estimated HPWH market share, new construction	21%
Estimated HPWH market share, retrofit	4%

Source: CalMTA estimates based on the HPWH Market Characterization Report

Annual Water Heater Sales

Table 5 provides the corresponding annual sales context for the adoption forecast, distinguishing the much larger existing-home replacement market from new construction and showing the estimated 2024 scale of HPWH sales within that broader market. CalMTA estimates approximately 753,052 annual dedicated, non-central water-heater sales in California, of which about 83,620 occur in new construction and about 669,432 occur in retrofit or replacement applications in existing buildings (Table 5).[14] The same market characterization work estimates roughly 43,002 HPWH sales in 2024 statewide, with HPWH market share substantially higher in new construction than in retrofit.[15]

Table 5. Annual California water heater sales

Metric	Value
Annual dedicated, non-central water-heater sales	753,052
Annual new-construction dedicated sales	83,620
Annual retrofit / replacement dedicated sales	669,432
Estimated 2024 HPWH sales	43,002

Source: CalMTA estimates, CalMTA, Appendix D: Market Characterization.

Although new construction is an important part of the broader California HPWH market, it is excluded from the adoption forecast modeled in this appendix because the MTI is focused on the existing-home replacement market, where customer economics, household fit, and installer confidence remain central barriers. New construction is also increasingly shaped by code and related policy signals rather than by the installer-confidence and customer-economics dynamics that define the existing-home replacement market. Beginning January 1, 2026, California's 2025 Title 24 Energy Code makes HPWHs or solar water heating with electric backup the core

[14] For more information, please refer to Appendix D: Market Characterization, Section 4.3, and Attachment G, estimating approximately 753,052 annual dedicated, non-central water-heater sales in California, of which approximately 83,620 occur in new construction and 669,432 occur in retrofit or replacement applications in existing buildings.

[15] For more information, please refer to Appendix D: Market Characterization, Section 4.3, and Attachment G.

prescriptive pathway for low-rise residential new construction, while the removal of gas line extension allowances for new residential construction further strengthens the shift away from gas in that segment.[16] CalMTA therefore treats new construction as a critical market context, but not as part of the modeled adoption forecast for this appendix.

Table 6 summarizes the installation scenario segmentation used in the adoption forecast model. The annual product flow to each group is assumed to be constant over the forecast period. The annual HPWH market shares calculated with the discrete-choice model are multiplied by product flow to determine annual HPWH installations.

Table 6. adoption model segmentation summary

Competition Group	Baseline Water Heater Equipment Type	Eligible HPWH Type	Stock Size	Product Flow[17]
Group 1 – 120V Fuel Substitution	Natural gas, household not 240V-capable without major electrical upgrades	120V HPWH	2,601,300	151,426
Group 2 – 240V Fuel Substitution	Natural gas, household 240V-capable without major electrical upgrades	240V HPWH	6,069,700	353,326
Group 3 – Electric Baseline	Electric	240V HPWH	2,829,000	164,680
		Total	**11,500,000**	**669,432**

3.2.2 HPWH size and efficiency

CalMTA included multiple HPWH product configurations in the adoption model and technical analysis. After total HPWH adoption is estimated within each market segment, adopted units are allocated across modeled HPWH product configurations by voltage, tank size, and efficiency level. Each modeled configuration is associated with a distinct cost assumption and a distinct hourly load shape. This granularity allows the model to preserve meaningful differences in utility-

[16] For more information, please refer to the Residential HPWH MTI Plan, Energy policy landscape section, stating that California's 2025 building energy code supports HPWH adoption in new construction through electric-ready requirements and a prescriptive compliance path limited to HPWHs and solar thermal systems with electric backup, and noting that CPUC's 2023 elimination of gas line extension allowances for new residential construction makes gas installation more difficult; see also Appendix D: Market Characterization, Section 3.2.3, noting stakeholder feedback that removal of gas line subsidies is leading to greater adoption of HPWHs in new construction.

[17] Please refer to Appendix D: Market Characterization, Table 12, Table 13, and Attachment G.

bill impacts, avoided costs, and incremental measure costs across HPWH pathways, while keeping the adoption model itself at a tractable segment level.

The size and efficiency distributions are treated as exogenous inputs to the model. CalMTA analyzed historical HPWH program data from TECH Clean California to develop representative distributions of installed HPWHs by voltage, tank size, and efficiency level, and then applied those distributions after total HPWH adoption is estimated within each household installation scenario group.[18] The HPWH Market Characterization Report uses TECH data extensively to characterize HPWH program activity and market composition and identifies TECH as one of the leading statewide sources of observed HPWH installation data in California. For example, the report uses TECH Clean California working and download datasets to track total incentivized HPWHs, including distinctions among 240V, 120V, split-system, and unspecified HPWH installations.

In the adoption calculations, the discrete-choice model does not separately model a customer's choice among every individual HPWH size and efficiency combination. Instead, for each household installation scenario group, the HPWH-versus-baseline decision is based on the relative economics of a representative average HPWH option for that segment. For Group 1, this reflects the weighted-average economics of eligible 120V HPWH configurations. For Groups 2 and 3, this reflects the weighted-average economics of eligible 240V HPWH configurations. After the model estimates total HPWH adoption within a segment, those adopted units are then allocated across the underlying size and efficiency combinations using the exogenous TECH-based distributions. This approach preserves the influence of differentiated costs and savings across HPWH subtypes in the total system benefit (TSB) and cost-effectiveness analysis without requiring the adoption model to estimate separate choice behavior for every individual HPWH configuration.

For 240V HPWHs, the model includes three tank sizes (50-, 65-, and 80-gallon) and three efficiency levels (3.3, 3.75, and 4.0 UEF).[19] For 120V HPWHs, the model includes one tank size (80 gallons) and three efficiency levels (2.2, 2.75, and 3.0 UEF). These modeled options are intended to represent the range of HPWH product types included in the technical and cost analysis rather than a prediction that customers explicitly optimize across all listed combinations at the point of purchase. The assumed efficiency and size distributions are shown in Table 7 and Table 8, respectively

[18] CalMTA's HPWH Market Characterization Report uses TECH Clean California data as a primary source for observed California HPWH installation activity and market characterization, including analysis of total incentivized HPWHs and distinctions among 240V, 120V, split-system, and unspecified HPWH installations. See CalMTA, Appendix D: Market Characterization, Section 3.3.1, and Figure 7, citing the TECH Clean California Working Dataset (5-26-2025) and TECH download data accessed June 9, 2025.

[19] Uniform energy factor (UEF) is the residential water heater overall efficiency metric defined by the DOE test procedure.

Table 7. HPWH efficiency distribution

Voltage	UEF	Share
240V	3.3	2.3%
240V	3.75	54.4%
240V	4.00	43.3%
120V	2.2	2.3%
120V	2.75	54.4%
120V	3	43.3%

Table 8. HPWH size distribution

HPW Voltage	Tank Size (gallons)	Share
120V	80	100%
240V	50	18%
240V	65	64%
240V	80	18%

3.2.3 Upfront costs

Upfront costs are calculated as the sum of equipment cost and installation labor cost. CalMTA drew these costs from two California eTRM measures: SWWH025-10, which characterizes residential fuel-substitution HPWH installations, and SWWH014-08, which characterizes HPWH installations replacing existing electric resistance water heaters. The eTRM measures provide baseline-unit and HPWH costs for multiple tank sizes and efficiency levels, including both equipment and installation-labor inputs.[20]

Because the current eTRM measure package does not include every exact efficiency level used in the adoption model, CalMTA interpolated certain values, where needed, to represent higher-efficiency offerings not directly listed in the source measures. Table 9 summarizes the upfront costs of HPWH and baseline water heaters used in the market adoption forecast. These values include both equipment and installation labor and serve as the starting-point cost assumptions in the adoption model before the forecasted BMA and TMA cost-decline trajectories are applied. The upfront cost values from the eTRM serve as the starting point in the model. In both BMA and TMA, upfront costs are forecasted to decline over time (see the BMA and TMA sections below for details on the forecasted cost declines).

[20] California eTRM (2026). *HeatPumpWaterHeater, Residential, FuelSubstitution* Measure Characterization, SWWH025-10, effective Jan. 1, 2026; California eTRM measure SWWH014-08

Table 9. Upfront water heater costs

Water Heater Type	Efficiency (UEF)	Tank Size (gallons)	Equipment Cost	Labor Cost	Total Upfront Cost
120V HPWH	2.2*	80	$5,183	$1,000	$6,183
120V HPWH	2.75	80	$5,183	$1,000	$6,183
120V HPWH	3	80	$5,183	$1,000	$6,183
240V HPWH	3.3	50	$3,690	$1,115	$4,805
240V HPWH	3.75	50	$4,073	$1,115	$5,188
240V HPWH	4.0**	50	$4,457	$1,115	$5,572
240V HPWH	3.3	65	$4,299	$1,193	$5,492
240V HPWH	3.75	65	$4,994	$1,193	$6,187
240V HPWH	4.0**	65	$5,690	$1,193	$6,883
240V HPWH	3.3	80	$4,908	$1,291	$6,199
240V HPWH	3.75	80	$5,916	$1,291	$7,206
240V HPWH	4.0**	80	$6,923	$1,291	$8,213
240V HPWH	3.3	50	$3,563	$703	$4,267
240V HPWH	3.75	50	$3,947	$703	$4,650
240V HPWH	4.0**	50	$4,330	$703	$5,034
240V HPWH	3.3	65	$4,173	$781	$4,954
240V HPWH	3.75	65	$4,868	$781	$5,649
240V HPWH	4.0**	65	$5,563	$781	$6,345
240V HPWH	3.3	80	$4,782	$879	$5,661
240V HPWH	3.75	80	$5,789	$879	$6,668
240V HPWH	4.0**	80	$6,796	$879	$7,676
Gas WH	0.68	50	$2,095	$781	$2,876
Electric Resistance WH	0.92	50	$2,269	$703	$2,972

** The eTRM does not include a 2.2-UEF HPWH measure. Costs for 120V HPWH units in the eTRM do not vary by efficiency level so CalMTA assumed the cost of a 2.2-UEF was equal to the other eTRM 120V options.*

*** The eTRM does not include a 4.0 UEF HPWH measure. CalMTA assumed the difference in cost between a 3.3-UEF and 3.75-UEF was equal to the difference in cost between a 3.75-UEF and 4.0-UEF HPWH.*

Although CalMTA estimates that approximately 80% of 2024 HPWH installations received incentives,[21] CalMTA's market adoption model does not assume any incentives offset the upfront cost paid by consumers. Given CalMTA's expectation that California programs will continue to

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[21] CalMTA's HPWH Market Characterization Report found that incentives are widespread and often substantial, with more than 50 energy-efficiency and decarbonization programs supporting HPWH adoption and some statewide incentives exceeding $5,000 for certain customer segments. Despite that program activity, the adoption model does not assume incentives reduce customer upfront cost in the market-share calculation. This yields a conservative adoption forecast because incentives reduce MTI-attributed net adoption through the PA-verified adjustment, but do not increase adoption in the model itself.

provide incentives for gas-to-electric HPWH installations (see Section 3.5), this assumption yields conservative TMA and incremental market adoption estimates. CalMTA chose this conservative approach because the MTI budget does not include incentives and CalMTA does not control incentives offered by other programs.

3.2.4 Policy

The adoption model incorporates policy assumptions that apply to both BMA and TMA. These policies do not eliminate the distinction between the two scenarios, but they establish common background conditions that shape HPWH adoption over the forecast period. There are two enacted policies going into effect before or during the model forecast period that are expected to significantly impact HPWH installations in California: the DOE federal water-heater efficiency standard,[22] and the BAAQMD residential water heater rule.[23]

Federal Standard

The federal water-heater efficiency standard is scheduled to take effect on May 6, 2029. This final rule from DOE establishes higher minimum efficiency levels for electric storage water heaters and reinforces the long-run market shift toward HPWH technology, particularly in larger-capacity electric storage applications. The current California eTRM measure characterization also identifies the May 6, 2029, federal standard as an applicable code requirement for residential HPWH measures. In practical terms, this federal standard will eliminate the option for replacing an electric resistance water heater with a like-for-like unit. This policy effectively forces HPWH adoption for the entire electric resistance baseline market segment in the adoption model. The model accounts for this policy by forcing HPWH market share to 100% in both BMA and TMA for electric resistance replacements starting in 2030.

Bay Area Air Quality Management District

The BAAQMD's residential water heater rule is scheduled to go into effect January 1, 2027. This rule includes a zero-NOx sales requirement for residential water heaters under 75,000 Btu/hour within BAAQMD jurisdiction. This requirement limits the sale of new gas water-heater replacements in the affected size class and therefore increases the likelihood of HPWH adoption in the relevant portion of the Bay Area replacement market. This policy is accounted for in the model by forcing a portion of statewide gas water heater replacements to be HPWH in both the BMA and TMA.

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[22] U.S. Department of Energy (2024). "Energy Conservation Standards for Residential Water Heaters," Final Rule, 89 Fed. Reg. 33,820 (Apr. 29, 2024) (codified at 10 C.F.R. pt. 430), establishing a May 6, 2029, compliance date for new minimum efficiency standards for electric storage water heaters.

[23] Bay Area Air Quality Management District, Regulation 9, Rule 6: *Limits on NOx Emissions from Natural Gas-Fired, Fan-Type Central Furnaces*, establishing a zero-NOx sales requirement for residential water heaters under 75,000 Btu/hr effective January 1, 2027.

CalMTA estimated the portion of forced gas to HPWH replacements by multiplying the Bay Area share of California households by a portion of those homes estimated to be non-exempt from pending amendments to the rule that may include provisions for low-income households, and by an assumed forecasted compliance rate.[24] The product of these three factors is the statewide portion of gas replacements assumed to be forced to HPWH in each year of the forecast period.

These policy assumptions are treated as shared background conditions rather than MTI-attributed effects. The distinction between BMA and TMA therefore rests not on whether these policies exist, but on how quickly the broader market responds to them through changes in installer confidence and acceptance and through the pace of HPWH cost decline. Statewide code and policy still do not require HPWHs for all residential replacement events, so the forecast continues to depend on customer economics, baseline conditions, and the pace at which installers become comfortable recommending HPWHs as a replacement option. CalMTA estimates that the BAAQMD policy will adopt amendments that exempt approximately 20% of households and will experience a compliance rate of between 13% (at the start) and 29% (by 2048).[25]

Title 24

California's Title 24 Building Energy Efficiency Standards are an important shared background condition in both BMA and TMA, particularly for new construction. For permit applications on or after January 1, 2026, the 2025 Energy Code makes HPWHs or solar water heating with electric backup the core prescriptive water-heating pathway for low-rise residential new construction, with limited exceptions for very small dwelling units and certain one-bedroom-or-smaller applications that may use 120V HPWHs. In multifamily new construction, the 2025 code materials also add HPWH-ready requirements for both individual dwelling units and central systems, including designated space, receptacle, condensate drainage, and ventilation provisions that reduce barriers to future HPWH installation.[26]

For existing-home water-heater replacements, however, statewide Title 24 remains more permissive. CalMTA's policy review indicates that the 2025 alteration pathway still allows multiple prescriptive replacement options, including gas or propane water heating and certain qualifying HPWH pathways, depending on existing conditions. In practice, the strongest statewide Title 24 signal is in new construction and electric readiness, while the existing-home replacement market

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[24] BAAQMD, *Myths vs. Facts: Understanding the Bay Area's Building Appliance Rules*, Appliance Rules-Myths vs Facts_V2.

[25] U.S. Census Bureau (2026). Population Division, Annual Estimates of the Resident Population for Counties in California: April 1, 2020 to July 1, 2025 (CO-EST2025-POP-06), March 2026.

[26] California Energy Commission (2026). *2025 Building Energy Efficiency Standards (Title 24, Part 6)* and associated 2025 residential compliance materials describing HPWH prescriptive pathways and HPWH-ready requirements for new construction. See also CalMTA, *Residential Heat Pump Water Heating Market Characterization Report* (Feb. 13, 2026), Section 3.2.3.

continues to depend more heavily on customer economics, installation feasibility, local policy, and installer willingness to recommend HPWHs.

CalMTA therefore treats Title 24 as a shared market and policy input rather than as an MTI-attributed effect. In the adoption model, Title 24 helps explain why new construction is not included in the forecast scope and why HPWH adoption is already stronger in that segment. Within the modeled replacement market, however, Title 24 mainly serves as a background market-normalization factor that supports product familiarity, installer exposure, and long-run readiness for electrified water heating, rather than as a direct statewide mandate for HPWH replacement.[27]

3.2.5 Utility rates

CalMTA developed weighted-average residential electricity and natural gas rates for each IOU territory for use in the customer-bill calculations. These weighted rates reflect the mix of residential customers on standard and discounted tariffs, including CARE and FERA where applicable, and are intended to represent average bill conditions faced by households in each service territory. CalMTA used utility tariff and customer-enrollment data to estimate the share of customers on each major residential electric and gas rate by IOU, then calculated weighted-average rates for use in the adoption model. Table 10 summarizes the assumed rate shares by tariff and IOU.

Table 10. Utility rate shares by IOU

IOU	Fuel	% CARE	% FERA	% Standard	% EV[28]
PG&E	Electricity	23.9%	0.8%	69.6%	5.85%
PG&E	Gas	23.9%	NA	76.1%	NA
SDG&E	Electricity	23.8%	1.0%	74.1%	1.44%
SDG&E	Gas	20.7%	NA	79.3%	NA
SCE	Electricity	29.0%	0.7%	98.6%	0%
SoCalGas	Gas	30.4%	NA	69.6%	NA

[27] For more information, please see Appendix D: Market Characterization, Section 3.2.3, stating that the 2025 standards are intended to support wider adoption of heat pumps in new construction and that even where gas water heaters remain possible under the performance path, electric-ready requirements remove barriers for future HPWH change-outs.

[28] Calculated from public utility filings made pursuant to CPUC Resolution E-5105, which requires investor-owned utilities to report customer-specific information derived from rates, including the number of customers on specific rate schedules. See CPUC, Resolution E-5105 (Nov. 19, 2020); Southern California Edison, *E-5105_Data_#_of_Cust_Rate_Schedule_CZ_Public.csv* (posted on SCE's E-5105 Data Documents page); San Diego Gas & Electric, *2. No. of Cust RateSch_CZ - Public (E-5105)*, in *Resolution E-5105 Data Share PY 2024* (Sept. 2, 2025); and Pacific Gas and Electric Company, public *Building Decarbonization Resolution E-5105* workbook (2025).

The calculated weighted average utility rates are used in the calculation of customer utility bills, which is a key input to the market share equation.

3.2.6 Utility rate forecast

CalMTA used California Energy Commission (CEC) demand-forecast materials to estimate changes in utility rates over the forecast period. The California Energy Demand Forecast, developed for the 2025 Integrated Energy Policy Report, incorporates recent electricity and gas sales data, economic and demographic drivers, and anticipated electricity and gas rates.[29] CalMTA applied forecasted electricity-rate changes by IOU to the weighted average electricity rates used in the adoption model and used the CEC natural gas forecast series to project changes in residential gas costs over time. For the primary adoption forecast, CalMTA used the standard natural gas forecast for each IOU territory. CalMTA also tested alternative gas-forecast assumptions as sensitivity cases to evaluate how different gas-price trajectories affect customer economics, fuel-switch adoption, and cost-effectiveness. This forward-looking rate treatment is particularly important for HPWH adoption because future customer bill impacts depend both on equipment efficiency and evolving electricity and gas rate conditions.

3.2.7 Lifetime utility bill costs

Utility bill impacts are an important component of customer economics and play a key role in the market share calculations. Utility bills are calculated using hourly consumption shapes (unique by water heater type, UEF, and tank size) multiplied by the weighted average utility rates per IOU (described above). See Attachment 1 for details on the consumption shapes used in the adoption model. Customer utility bills after the installation year are discounted at a rate of 20%, reflecting typical customer behavior, which significantly discounts future impacts compared to upfront costs.[30] These discounted lifetime utility-bill costs are combined with upfront costs to determine the relative cost-of-ownership term used in the adoption model.

3.2.8 Installer acceptance/confidence constraint

The installer confidence and acceptance constraint is represented as a single factor over time. Conceptually, this factor reflects the extent to which HPWHs are understood, accepted, and

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[29] California Energy Commission (2026). *CED 2025 Demand Side Modeling* webpage, including "Rates by CEC Forecast Planning Area," accessed March 31, 2026.

[30] Haq, G., and Weiss, M. (2018). "Time preference and consumer discount rates – Insights for accelerating the adoption of efficient energy and transport technologies," *Technological Forecasting and Social Change*, Vol. 137. This literature supports the use of high consumer discount rates in appliance-adoption analysis because households tend to discount future bill savings much more heavily than utility or societal cost-effectiveness frameworks do, reflecting uncertainty, liquidity constraints, risk, and transaction costs. CalMTA applies a 20% discount rate as a rounded planning assumption consistent with that literature and prior CalMTA Appendix B work.

recommended by installers in each year. It is intended to capture important non-price barriers that are not fully represented by customer economics alone, including installer familiarity, confidence in household fit, installation complexity, and the practical ease of delivering HPWH projects in the field. The value of this constraint differs between BMA and TMA to reflect the extent to which coordinated MTI activities are expected to reduce those frictions over time.

The adoption model uses the same core market, policy, utility-bill, and technical assumptions in both BMA and TMA. The primary differences between the two scenarios are the forecasted pace of HPWH cost decline and the pace of improvement in the installer confidence and acceptance constraint. Framing the two scenarios this way isolates the effects of market transformation from the broader background conditions that affect HPWH adoption statewide. The assumed values of the installer confidence and acceptance constraint in the BMA and TMA scenario are shown below in Figure 2. Additional scenario-specific details are provided in Section 3.3 & Section 3.4.

3.3 Baseline market adoption

The BMA forecast represents the expected "naturally occurring" market adoption, taking into account current and expected market, regulatory, and technological trends. The BMA forecast uses the common market, policy, cost, utility-bill, and technical inputs described above, but assumes slower improvement in installer confidence and recommendations and slower decline in HPWH costs than TMA.

3.3.1 Installer confidence and acceptance

Under BMA, installer confidence and acceptance improve gradually over time, reflecting ongoing background market evolution rather than coordinated MTI-driven acceleration. Existing policy signals, incentive activity, product development, and broader electrification awareness are expected to support some increase in installer willingness to recommend HPWHs. However, the BMA forecast assumes that installer hesitation remains an important barrier in the absence of additional coordinated market transformation activity.

CalMTA's 2025 installer survey provides the primary empirical basis for this constraint. The HPWH Market Characterization Report found that surveyed installers recommended HPWHs in an average of 44% of cases overall, with recommendation rates highest in single-family applications and lower in multifamily and mobile homes.[31] The same research found that most installers expect to recommend HPWHs more often in the future, but that greater exposure to the technology, help

[31] Please see Appendix D: Market Characterization, Section 5.3.3, reporting that surveyed installers recommended HPWHs in an average of 44% of cases overall, with recommendation rates varying across single-family, multifamily, and mobile-home applications.

with incentive applications, and confidence in avoiding customer bill increases would be needed to materially increase recommendations.[32]

For modeling purposes, CalMTA does not use the raw 44% survey average directly as the statewide installer confidence and acceptance constraint. That survey result reflects recommendations across a mix of residence types and installation contexts, including some settings where HPWHs are comparatively easier to recommend. Because the installer survey does not directly identify recommendation rates by existing fuel type, CalMTA converted the survey findings into an estimated 2025 value for gas-to-electric installation cases (28%) for use in the adoption model.[33] This adjustment is intended to better reflect the full statewide replacement market, where most households currently have gas water heaters and where installer concerns about bill impacts, electrical readiness, product fit, product availability, and installation complexity remain significant. CalMTA therefore uses a modeled baseline value of 28% for current installer confidence and acceptance in BMA.

Under BMA, this effective recommendation constraint rises only modestly over time, increasing to 34% by 2032. After 2032, the BMA constraint continues to improve gradually through the end of the forecast period, consistent with Figure 2, reflecting continued market normalization from policy exposure and higher installation volume, but without the stronger acceleration assumed under coordinated MTI intervention. This gradual increase reflects expected background improvements in product familiarity and market normalization but assumes that several barriers identified in the Market Characterization Report continue to suppress broader installer confidence. In particular, installers identified low customer awareness, uncertainty around bill impacts, high upfront cost, lack of availability, installation complexity, and lack of trained staff as recurring reasons HPWHs are not selected. Taken together, these findings support a modest baseline improvement path rather than a rapid increase in installer recommendation rates.

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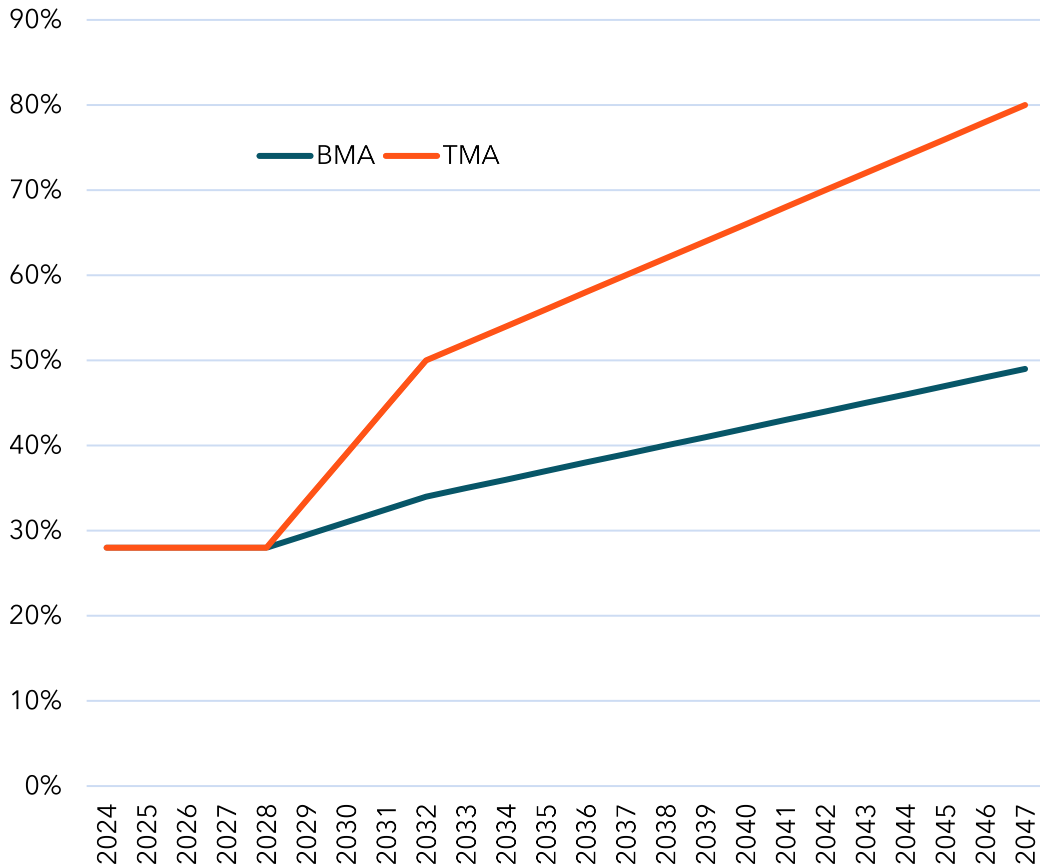
[32] Please see Appendix D: Market Characterization, Section 5.3.3, reporting that the leading factors that would increase installer recommendations of HPWHs are greater exposure to the technology, help with incentive applications, and confidence that customers can avoid utility bill increases.
[33] The first-year MTI evaluation will validate the current proportion of installers recommending HPWHs for households with gas water heating.

Figure 2. Installer confidence and acceptance constraint



3.3.2 Cost declines

Under BMA, CalMTA assumes gradual cost declines in HPWH pathways over time. These declines are applied as a flat percentage to the combined equipment and installation-labor cost of each pathway. The BMA cost-decline trajectory is intended to reflect background market evolution rather than MTI-driven acceleration.

This assumption reflects the expectation that HPWHs will become a more normalized product category in California over the forecast period as the policy and market environment continues to shift toward electrified water heating. California's policy stack is increasingly favorable to HPWH adoption, including the 2025 Title 24 code changes for new construction, the 2027 BAAQMD zero-NOx sales requirement for small water heaters in the Bay Area, and the 2029 federal water-heater efficiency standard. Together, these developments support gradual growth in product availability, broader manufacturer and distributor attention, and increased labor efficiencies in HPWH installations over time. Historical appliance standards literature also suggests that standards-driven market shifts do not necessarily produce sustained retail price increases over time, as innovation, lower markups, and economies of scale can offset added efficiency costs.[34]

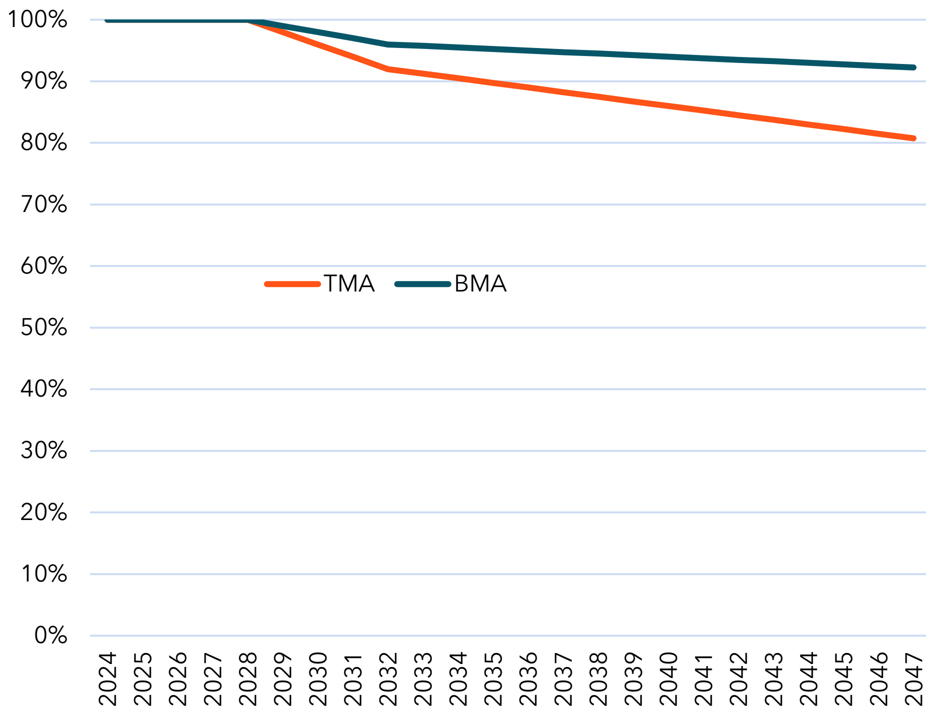
At the same time, the BMA does not assume that policy changes alone will rapidly compress costs. CalMTA's HPWH Market Characterization Report identifies upfront cost as a top barrier, with HPWH installed costs remaining materially above conventional alternatives. Manufacturer/stakeholder feedback in that report indicates that the 2029 federal standard is expected to increase HPWH volume but not necessarily reduce unit costs on its own. For that reason, the BMA cost trajectory is deliberately modest. It reflects incremental improvements in manufacturing scale, product variety, and installer familiarity, while recognizing that key barriers – installation complexity, home-fit challenges, permitting friction, and inconsistent program delivery – would still limit the pace of cost reduction absent coordinated market transformation activity.

This treatment is also consistent with broader heat-pump cost literature reviewed for this analysis,[35] which suggests that as markets scale, both equipment costs and non-equipment "soft" costs can decline, but that reductions are often gradual and uneven, especially where installation conditions remain heterogeneous and labor practices are still maturing. CalMTA therefore treats the BMA decline as a conservative market-maturation assumption rather than a precise forecast of near-term price movement.

Figure 3 summarizes the assumed HPWH cost trajectories used in the forecast, indexed to 2028 = 100. Under BMA, costs decline gradually over time, reflecting background market maturation and modest improvements in product availability, installer familiarity, and market normalization. Under TMA, costs decline more quickly because coordinated MTI activities are assumed to reduce installation friction, improve repeatability in targeted submarkets, and support more efficient market delivery. These trajectories are intended as simplified planning assumptions about the pace of cost compression under baseline conditions versus coordinated market transformation, not as precise price forecasts.

[34] Dale, L., Antinori, C., McNeil, M., and McMahon, J.E. (2002). "Retrospective Evaluation of Declining Price for Energy Efficient Appliances," in *Proceedings of the 2002 ACEEE Summer Study on Energy Efficiency in Buildings*, Panel 9: Energy and Environmental Policy (American Council for an Energy-Efficient Economy, 2002)
[35] Winskel, M., Heptonstall, P. and Gross, R. (2024). "Reducing Heat Pump Installed Costs: Reviewing Historic Trends and Assessing Future Prospects," *Applied Energy* 375 (2024): 124014.

Figure 3. Assumed HPWH cost trajectories in BMA and TMA



3.4 Total market adoption

The TMA forecast represents the adoption predicted as a result of the strategic market interventions described in the MTI Plan. Like BMA, TMA uses the common market, policy, cost, utility-bill, and technical inputs described above. The difference is that TMA assumes faster improvement in installer confidence and acceptance and faster cost decline as a result of MTI-driven market transformation activities.

3.4.1 Installer confidence and acceptance

Under TMA, CalMTA assumes faster improvement in installer confidence and acceptance than under BMA. The TMA forecast reflects the expectation that MTI interventions will address several of the non-price barriers that currently limit installer willingness to recommend HPWHs, including uncertainty around household fit, limited repeatable installation experience, inconsistent program requirements, and lack of clear market signals. Rather than assuming installer behavior improves simply because adoption rises, TMA assumes that confidence improves because the MTI is designed to make HPWHs easier to understand, easier to sell, and easier to deliver in targeted applications.

This assumption is directly aligned with the HPWH logic model and MTI strategy. The MTI's three main strategic pathways – product development and better matching of technology to housing stock, aggregation of market and program activity to build scale in easier submarkets, and stronger statewide operational infrastructure – are all intended to reduce installer friction and increase confidence in recommending HPWHs. The logic model explicitly identifies increased installer confidence and acceptance of HPWH technology as a short-term market outcome, and the MTI Plan ties that outcome to easier-to-install submarkets, better product-to-home matching, and reduced complexity for market actors.[36]

The Market Characterization Report supports this causal pathway. It found that installers are already more likely to recommend HPWHs in some applications than others, and that the top factors that would further increase recommendations are greater exposure to the technology, help with incentive applications, and confidence in avoiding utility bill increases.[37] These findings align closely with the MTI design: the MTI aims to build repeatable volume in easier submarkets, reduce administrative friction, improve messaging consistency, and better match products to California housing conditions. CalMTA therefore assumes that TMA interventions accelerate the same drivers installers themselves identified as most likely to increase recommendation rates.

For modeling purposes, TMA starts from the same current effective baseline value used in BMA, but increases more quickly over time. CalMTA assumes that the installer confidence and acceptance constraint rises from 28% today to 50% by 2032, consistent with the MTI's short- and medium-term market progress expectations. After 2032, the TMA constraint continues to rise through the end of the forecast period, consistent with Figure 2, reflecting the expectation that MTI-driven scale-up, better product-to-home matching, and stronger statewide market infrastructure continue to improve installer confidence beyond the medium-term milestone period. This faster trajectory is intended to represent the cumulative effect of targeted scale-up activity, improved installer familiarity through repeatable jobs, stronger product-to-home matching, and more consistent statewide program support. While still an assumption, this trajectory is grounded in CalMTA's survey findings and in the MTI's stated theory of change, rather than being treated as a purely aspirational forecast.[38]

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[36] Please see Appendix A: Logic Model and Appendix D: Market Characterization, Executive Summary and Strategic Interventions sections, identifying increased installer confidence and acceptance as a short-term market outcome and tying that outcome to product-to-housing matching, scale-building in easier submarkets, and stronger statewide operational infrastructure.

[37] Please see Appendix D: Market Characterization, Section 5.3.3, reporting that the leading factors that would increase installer recommendations of HPWHs are greater exposure to the technology, help with incentive applications, and confidence that customers can avoid utility bill increases.

[38] Please see Appendix D: Market Characterization, Section 5.3.3, reporting that the leading factors that would increase installer recommendations of HPWHs are greater exposure to the technology, help with incentive applications, and confidence that customers can avoid utility bill increases.]

3.4.2 Cost declines

Under TMA, CalMTA assumes faster cost declines than under BMA. As in BMA, these declines are applied as a flat percentage to the combined equipment and installation-labor cost of each HPWH pathway. The faster decline rate reflects the expected effects of MTI-driven market transformation activities that improve scale, reduce market friction, and increase supply-chain confidence in prioritized submarkets.

This assumption is directly aligned with the HPWH logic model and MTI strategy. The MTI is designed to coordinate market and program activity in ways that reduce both equipment and installation costs, including use of collective buying power, partnership with manufacturers to decrease cost, and a near-term focus on easier-to-install submarkets such as electric replacement, new construction, and other comparatively lower-friction applications. The logic model explicitly links these activities to increased installer confidence and acceptance and to declining total installation cost in targeted submarkets.[39]

The HPWH Market Characterization Report supports this causal pathway. Stakeholders and manufacturers interviewed for that report identified several concrete opportunities to reduce cost as the market develops: building market share first in "low-hanging fruit" segments such as electric-resistance replacement and homes with solar panels; using bulk purchasing through distributors; expanding turnkey and fixed-price implementation models; simplifying incentive delivery; and standardizing permitting and training to reduce transaction costs and installation friction. The report also notes that newer product form factors can improve fit in constrained homes, which can reduce costly installation complications in some segments. Under TMA, CalMTA assumes these types of coordinated interventions allow the market to capture cost reductions more quickly than would occur under baseline market conditions alone.[40]

Importantly, the TMA does not assume that HPWH costs fall simply because adoption increases. Rather, it assumes that CalMTA's interventions help convert growing demand into more efficient market delivery: stronger installer familiarity, better product-to-home matching, more consistent program rules and messaging, and greater ability for manufacturers, distributors, and implementation partners to plan around stable volume. Because current HPWH costs partly reflect a still-maturing market, these interventions are expected to reduce both hardware-related costs and installation-related soft costs faster than in BMA. Even so, the TMA cost trajectory remains

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[39] Please see Appendix A: Logic Model, identifying "Aggregate Market/Programs to Build Scale & Momentum by Submarkets," including use of collective buying power to reduce equipment and installation costs, a near-term focus on easy-to-install markets to build installer confidence, partnership with manufacturers to decrease cost, and the expected outcome that "Total installed cost decreases for targeted submarkets."

[40] Please see Appendix D: Market Characterization*,* 152–154 (describing opportunities to reduce HPWH costs through focus on "low-hanging fruit" segments such as electric-resistance replacement and new construction, bulk purchasing through distributors, turnkey and fixed-price delivery models, simplified program requirements, and permitting and training standardization).

moderate rather than aggressive, reflecting a plausible acceleration of market learning and economies of scale rather than a claim of rapid price parity in all pathways.

As shown in Figure 3, the TMA trajectory assumes earlier and deeper cost reductions than BMA, reflecting the expected effect of coordinated market activity, scale-building in easier submarkets, and improved installer efficiency over time.

3.5 IOU Territory and PA-verified units

This section describes how CalMTA accounts for adoption outside IOU territory and adoption associated with PA-verified units when estimating the adoption used in TSB and cost-effectiveness.

CalMTA first estimates statewide incremental adoption as the difference between TMA and BMA. To estimate the adoption used in TSB and cost-effectiveness, CalMTA allocates the statewide result to IOU service territories using each utility's share of California residential electric customers, derived from Form EIA-861 Schedule 4 (latest available data, 2024).[41] This yields approximate service territory shares of 36% for PG&E, 32% for SCE, and 10% for SDG&E, with the remaining 22% attributed to non-IOU utilities and excluded from IOU-level TSB and cost-effectiveness estimates. CalMTA then adjusts the statewide result to account for adoption attributed to households outside IOU service territories and for adoption associated with PA-verified units. PA-verified units represent the estimated portion of incremental adoption that are forecasted to be reported as verified savings in CEDARS by PAs and therefore shall be subtracted from incremental adoption to avoid double counting between MTI-attributed adoption and PA-claimed program activity.[42]

For the primary forecast, CalMTA assumes the share of HPWH installations receiving incentives declines from approximately 75% in 2028 to 30% by 2042, where it remains through the end of the forecast. CalMTA assumed this declining proportion over time because although the majority of HPWH installations in recent years have occurred through programs, California's HPWH incentive landscape is currently in flux, with several major program offerings expected to wind down, change, or become less central over time.[43] This assumption results in approximately 47%

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[41] Calculated from U.S. Energy Information Administration (EIA) Form EIA-861, Schedule 4 California residential customer counts, using bundled customers (Part A) plus delivery-only/unbundled customers (Part C) for PG&E, SCE, and SDG&E; the remainder of statewide residential customers was classified as "Other" (non-IOU territory). EIA-861 instructs respondents to report customer counts on Schedule 4 as the average of the 12 close-of-month customer accounts, and defines Part C as customers for whom the reporting utility provides delivery service while another company supplies the energy. The HPWH Market Characterization Report reflects the resulting rounded allocation of 36% PG&E, 32% SCE, 10% SDG&E, and 22% Other.

[42] To learn more about the CalMTA MTI Evaluation Framework, see https://calmta.org/wp-content/uploads/2025/04/Market-Transformation-Evaluation-Framework-FINAL.pdf.

[43] To learn more about program changes, please reference Appendix D: Market Characterization.

of incremental HPWH installations in IOU service territories being treated as PA-verified units on a cumulative basis, leaving the remaining 53% to contribute to net incremental TSB and cost-effectiveness estimation.

CalMTA's forecast market adoption is conservative because the model does not factor in the upfront cost reduction implied by the assumed incentives; incentives reduce the adoption attributed to the MTI, but do not increase forecasted adoption in the model itself. This approach is particularly conservative due to the high proportion of units assumed to receive incentives. CalMTA chose this conservative approach because it is not responsible for determining IOU HPWH program or incentive budgets. Because California's HPWH program landscape is evolving rapidly, this assumption is uncertain and should be trued up annually using actual units reported in CEDARS.

3.6 Net incremental market adoption

After developing the BMA and TMA forecasts, CalMTA calculated net incremental adoption for use in the TSB and cost-effectiveness forecasts, using the equation below:

$$Y^{N.incremental} = Y^{TMA} - Y^{BMA} - Y^{PA}$$

Where Y represents cumulative adoption of HPWHs over the forecast period (2028-2047). The superscripts $N.incremental$, TMA, BMA, and PA represent net incremental adoption attributed to the MTI, Total Market Adoption, Baseline Market Adoption, and PA-verified savings respectively.

The approach described above estimated TMA, BMA, and PA-adjusted net incremental adoption at a statewide level. Table 11 shows the portion of incremental adoption attributed to non-IOU territories, the portion treated as PA-verified within IOU territories, and the resulting net incremental adoption used in TSB and cost-effectiveness estimation. While the adjusted values are the appropriate values for CPUC cost-effectiveness tests, they do not fully represent the statewide benefits that will result from investment in the HPWH MTI, which are shown in Table 1.

Table 11. Net incremental adoption – HPWH units

Market Segment	Statewide incremental units	Non-IOU Territory Units	PA	Net Incremental
Group 1 – 120V Fuel Substitution	82,081	18,058	30,091	33,932
Group 2 - 240V Fuel Substitution	417,024	91,745	152,881	172,398
Group 3 – Electric baseline	1,906	420	699	788
Total	501,011	110,222	183,671	207,118

Note: Unit adoption may not sum to total due to rounding.

4 Load shapes

CalMTA used hourly electric and gas load shapes developed from building energy simulations of baseline and proposed water-heating cases. These load shapes represent annual hourly impacts associated with a single HPWH installation condition and are used for customer utility bill calculations and also as inputs to the TSB and cost-effectiveness calculations. More detail on the energy-modeling methods, case definitions, hourly load-shape construction, weighting assumptions, and avoided-cost calculations used for this MTI is provided in Attachment 1: Documentation of unit energy savings and avoided cost calculations for residential heat pump water heatersEnergy savings.

5 Unit energy impacts

CalMTA developed unit energy impact estimates for the baseline and proposed HPWH pathways included in the MTI. These pathways distinguish between fuel-substitution cases, in which HPWHs replace gas water heaters, and electric-baseline cases, in which HPWHs replace electric-resistance water heaters. In general, fuel-substitution cases increase electricity use while reducing gas use, whereas electric-resistance replacement cases reduce electricity use.

The technical analysis uses EnergyPlus-based simulations built from CPUC DEER prototype models. The framework analyzes three representative residential building types (single-family, multifamily, and mobile home) and uses hourly load profiles to generate 8,760-hour savings shapes for the modeled installation scenarios. The resulting unit energy impacts are then applied in the avoided-cost and cost-effectiveness calculations. Annual unit energy savings values by installation case are summarized in Appendix C: Product Assessment Report, section 8.2.

6 Effective useful life

The model uses a 20-year effective useful life for residential HPWH installations. This value is based on the DEER/eTRM treatment of residential HPWHs and is applied under a normal-replacement assumption across the modeled installation cases.

7 Total system benefit

Total System Benefit is calculated as the present value of avoided electric, gas, and greenhouse gas (GHG) impacts associated with incremental HPWH adoption, less the corresponding additional cost components included in the analysis. In addition to the adjusted TSB values used for CPUC cost-effectiveness testing, CalMTA presents co-created and statewide TSB estimates to reflect the broader California market impacts associated with the MTI.

TSB is a function of the inputs described in earlier sections. The team used the following CET-based formula to determine TSB:[44]

$$(Electric\ Benefits + Gas\ Benefits + \ Refrigerant\ Benefits)$$

$$- (Electric\ Supply\ Cost + Gas\ Supply\ Cost + \ Refrigerant\ Costs)$$

CalMTA categorized the avoided cost components into three categories: energy benefits, grid benefits, and GHG benefits. Table 12 lists the ACC workbook factors from the electric and gas models by the three categories for reporting. The specific avoided-cost inputs and modeling assumptions corresponding to these categories are summarized in Table 13.

Table 12. Avoided cost components by category

Category	Electric Model	Gas Model
Energy	Energy	Market (commodity)
Grid	Generation capacity	Transmission and distribution
	Transmission capacity	
	Distribution capacity	
	Ancillary Services	
	Losses	
GHG	Cap and trade	Environment (CO_2 and NO_X emission)
	GHG adder	Upstream methane leakage
	GHG rebalancing	Behind-the-meter methane leakage
	Methane leakage	Gas air quality adder
	Air quality adder	N/A

7.1 Avoided costs

CalMTA used the CPUC Avoided Cost Calculator (ACC) to estimate avoided electric, gas, and refrigerant impacts associated with incremental HPWH adoption. Avoided-cost values are paired with hourly load shapes and unit energy impacts to estimate system benefits over the life of the measure. The analysis uses the 2024 ACC workbooks and applies representative climate zones for each IOU territory in the avoided-cost calculations.[45]

Table 13. Avoided cost inputs

Input	Assumption

[44] The CET formula *((ElectricBen+GasBen+NumUnits * (NTGRkWh+ MarketEffectsBenefits) * RefrigBens) - (ElecsupplyCost + GasSupplyCost) + NumUnits * (NTGRkWh + MarketEffectsCosts) * UnitRefrigCosts)* was simplified to represent refrigerant benefits and costs as total values, consistent with the electric and gas benefits. NTG Ratio is assumed to be 1 for this analysis and MarketEffectsBenefits are assumed to be 0.

[45] California Public Utilities Commission, *2024 Avoided Cost Calculator Documentation, Version 1b*; see also CPUC DER Cost-Effectiveness Tools and Updates.

Avoided-cost framework	CPUC Avoided Cost Calculator
ACC version	2024 ACC workbooks
Electric avoided costs	PG&E, SCE, SDG&E
Gas avoided costs	PG&E, SCE, SDG&E
Refrigerant avoided costs	Included
Avoided-cost years	2024–2054
Post-2054 treatment	2054 value used as proxy
TRC / PAC discounting	Average nominal discount rate of 7.30%
SCT discounting	3% real (5.06% nominal)
Representative climate zones	PG&E-CZ12, SDG&E-CZ7, SCE-CZ10

Avoided costs are defined as the marginal costs of energy that the utility would avoid in any given hour through lower energy consumption. The electric avoided costs include cap and trade, GHG adder, GHG rebalancing, energy, generation capacity, transmission capacity, distribution capacity, ancillary services, losses, and methane leakage. Gas-avoided costs include transmission and distribution, commodity, nitrogen oxides, carbon dioxide, and methane leakage.

CalMTA developed measure-specific avoided cost values using the latest E3 2024 ACC for PG&E, SCE, and SDG&E.[46] CalMTA included avoided costs from 2024 to 2054 in each utility's territory and used these to determine the TSB, as well as TRC and PAC ratios. For HPWHs in operation from 2055-2067, beyond the range of estimated avoided costs in the ACC, the analysis used the 2054 avoided cost value as a proxy. CalMTA applied avoided costs to the incremental adoption for PG&E, SCE, and SDG&E for each installation condition in each year. Next, CalMTA aggregated and discounted these benefits using the average nominal discount rate of 7.30%[47] to determine the MTI TSB in 2027 dollars. The discount rates applied in the analysis are shown in Table 14.

Table 14. Discount rate by IOU

IOU	Discount Rate
PG&E	7.27%
SCE	7.44%
SDGE	7.18%
Average discount rate	7.30%

The ACC incorporates these societal benefits in their avoided costs. The team applied the base and high SCT specific avoided costs to the incremental adoption for PG&E, SCE, SDG&E. Like the

[46] Avoided Cost Calculator for Distributed Energy Resources (DER) - E3 Version 2024 V1b.

[47] 2024 Avoided Cost Calculator Guidance. 2024-acc-documentation-v1b_clean_posted_nowm.pdf.

TRC and PAC analyses, the team aggregated and discounted these benefits to determine the base and high SCT TSB in 2027 dollars.

7.1.1 TSB results

Table 15 shows the TSB estimates disaggregated for energy, grid, GHG, and refrigerant impacts.

Table 15. TRC, PAC, base SCT, and high SCT TSB estimates, 2028-2047

MTI Approach	TSB ($M)[48]	Energy ($M)	Grid ($M)	GHG non-refrigerant ($M)	GHG refrigerant ($M)
TRC	618.68	70.53	10.08	557.41	-19.35
SCT base	1,267.28	108.95	15.34	1,172.19	-29.20
SCT high	1,262.82	108.95	15.34	1,167.73	-29.20

Source: CalMTA estimates.

7.1.2 Co-created and statewide TSB

Co-created TSB: Co-created impacts refer to the total impacts (including utility-reported savings) influenced by the MTI. As described earlier, CalMTA estimated market adoption associated with PA-verified savings and subtracted it from incremental market adoption to calculate net incremental adoption for each year of the forecasting period in accordance with guidance in the MTI Evaluation Framework. While the TSB reported in this plan was calculated applying net incremental adoption, CalMTA conducted an additional analysis to estimate "co-created" TSB that included PA-verified adoption influenced by the MTI for the three IOUs and on a statewide basis as shown in Table 16.

Co-created Statewide TSB: The HPWH MTI is a California-wide effort. Because avoided costs for PG&E, SCE, and SDG&E do not fully represent the entire state, CalMTA conducted an additional analysis to estimate statewide TSB. CalMTA developed adoption estimates for "non-IOU" territories (described in Program Verified Units) and developed avoided costs for non-program adoption by applying population-weighted average avoided costs for the three utilities. The resulting co-created TSB estimates are shown in Table 16.

Table 16. Co-created and statewide TSB

TSB Basis	TSB ($M)
TSB "attributed" to CalMTA (IOU service territory only, and excludes program verified units)	618.68
Co-created TSB (IOU service territory only, and includes program verified units)	1,167.31

[48] TSB refers to Total System Benefits for the TRC test and Total Societal Benefits for the SCT.

TSB Basis	TSB ($M)
Co-created Statewide TSB (statewide and includes program verified units)	1,496.56

8 Cost-effectiveness

CalMTA estimated TSB and cost-effectiveness by combining the MTI-driven adoption forecast with initiative costs, incremental measure costs, avoided costs, load shapes, and unit energy impacts. This application of inputs considers the baseline installation conditions, baseline and efficient technologies, fuel types, target segments, and the costs incurred by the relevant market actors. The key inputs to the cost-effectiveness analysis are: MTI-driven adoption, initiative costs, incremental measure costs, avoided costs, load shapes, and unit energy impacts.

8.1 Initiative costs

Initiative costs represent the cost of implementing the MTI over the forecast period. These costs include the activities required to develop and support the market, including program management, research and evaluation, data and market intelligence, messaging and marketing, manufacturer and supply-chain engagement, and related statewide coordination activities. Total initiative costs including Phase II and Phase III costs, are $46.4M (see Appendix H, Phase III Cost Estimate of the MTI plan).

Initiative costs are used as inputs for all cost-effectiveness tests. All test parameters are in line with California Cost-Effectiveness standard practices.[49]

8.2 Incremental measure cost

Incremental measure costs (IMCs) represent the cost borne by the participant and reflect the difference in cost between the baseline water-heating technology and the HPWH pathway. IMCs vary across baseline conditions and HPWH pathways and may include equipment costs, installation labor, electrical upgrade costs, and other installation-related costs where applicable.

Table 17. Incremental measure cost

Cost Type	Total Incremental Measure Costs ($M)
Nominal	815.3
Present Value (2027 dollars)	333.8

[49] CPUC (2001). California Standard Practice Manual. cpuc-standard-practice-manual.pdf.

8.3 Cost-effectiveness

8.3.1 Total resource cost test

The TRC test compares the life cycle benefits that the MTI will deliver to the costs associated with achieving those benefits from the perspective of the MTI administrator and the participant. Net benefits, initiative costs (not including FDIs), and IMC are used to determine TRC. The non-FDI initiative costs are summed together with the IMC and discounted over the period of the MTI's implementation. The discounted net life cycle benefits for all installation conditions are divided by the sum of the discounted IMC and non-FDI Initiative costs to determine the MTI TRC ratio. Below is the CET formula used by the Excel tool to determine TRC:

$$(Electric\ Benefits\ +\ Gas\ Benefits\ +\ Other\ Benefits)\ /\ TRC\ Cost$$

8.3.2 Program administrator cost test

The PAC test compares the life cycle benefits that the MTI will deliver to the costs associated with achieving those benefits from the perspective of the MTI administrator. Net benefits and initiative costs (including FDIs) are used to determine PAC. The initiative costs are discounted over the lifetime of the MTI's implementation. The discounted net life cycle benefits for all installation conditions are divided by the sum of the initiative costs to determine the MTI PAC ratio. Below is the CET formula used by the Excel tool to determine PAC:

$$(Electric\ Benefits\ +\ Gas\ Benefits\ +\ Other\ Benefits)\ /\ PAC\ Cost$$

8.3.3 Societal cost test

The SCT compares the life cycle benefits the MTI will deliver to the costs associated with achieving those benefits from the perspective of California as a whole. Net benefits, initiative costs (not including FDIs), and IMC are used to determine TRC. The non-FDI initiative costs are summed together with the IMC and discounted over the period of the MTI's implementation. The discounted net life cycle benefits for all installation conditions are divided by the sum of the respective discounted IMC and non-FDI Initiative costs to determine the MTI SCT ratio. Below is the formula used by the Excel tool to determine the base SCT ratio:

$$(Base\ SCT\ Electric\ Benefits\ +\ Base\ SCT\ Gas\ Benefits\ +\ Other\ Benefits)\ /\ SCT\ Cost$$

Below is the formula used by the tool to determine the high SCT ratio:

$$(High\ SCT\ Electric\ Benefits\ +\ High\ SCT\ Gas\ Benefits\ +\ Other\ Benefits)\ /\ SCT\ Cost$$

8.3.4 Cost-effectiveness results

Table 18 provides the cost-effectiveness estimates for the MTI over the period 2028-2047.

Table 18. MTI cost-effectiveness estimates, 2028-2047

TRC	PAC	Base SCT	High SCT
1.67	16.82	2.70	2.69

8.3.5 Cost-effectiveness schedule

Table 20 shows the cumulative TSB and cost-effectiveness estimates and incremental investment required every five years for the HPWH MTI. Although cost-effectiveness for MTIs is properly calculated only over the entire MTI lifetime (2028-2047),[50] Table 20 illustrates the fact that cost-effectiveness is fully realized only after the MTI affects the structural market changes described in the MTI logic model and program theory.

Table 19. Incremental Investment and Cost effectiveness, at five-year timepoints

Estimated incremental investment required over period	2028-2032	2033-2037	2038-2042	2043-2047
Nominal dollars ($M)	29.6 [a]	10.1	1.2	1.0
Cost-Effectiveness Forecast at time point	**2032**	**2037**	**2042**	**2047**
TSB ($M)	46.3	193.2	398.1	618.7
TRC ratio	0.66	1.12	1.43	1.67
PAC ratio	1.54	5.361	10.91	16.82

[a] Includes Q4 2027 expenses

9 Sensitivity analysis

CalMTA conducted sensitivity analyses to evaluate how key assumptions affect HPWH adoption, total system benefit (TSB), and cost-effectiveness (Table 18). CalMTA identified six model inputs or assumptions to which the MTI incremental impact forecast is sensitive (analyses 1-6). For each of these six variables, the analysis changes one input or assumption relative to the base model while holding the remaining model structure and assumptions constant. This approach isolates the effect of each variable on customer economics, installer-driven market adoption, and benefit-cost outcomes. The tested cases focus on assumptions that are especially important in the HPWH market:

- Future natural gas price trajectories (analyses 1 and 2)
- Installer confidence and recommendation (analysis 3)

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[50] Prahl, R. and Keating, K. (2014). Building a Policy Framework to Support Energy Efficiency Market Transformation in California. MT_Policy_White_Paper_final_Dec 9 2014.doc (live.com).

- The pace of HPWH cost decline (analysis 4)
- Electric rate design (analysis 5)
- Emerging policy requirements affecting electric water-heater sales (analysis 6)

In addition to analyzing the sensitivity of MTI incremental impacts and cost-effectiveness to individual variables, CalMTA analyzed results for two combinations of variables:

- a "low adoption" scenario that considers the combination of conditions that would be *less* favorable to market transformation (analysis 7)
- a "high adoption" scenario that considers the combination of conditions that would be *more* favorable to market transformation (analysis 8).

As illustrated in Table 20, the MTI is forecast to be cost-effective across all scenarios. Net incremental TSB is estimated to range from $217 million in a combined "low adoption" scenario, which features CEC's low gas forecast, lower-than-anticipated MTI influence on market acceptance, and timely, effective CARB regulation of appliance sales as currently proposed to $1.3 billion in the combined "high adoption" scenario, which features relatively higher increases in gas rates, faster declines in HPWH upfront costs, and substantial increases in electrification-friendly rates over the MTI lifetime.

The specific assumptions and results for each sensitivity analysis are described in the sections that follow.

Table 20. MTI cost-effectiveness estimates, 2028-2047 – sensitivity analysis

Sensitivity Analysis	Net Incremental Adoption	TSB ($M)	TRC Ratio	PAC Ratio	Base SCT Ratio	High SCT Ratio
Primary Forecast	207,118	618.68	1.67	16.82	2.70	2.69
Single Variable Analyses						
1) High gas forecast	366,178	1,069.26	1.82	29.07	2.91	2.9
2) Low gas forecast	152,081	465.18	1.54	12.65	2.50	2.49
3) Lower installer confidence/acceptance	121,542	364.26	1.55	9.90	2.53	2.52
4) Faster cost declines	260,833	772.86	1.91	21.01	3.09	3.08
5) Electrification-friendly rates	253,304	753.11	1.71	20.48	2.76	2.75
6) CARB regulations	163,206	488.23	1.61	13.27	2.62	2.61
Combined "Low" and "High" Scenarios						
7) Low adoption scenario (Combination of scenarios 2, 3 and 6)	70,597	217.07	1.33	5.9	2.20	2.19
8) High adoption scenario (Combination of scenarios 1, 4 and 5)	456,563	1,332.06	2.04	36.22	3.28	3.26

Additional context and summary findings for each of the eight sensitivity analyses follows, below.

9.1 High gas forecast

This sensitivity analysis replaces the central CEC natural gas forecast used in the base model with the CEC high gas forecast, while leaving all other assumptions unchanged.[51] The purpose of this case is to test the degree to which faster-than-expected growth in residential gas prices would improve the relative customer economics of HPWH adoption, particularly in fuel-switching applications. Because lifetime utility-bill impacts are an important component of the model's cost-of-ownership calculation, higher gas prices would be expected to make HPWHs more attractive relative to gas water heaters and therefore increase adoption, TSB, and cost-effectiveness relative to the base case. Results for this sensitivity analysis are shown in Table 21.

Table 21. MTI cost-effectiveness estimates, sensitivity analysis 1: high gas forecast

Sensitivity Analysis	Net incremental adoption	TSB ($M)	TRC
Primary Case	207,118	618.68	1.67
High gas forecast	366,178	1,069.26	1.82

9.2 Low gas forecast

This sensitivity analysis replaces the central CEC natural gas forecast with the CEC low gas forecast, while holding all other model assumptions constant. This case tests downside risk associated with more moderate gas-price growth over time, which would weaken the customer bill-savings case for fuel-switching to HPWHs. In this scenario, HPWH adoption is expected to be lower than in the base model because slower gas-price growth reduces the economic advantage of HPWHs relative to conventional gas water heaters in affected segments. Results for this sensitivity analysis are shown in Table 22.

Table 22. MTI cost-effectiveness estimates, sensitivity analysis 2: low gas forecast

Sensitivity Analysis	Net incremental adoption	TSB ($M)	TRC
Primary Case	207,118	618.68	1.67
Low gas forecast	152,081	465.18	1.54

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[51] California Energy Commission (2026). *California Energy Demand Forecast, 2025–2045*, adopted January 21, 2026, Docket No. 25-IEPR-03. Gas end-use rate forecasts: TN 268728, "CA Gas End Use Rates" (Feb. 19, 2026). Demand-side modeling materials available at https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report-iepr/2025-integrated-energy-policy-report.

9.3 Lower installer confidence/acceptance in TMA

This sensitivity analysis assumes slower improvement in installer confidence and acceptance under TMA than in the base model, while holding all other assumptions unchanged. In the HPWH adoption model, this constraint represents non-price barriers that are not fully captured through customer economics alone, including installer familiarity with the technology, confidence in household fit, perceived installation complexity, and willingness to recommend HPWHs in the field. This case is intended to test the importance of market-readiness barriers and to reflect a scenario in which CalMTA's efforts to improve product recommendation, familiarity, and repeatable installation experience are less successful than assumed in the primary forecast. The constraint values used in this sensitivity analysis are shown in Figure 4 and the results are shown in Table 23.

Figure 4. Constraint values used in sensitivity analysis

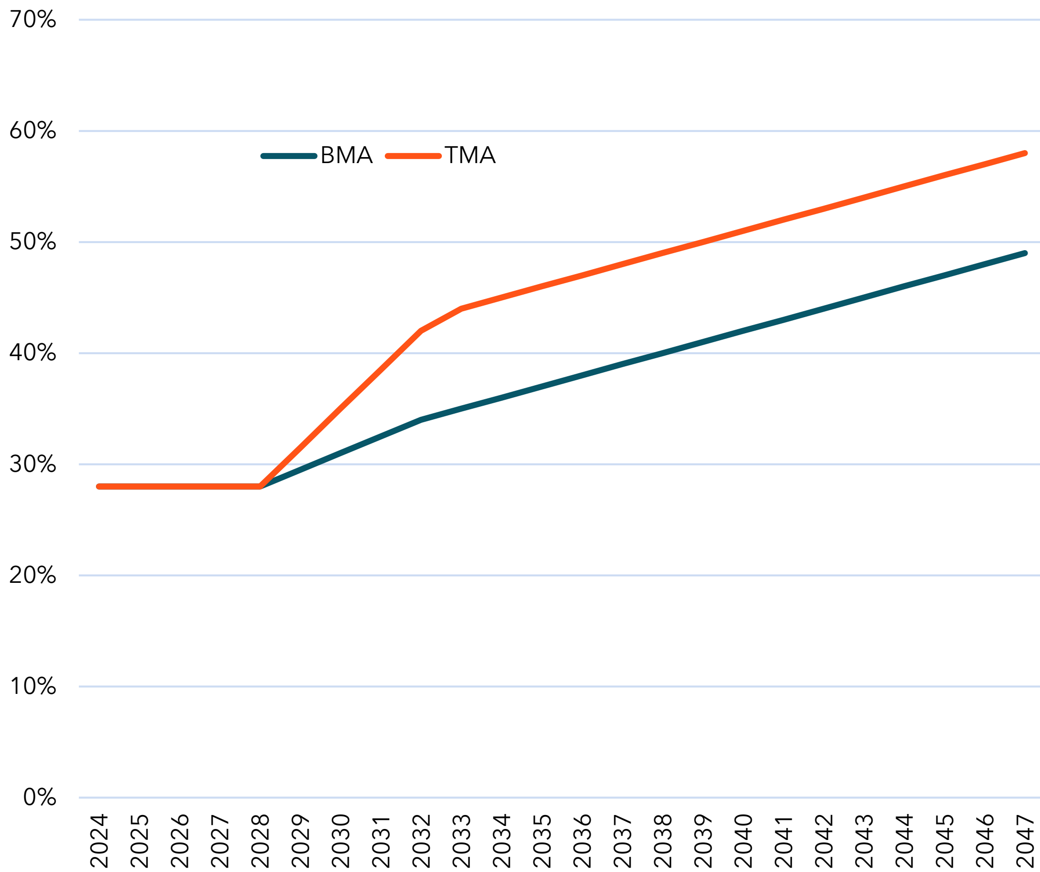

Table 23. MTI cost-effectiveness estimates, sensitivity analysis 3: lower installer confidence/acceptance in TMA

Sensitivity Analysis	Net incremental adoption	TSB ($M)	TRC
Primary Case	207,118	618.68	1.67
Lower installer confidence and acceptance in TMA	121,542	364.26	1.55

9.4 Faster cost declines

This sensitivity analysis assumes faster decline in HPWH costs under TMA than in the base model, while leaving the remaining assumptions unchanged. The purpose of this case is to test upside potential if CalMTA's market transformation activities reduce equipment and installation costs more quickly than assumed in the primary forecast. This assumption is consistent with the MTI theory of change, which links greater installer experience, more repeatable installations, coordination across programs, and increased market scale to lower installation friction and lower total installed cost. Because lower incremental costs improve both customer economics and benefit-cost ratios, this case is intended to capture the potential for stronger adoption and higher cost-effectiveness if the market matures faster than expected. The cost decline values used in this sensitivity analysis are shown in Figure 5 and the results are shown in Table 24.

Figure 5. Cost declines used in sensitivity analysis

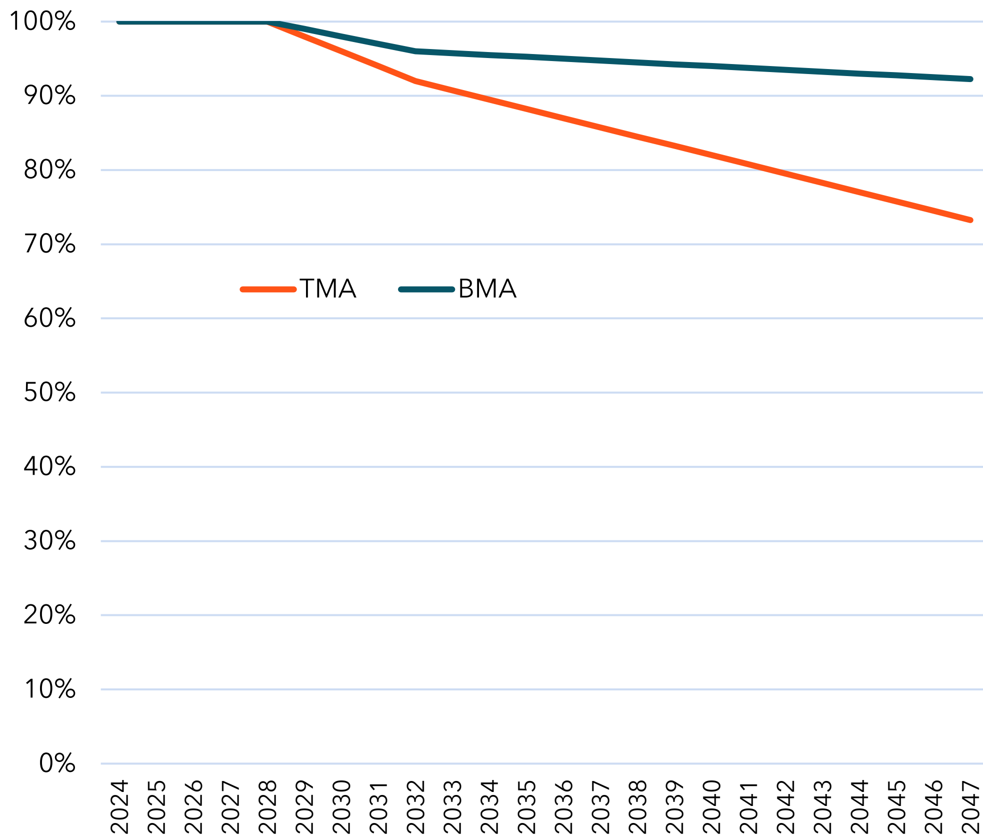

Table 24. MTI cost-effectiveness estimates, sensitivity analysis 4: faster cost declines in TMA

Sensitivity Analysis	Net incremental adoption	TSB ($M)	TRC
Primary Case	207,118	618.68	1.67
Faster cost declines	260,833	772.86	1.91

9.5 Electrification-friendly rates

This sensitivity analysis assumes that the share of customers on electrification-friendly rates increases substantially above the base case, using each IOU's EV time-of-use rate offerings as a proxy. The scenario is intended to represent a market in which rate designs better aligned with HPWH load profiles become much more common over time, rising from a small share today to a substantial share of customers by 2030 and increasing further in later years. This case tests the degree to which more favorable electric rate design could improve HPWH bill impacts and, in turn, support greater fuel-switch adoption and stronger cost-effectiveness outcomes. Because California's rate landscape is evolving rapidly, the proportion of consumers on and forecast to be on electrification-friendly rates should be trued up periodically. For this sensitivity analysis, the model assumes electrification-friendly rates rising to 50% by 2035 and 70% by 2047 statewide. The results for this sensitivity analysis are shown in Table 25.

Table 25. MTI cost-effectiveness estimates, sensitivity analysis 5: electrification-friendly rates

Sensitivity Analysis	Net incremental adoption	TSB ($M)	TRC
Primary Case	207,118	618.68	1.67
Electrification-Friendly Rates	253,304	753.11	1.71

9.6 CARB regulations

This sensitivity analysis applies an alternative policy case in which future CARB regulations increase the required share of water-heater sales that must be zero-emission, beginning with a meaningful sales requirement in 2030 and increasing further in later years. For this analysis, HPWHs are treated as the relevant electric storage water-heater pathway, consistent with the federal 2029 water-heater standard. The purpose of this case is to test how an additional statewide policy driver beyond those already embedded in the base model could accelerate HPWH market adoption and improve MTI outcomes. This scenario is best understood as a policy-overlay case that tests the incremental effect of stronger zero-emission sales requirements on top of the underlying market transformation forecast.

For this analysis, the model enforces statewide HPWH share targets of 40% of total water-heater sales beginning in 2030, ramping linearly to 50% by 2040 and held flat at 50% thereafter. When the BMA scenario's modeled HPWH share falls below the CARB target in a given year, the shortfall is treated as policy-forced HPWH adoption and allocated across Group 1 and Group 2 proportionally to each group's share of statewide replacement flow. The forced units are applied equally to both BMA and TMA, which narrows the incremental difference between the two scenarios and reduces net incremental adoption attributed to the MTI. The results for this sensitivity analysis are shown in Table 26.

Table 26. MTI cost-effectiveness estimates, sensitivity analysis 6: CARB regulations

Sensitivity Analysis	Net incremental adoption	TSB ($M)	TRC
Primary Case	207,118	618.68	1.67
CARB regulations	163,206	488.23	1.61

9.7 Low adoption scenario

This sensitivity analysis combines the individual assumptions that reduce HPWH adoption relative to the base model, including the low gas forecast and slower improvement in installer confidence and acceptance. The purpose of this case is to illustrate a plausible downside scenario in which customer economics and market readiness both evolve less favorably than assumed in the primary forecast. This scenario is not intended to represent CalMTA's expected outcome; rather, it tests the robustness of the MTI under materially less favorable conditions. The results for this sensitivity analysis are shown in Table 27.

Table 27. MTI cost-effectiveness estimates, sensitivity analysis 7: low adoption scenario

Sensitivity Analysis	Net incremental adoption	TSB ($M)	TRC
Primary Case	207,118	618.68	1.67
Low Adoption Scenario	70,597	217.07	1.33

9.8 High adoption scenario

This sensitivity analysis combines the individual assumptions that increase HPWH adoption relative to the base model: the high gas forecast, broader adoption of electrification-friendly rates, and faster HPWH cost declines. The combined case is intended to illustrate a plausible upside scenario in which multiple favorable market conditions occur simultaneously and reinforce one another. Together, these conditions improve customer economics both by increasing the cost of the baseline gas alternative and by reducing the cost and bill impacts of the HPWH option. This case provides an estimate of the MTI's upside potential if market conditions and MTI-driven improvements prove more favorable than assumed in the primary case. The results for this sensitivity analysis are shown in Table 28.

Table 28. MTI cost-effectiveness estimates, sensitivity analysis 8: high adoption scenario

Sensitivity Analysis	Net incremental adoption	TSB ($M)	TRC
Primary Case	207,118	618.68	1.67
High Adoption Scenario	456,563	1,332.06	2.04

Attachment 1: Documentation of unit energy savings and avoided cost calculations for residential heat pump water heaters

This document provides a reference of the scenarios and methodology used to develop unit energy savings shapes and avoided cost calculations that serve as inputs to the cost-effectiveness and TSB models for the HPWH MTI.

Product information

The residential HPWH market transformation initiative (MTI) will target HPWH products with the following attributes:

1) Integrated units or split-systems
2) Shared- or dedicated-circuit 120V and/or 240V configurations
3) Certified effective storage volume less than or equal to 120 gallons
4) Meets *Version 5.0 ENERGY STAR Program Requirements for Residential Water Heaters*, including minimum uniform energy factor (UEF) and warranty

The scope of the Residential HWPH MTI does not include HPWHs used in nonresidential applications, commercial water heaters, central water heaters, point-of-use water heaters, or other water heating systems composed of multiple heating units.

Most integrated HPWHs include supplemental electric resistance heat in addition to the heat pump; these are known as hybrid HWPHs. HPWHs that meet the MTI definition may include supplemental electric resistance heat, but it is not required for the MTI.

This MTI includes HPWHs with an effective storage volume less than or equal to 120 gallons, consistent with the maximum effective storage volume defined by the DOE 2029 federal standards for residential electric water heaters.[52] While HPWH units with nominal storage capacity less than 40 gallons are not currently available on the market, alignment with DOE standards extends to possible future product development, such as compact or point-of-use HPWHs.

[52] Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 430, Subpart C, 430.32, Table 14 to Paragraph (d)(2). https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32.

UEF is the residential water heater overall efficiency metric defined by the DOE test procedure.[53] Products qualifying for the Residential HPWH MTI shall meet the most current minimum UEF requirements in the ENERGY STAR Program Requirements for Residential Water Heaters, which vary by HWPH type. At the time of writing, the ENERGY STAR Version 5.0 UEF requirements are as follows:

- Integrated HWPH: UEF ≥ 3.30
- Integrated HWPH, 120 Volt / 15 Amp Circuit: UEF ≥ 2.20
- Split-system HPWH: UEF ≥ 2.20

The CalMTA team conducted whole-building energy modeling to simulate annual energy demand using DEER prototypes for the California HPWH eTRM measures, SWWH025[54] and SWWH014.[55] To best align with the energy savings estimates in the eTRM, the models were used without modification, except to adjust the HPWH unit UEF when the existing eTRM values did not match the MTI product definition. The modeling incorporated DEER models for gas storage, electric resistance storage, 240V HPWH, and 120V HPWH models for single-family, multifamily, and mobile home building prototypes. Each building type has a unique hot water draw profile with 1-minute resolution developed for the 2026 eTRM measures.

Baseline equipment

For normal replacement, we consider baseline installation cases of gas storage tank water heaters, electric storage tank water heaters, and lower efficiency HPWHs. Baseline efficiencies are consistent with DOE's minimum efficiency requirements. The current federal minimum UEF for electric storage water heaters less than 50 gallons is 0.92. Baseline UEF values for gas storage water heaters and HPWHs correspond to the federal minimum efficiency standards effective on May 6, 2029, with UEF of 0.68 and 2.3 for gas storage water heaters and HPWHs, respectively. Table 29 summarizes energy source, voltage, UEF, and nominal tank volume for the baseline equipment.

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[53] "Uniform Test Method for Measuring the Energy Consumption of Water Heaters," 10 C.F.R. pt. 430, subpt. B, app. E (2025) https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B/appendix-Appendix%20E%20to%20Subpart%20B%20of%20Part%20430

[54] Database for Energy Efficient Resources (DEER) (2025). "HPWH eTRM Measure: Residential, Fuel Substitution, SWWH025-09," California Technical Forum, https://www.caetrm.com/measure/SWWH025/09/.

[55] Database for Energy Efficient Resources (DEER), (2025). "HPWH eTRM Measure: Residential, SWWH014-07," California Technical Forum, https://www.caetrm.com/measure/SWWH014/07/. At the time of analysis these measures were in draft final form, and the team used the values published in the draft measures on January 8th, 2026.

Table 29. Baseline water heater characteristics and efficiency levels

Characteristic	Electric resistance storage	Gas storage	Minimum efficiency HPWH
Energy source	Electric	Natural Gas	Electric
Voltage	240V	N/A	240V
UEF	0.92	0.68	2.3
Nominal tank volume (gal.)	50	50	50 or 80

Proposed equipment

Proposed equipment are HPWHs that meet the ENERGY STAR definition as mentioned previously. These products have a UEF of 2.20 for the 120V products and 3.30 for the 240V products. Fifty- and 80-gallon storage tanks are considered for the 240V HPWHs, while only 80-gallon tanks are considered for the 120V HPWHs. Table 30 summarizes the energy source, voltage, UEF, and nominal tank volume for proposed HPWHs.

Table 30. Proposed water heater efficiency levels and design characteristics

Characteristic	120V HPWH	240V HPWH
Energy source	Electric	Electric
Voltage	120V	240V
UEF	2.2	3.3
Nominal tank volume (gal.)	80	50 or 80

Energy modeling software

DOE's open-source building energy modeling software, EnergyPlus, was used in this work (version 22.1). EnergyPlus simulates whole-building energy consumption on sub-hourly timesteps and can output hourly energy consumption of the whole building and water heating equipment on an hourly basis, which is used here as the basis of the generated savings shapes. In this case, the simulations are set to run with 60 timesteps per hour to accurately model HPWH operation.[56] Each savings shape is an annual hourly profile of electricity consumption (in kWh) and gas consumption (in therms) that is the difference between the baseline and proposed residential HPWH equipment for different energy models. The final hourly savings shapes include contributions from multiple building types and climate zones as discussed in subsequent sections.

[56] For most EnergyPlus models it is common to use 10 or less timesteps per hour to balance computation time with accuracy; however, a higher resolution of 60 time steps per hour is required to more accurately model water heater temperature stratification. This is the default setting in the eTRM HPWH models.

Building models

Building energy modeling was performed using EnergyPlus with DEER residential prototype building models to represent existing residential building stock in California. The water heater eTRM measures place the water heaters in an unconditioned interior space and include a dependency upon the ambient air temperature within the energy model and the supply water temperature from the local weather file. The DEER modeling framework uses the same single-family building prototype to simulate water heating energy consumption for all building types, by just changing the hot water demand profile as noted in Table 31. This was not a decision made by the MTI team and is directly following the DEER modeling framework for residential water heating. It should be noted that the single-family existing building prototype is the basis of the energy model, but this can represent the energy savings for new construction as well since only the energy from the water heating is being used in the calculation.

Table 31. Description of buildings used for energy modeling

Source	Building Vintage	Represented Building Type	Actual Building Type	Building Area [ft²]	Average Daily Hot Water Draw (gal.)
DEER	Existing	Single-family	Single-family	1,671	43.0
DEER	Existing	Multifamily	Single-family	1,671	39.1
DEER	Existing	Mobile home	Single-family	1,671	36.3

Case descriptions

There are eight different modeling cases that are used to create the proposed and baseline installations in the final seven blended scenarios for final savings shapes and avoided cost calculations. Table 32 gives a description of each modeling case.

Table 32. Summary of case characteristics

#	Case name	Case description[57]
1	Stor_UEF-120vHP-080gal-2.20UEF	120V HPWH, UEF=2.2, TV=80 gal, with ER[58]
2	Stor_UEF-120vHP-080gal-2.20UEF_no-ER	120V HPWH, UEF=2.2, TV=80 gal, no ER
3	RE-WaterHtg_eq-HP_UEF-50g-MDHI-3.30UEF-240V	240V HPWH, UEF=3.3, TV=50 gal, with ER
4	RE-WaterHtg_eq-HP_UEF-80g-MDHI-3.30UEF-240V	240V HPWH, UEF=3.3, TV=80 gal, with ER
5	RG-WaterHtg_eq-Stor_UEF-50g-HI-0.68UEF	Gas storage tank, UEF=0.68, TV=50 gal

57 TV = tank volume

58 ER = electric resistance

#	Case name	Case description[57]
6	RE-WaterHtg_eq-Stor_UEF-50g-MD-0.92UEF-240V	Electric resistance storage tank, UEF=0.92, TV=50 gal
7	RE-WaterHtg_eq-HP_UEF-50g-MDHI-2.30UEF-240V	240V HPWH, UEF=2.3, TV=50 gal, with ER
8	RE-WaterHtg_eq-HP_UEF-80g-MDHI-2.30UEF-240V	240V HPWH, UEF=2.3, TV=80 gal, with ER

[1] References for baseline is 2022 Title 24 and measure case is product availability research
[2] Engineering judgment was used for the baseline and measure case characteristics
[3] Pacific Northwest National Lab Rooftop Unit Embedded Diagnostics: Automated Fault Detection and Diagnostics
(AFDD) Development, Field Testing and Validation

Water heater properties

All water heater properties evaluated were specified by the eTRM measures and were not chosen or altered in this MTI work. The only adjustments were to the UEF levels in several cases noted below.

Baseline systems

For electric resistance storage water heaters, the UEF and tank volume from our installation case exists within the eTRM models (UEF = 0.92, tank volume = 50 gal); this corresponds to 98% thermal efficiency in the EnergyPlus model. The baseline electric storage water heater has a hard-sized total heating capacity of 16,718 Btu/h.

The current baseline gas storage water heater has a 0.63 UEF. We increased the UEF level to 0.68, consistent with the federal minimum efficiency standard for a unit with a high draw pattern, as of May 6, 2029, to avoid shifting the baseline conditions several years into the 20-year program. This is a more conservative estimate (i.e., slightly reduced savings for fuel substitution scenarios) and simplifies the model. A UEF of 0.68 is equivalent to a heater thermal efficiency of 82.5% in the EnergyPlus model. The baseline gas storage water heater has a hard-sized total heating capacity of 40,998 Btu/h.

All baseline and proposed water heaters use the WaterHeater:Stratified object in EnergyPlus for more accurate tank temperatures with 10 nodes.

The temperature setpoint for the electric and gas water heater storage tanks is 130°F with a deadband temperature difference of 3.6°F.

Proposed systems

The 240V HPWHs are all integrated hybrid systems that include electric resistance heating within the storage tank. The heat pump capacity is set to 4,196 Btu/h and the electric resistance capacity is 15,354 Btu/h. The 120V HPWH contains versions with and without electric resistance heating. For the final 120V HPWH models used in this work, we average the two types together to account for both cases. The 120V heat pump capacity is set to the same value as the 240V system (4,196 Btu/h), and the electric resistance heater capacity is decreased to 3,070 Btu/h. HPWHs were modeled with the three EnergyPlus objects:

- Coil:WaterHeating:AirtoWaterHeatPump:Wrapped
- WaterHeater:HeatPump:WrappedCondenser
- WaterHeater:Stratified

The temperature setpoint for the HPWH coils is set to 135°F with a deadband temperature difference of 3.6°F and the backup electric resistance temperature setpoint is 130°F with a deadband temperature difference of 20°F. Due to the settings on the backup electric resistance heating control, the electric resistance heater will not turn on until the tank temperature at the sensor location has dropped to 110°F, which was observed to result in occasional water heater outlet temperatures in the range of 105°F-115°F. No adjustments were made to the model since it was the intent to exactly match the eTRM measure energy consumption estimates.

The rated coefficient of performance (COP) and heater thermal efficiency values used in EnergyPlus for each type of water heater are summarized in Table 33.

Table 33. UEF and modeled efficiencies for each water heater

Type	UEF	Storage Volume (gal)	Modeled Rated COP[59]	Heater Thermal Efficiency
Electric Resistance Storage	0.92	50	-	0.98
Gas Storage	0.68	50	-	0.825
120V HPWH	2.2	80	1.71	0.98
240V HPWH	2.3	50	1.77	0.98
240V HPWH	2.3	80	1.77	0.98
240V HPWH	3.3	50	2.84	0.98
240V HPWH	3.3	80	2.87	0.98

Per the eTRM model configuration, the entire system is located within an unconditioned zone including the air inlet and outlet for the heat pump coils.

[59] Rated COP is the input to the EnergyPlus object Coil:WaterHeating:AirToWaterHeatPump:Wrapped

Effective useful life

Effective Useful Life (EUL) is the estimated median life in years that a measure is still in operation. We use the EUL for residential HPWHs from the DEER database, which is 20.0 years.[60] All installation cases are using the normal replacement scenario.

Climate zones

We analyze energy consumption and bill impacts across three California climate zones to simplify processing and minimize computation time. This reduced the number of energy models from 384 to 72. The CZ2022 weather files are used, which represent 20 years of weather from 1998 to 2017 and were adopted for Title 24 Version 2022.[61] The weather files used are shown in Table 34.

Table 34. Weather files for energy modeling in each climate zone

Climate Zone	Weather file	Included in TSB Calculations
7	CA_SAN-DIEGO-LINDBERGH-FLD_722900S_CZ2022.epw	Yes
10	CA_RIVERSIDE-MUNI_722869S_CZ2022.epw	Yes
12	CA_STOCKTON-METRO-AP_724920S_CZ2022.epw	Yes

Avoided cost calculations

The CPUC's ACC provides a robust framework for evaluating the benefits of distributed energy resources such as energy efficiency and fuel switching measures. [62] The ACC estimates system-level costs of providing electric or gas service on an hourly basis in $/kWh and $/therm.[63] The calculator is comprised of three parts: an electric ACC, a natural gas ACC, and a refrigerant calculator. The calculator converts gas and electricity use into avoided cost dollars, providing a metric to quantify savings from fuel switching and efficiency measures. The avoided cost factors (in $/kWh and $/therm) are applied to a unit energy savings shape on an hourly basis to calculate the avoided cost benefit per scenario, which is an input for the estimate of the MTI's cost-effectiveness and TSB. The previous TSB calculations for residential HPWHs in the CalMTA

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[60] Heat Pump Water Heater, Residential, SWWH014-07, https://www.caetrm.com/measure/SWWH014/07/.
[61] Weather data pulled from https://www.calmac.org/weather.asp.
[62] Per the CPUC, "The primary benefits of demand-side resources are the avoided costs related to generation and distribution of energy. The avoided costs of electricity are modeled based on the following components: generation energy, generation capacity, ancillary services, transmission, and distribution capacity, and decarbonization policy compliance. The Avoided Cost Calculator was established in 2005 and is updated biennially to improve the accuracy of how the benefits of demand-side resources are calculated."
[63] 2024 Distributed Energy Resources Avoided Cost Calculator Documentation. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-side-management/acc-models-latest-version/2024-acc-documentation-v1b.pdf.

advancement plan used the 2022 version of the ACC workbook. A new version was released in 2024 and all calculations in this analysis are based on the 2024 version. There are significant changes in the factors between the 2022 and 2024 ACC workbooks, including the following, per E3:[64]

- Energy value is more time dependent (lower midday and higher overnight and early morning)
- Higher GHG value concentrated in evenings and early mornings
- Lower annual generation capacity value spread out over more hours
- Gas avoided costs are slightly higher, with the largest increases in winter months

CalMTA uses the electric, gas, and refrigerant workbooks. The electric and gas ACC workbook settings used to produce hourly factors are shown in Table 35.[65] One climate zone was used for each IOU to develop avoided cost factors as a simplification due to the large amount of data required from the avoided cost workbooks for each new set of factors, the factor data file for a single climate zone contains approximately 9 million entries.

Table 35. Avoided cost workbook settings

Cost test	Total Resource Cost (TRC)	Societal Cost Test (SCT)
ACC workbook version	2024 v1b	2024 v1b
Discount rate	7.30%	5.06%
Social cost of carbon	-	Base and high
Start year	2024	2024
End year	2054	2054
IOU climate zones		
PG&E	12	12
SCE	10	10
SDG&E	7	7
Electric components to include		
Cap & trade	TRUE	TRUE
GHG adder	TRUE	TRUE
GHG rebalancing	TRUE	TRUE
Energy	TRUE	TRUE
Generation capacity	TRUE	TRUE
Transmission capacity	TRUE	TRUE

[64] 2024 CPUC Draft Avoided Cost Calculator Workshop (July 2024). https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-response/cost-effectiveness/2024-draft-acc-workshop---final.pdf.

[65] The final air quality adders for both electric and gas are FALSE for TRC and TRUE for SCT, as these are hard-coded settings in the workbook that adjust based on the chosen cost test.

Cost test	Total Resource Cost (TRC)	Societal Cost Test (SCT)
Distribution capacity	TRUE	TRUE
Ancillary services	TRUE	TRUE
Losses	TRUE	TRUE
Methane leakage	TRUE	TRUE
Air quality adder	TRUE	TRUE
Final air quality adder	FALSE	TRUE
Gas main inputs		
Class	Residential	Residential
End use	Residential Furnace	Residential Furnace
Emission control	Uncontrolled	Uncontrolled
Gas components to include		
Market	TRUE	TRUE
Transmission & distribution (T&D)	TRUE	TRUE
Environment	TRUE	TRUE
Upstream methane leakage	TRUE	TRUE
Behind-the-meter methane leakage	TRUE	TRUE
Air quality adder	TRUE	TRUE
Final air quality adder[66]	FALSE	TRUE

Weighting factors

The final seven ACC scenarios included energy modeling results from three climate zones, three building types, and eight different modeling cases for 72 unique load shapes. Final unit energy savings (UES) hourly profiles are weighted using the relative contribution of each building type, climate zone, and modeling case. The unit for energy savings is one residential water heater. A single UES is derived as follows:

$$UES_n = \sum_{i=1}^{3}\sum_{j=1}^{3} w_{bldg,i} \cdot w_{cz,j} \left[\sum_{k=1}^{8} w_{base,k} \cdot BLS_{base,k} - \sum_{m=1}^{8} w_{prop,m} \cdot BLS_{prop,m}\right]$$

Where:

UES_n represents the savings shape for the nth scenario (in either kWh or therms)

w_{bldg} is the weighting of building type

w_{cz} is the weighting of the climate zone

[66] The final air quality adder is controlled by the cost test and is automatically FALSE for TRC and TRUE for SCT.

$w_{base,k}$ is the weighting of case k for the baseline equipment

$BLS_{base,k}$ is the hourly building load for the base equipment in case k (in either kWh or therms)

$w_{prop,m}$ is the weighting of case m for the proposed equipment

$BLS_{prop,m}$ is the hourly building load for the proposed equipment in case m (in either kWh or therms)

The building weighting factors are a simple average of single-family, multifamily, and mobile home water draw profiles. Building weighting factors are shown in Table 36.

Table 36. Building weighting factors

Building Type	Factor
Single-family	0.773
Multifamily	0.191
Mobile home	0.036
Total	1.000

Avoided cost factors are calculated separately for each IOU because the avoided cost factors differ for each utility. Climate zone weighting factors vary for each utility based upon the energy consumption by IOU and climate zone. The climate zone weighting factors are shown in Table 37.

Table 37. Climate zone weighting factors for investor-owned utilities

Climate Zone	PG&E	SCE[67]	SDG&E
7	-	-	1.0
10	-	1.0	-
12	1.0	-	-
Total	1.0	1.0	1.0

The eight cases are used to create seven unique scenarios for avoided costs and market adoption. Except for Scenario 1, each scenario contains a single type of baseline and a single type of proposed equipment. In Scenario 1, 120V HPWHs with and without electric resistance heat are averaged together (each with a weighting of 0.5).

[67] SCE weighting factors are used for SoCalGas natural gas avoided costs as well.

The equipment and efficiency packages are combined for each baseline scenario as shown in Table 38 and for each proposed scenario as shown in Table 39.

Table 38. Weights for modeling cases for each ACC – baseline cases

Baseline load shape	S01	S02	S03	S04	S05	S06	S07
Stor_UEF-120vHP-080gal-2.20UEF	0	0	0	0	0	0	0
Stor_UEF-120vHP-080gal-2.20UEF_no-ER	0	0	0	0	0	0	0
RE-WaterHtg_eq-HP_UEF-50g-MDHI-3.30UEF-240V	0	0	0	0	0	0	0
RE-WaterHtg_eq-HP_UEF-80g-MDHI-3.30UEF-240V	0	0	0	0	0	0	0
RG-WaterHtg_eq-Stor_UEF-50g-HI-0.68UEF	-1	-1	-1	0	0	0	0
RE-WaterHtg_eq-Stor_UEF-50g-MD-0.92UEF-240V	0	0	0	-1	-1	0	0
RE-WaterHtg_eq-HP_UEF-50g-MDHI-2.30UEF-240V	0	0	0	0	0	-1	0
RE-WaterHtg_eq-HP_UEF-80g-MDHI-2.30UEF-240V	0	0	0	0	0	0	-1

Table 39. Weights for modeling cases for each ACC – proposed cases

Proposed load shape	S01	S02	S03	S04	S05	S06	S07
Stor_UEF-120vHP-080gal-2.20UEF	0.5	0	0	0	0	0	0
Stor_UEF-120vHP-080gal-2.20UEF_no-ER	0.5	0	0	0	0	0	0
RE-WaterHtg_eq-HP_UEF-50g-MDHI-3.30UEF-240V	0	1	0	1	0	1	0
RE-WaterHtg_eq-HP_UEF-80g-MDHI-3.30UEF-240V	0	0	1	0	1	0	1
RG-WaterHtg_eq-Stor_UEF-50g-HI-0.68UEF	0	0	0	0	0	0	0
RE-WaterHtg_eq-Stor_UEF-50g-MD-0.92UEF-240V	0	0	0	0	0	0	0
RE-WaterHtg_eq-HP_UEF-50g-MDHI-2.30UEF-240V	0	0	0	0	0	0	0
RE-WaterHtg_eq-HP_UEF-80g-MDHI-2.30UEF-240V	0	0	0	0	0	0	0

Refrigerant avoided costs

In this MTI plan, the proposed technology contain refrigerant in a direct expansion process, while the gas storage water heater and electric resistance water heater baseline technologies do not contain refrigerant. Therefore, avoided cost estimates must include a negative benefit of the release of refrigerant from the HPWH system. The CPUC refrigerant ACC (RACC) uses refrigerant leak rates from CARB, [68] which is 1% per year for HPWHs with 100% of the remaining refrigerant released at end of life. While in some cases refrigerant may be recovered at end of life, the RACC does not allow for this scenario.

Currently, 94% of the products in the TECH Clean California's HPWH qualified products list use R-134a as the refrigerant (GWP_{100} = 1,430). For this reason, the avoided cost calculations assume R-134a as the refrigerant. Beginning in 2027, however, the CPUC will require all HPWHs incentivized by the TECH Clean California program to have a GWP_{100} less than 750.[69] This requirement makes it prudent to evaluate future versions of the product that use lower GWP refrigerants such as R-32 (GWP_{100} = 675) and carbon dioxide (R-744, GWP_{100} = 1). Using the standard calculations for HPWHs in the RACC calculation workbook (v3.1),[70] the CalMTA analysis calculated the total lifetime avoided cost for a HPWH unit using all three refrigerants for informational purposes for the future program, but current avoided cost calculations use R-134a as the refrigerant for all products. Assuming lower-GWP refrigerants in future years would increase the avoided cost benefit compared to what is reported here.

Table 40 summarizes the lifetime avoided costs of a HPWH installed in 2027 with each refrigerant considered by the CalMTA team and includes a breakdown of costs by lifetime leakage and EOL release of refrigerant.[71]

Table 40. Lifetime refrigerant avoided costs

Refrigerant	GWP_{100}	Avoided Cost of Annual Leakage, NPV [2027$]	Avoided Cost of EOL Leakage, NPV [2027$]	Total Avoided Costs, NPV [2027$]
R-134a	1,340	-56.21	-224.28	-280.37
R-32	675	-26.47	-105.87	-132.35
R-744	1	-0.04	-0.16	-0.20

[68] Refrigerant Avoided Cost Calculator and Fuel-Sub Calculator Technical Guidance.

[69] California Public Utility Commission (CPUC). Rulemaking 19-01-011 - Prohibition on High GWP Refrigerants in Appliances Incentivized by Building Decarbonization Programs. 2025. https://efiling.energy.ca.gov/GetDocument.aspx?tn=262498&DocumentContentId=99028.

[70] California Energy Data and Reporting System (CEDARS). "RACC-FSC_v3.1.xlsx." https://cedars.cpuc.ca.gov/deer-resources/tools/supporting-files/resource/2/history/.

[71] The refrigerant avoided costs come from the CPUC refrigerant avoided cost calculator, RACC-FSC_v3.1.xlsx. The HPWH product was modified to have a 20-year EUL to match the eTRM value.