TECH Clean California Best Practices Draft Report

MARCH 2026

REPORTING PERIOD: JULY 1, 2021—DECEMBER 31, 2025

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Disclaimer

This report reflects the analysis and findings of Energy Solutions and Opinion Dynamics. It does not necessarily reflect the opinions or views of the California Public Utilities Commission (CPUC) and has not been reviewed or approved by the CPUC or its employees. This report will be revised and updated for clarity and conciseness based on input from parties to the Building Decarbonization proceeding R.19-01-011.

Acknowledgements

We would like to thank the following people and organizations for their support:

- Members of the TECH Clean California implementation team (Association for Energy Affordability, Building Decarbonization Coalition, Central Coast Energy Services, Electrify My Home, Energy Outlet, Frontier Energy, National Comfort Institute, Recurve, The Ortiz Group, Tre'Laine and VEIC).
- Members of the TECH Clean California evaluation team (Guidehouse and J. Mitchell Analytics) for their contributions supporting TECH Clean California and the insights that informed this report.
- The TECH Clean California contract administrator, Southern California Edison, particularly Jose Buendia, Hector Aguilar, and Andres Fergadiotti, for their support and collaboration since TECH Clean California's inception.
- The California Energy Commission staff, particularly Jason Harville, whose team worked diligently to organize a statewide meter dataset across nearly all California utilities to support many of the meter-based measurements and insights contained in this report.
- The California Public Utilities Commission (CPUC) Energy Division staff, particularly Abhilasha Wadhwa, Nick Zanjani, Garima Chatrath, Meghan Cook, and Sasha Cole, as well as former CPUC Staff Sebastian Sarria and Rory Cox, for their vision and leadership in advancing TECH Clean California.

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1. Executive Summary

Space and water heating account for 91 percent of residential gas usage and contribute 43 percent of residential greenhouse gas emissions.[1] The Technology and Equipment for Clean Heating (TECH) Clean California initiative supports the adoption of low-emissions space- and water-heating technologies and was launched in December 2021 with $120 million in funding from the California Air Resources Board's Cap and Trade program. Publicly known as TECH Clean California, the initiative is designed to advance California's goal of carbon neutrality by 2045 (Executive Order B-55-18, 2018) through contractor incentives, supply chain engagement, workforce development, consumer education, regional pilots, Quick Start Grants, and public data reporting.

TECH Clean California has had significant contractor and customer participation, with more than 75,000 heat pumps installed and 1,600 contractors participating across 54 of the state's 58 counties.[2] Energy Solutions serves as the program implementer, and Opinion Dynamics serves as the independent evaluator. This report summarizes lessons learned through more than four years of program implementation and evaluation.

Findings

TECH Clean California's investments in heat pump market development are making an impact. TECH Clean California has invested heavily in capacity building by working closely with manufacturers and distributors, leveraging their roles as "trusted messengers" to support contractor recruitment and more broadly align the initiative with supply chain needs. More than 68 percent of surveyed HVAC and heat pump water heater contractors reported receiving heat pump equipment training most commonly from distributors or through a manufacturer; the latter being a contractor's preferred training source.[3]

> *"The TECH program is a significant driver supporting the adoption of HPWHs from a national point of view. While many US states have very low adoption rates for HPWHs, California and its TECH program have progressively made in-roads in year-over-year increases driving the adoption of the technology."*
> ***Participating Manufacturer***

The TECH Clean California evaluator found evidence of market transformation for HVAC heat pumps in California. Contractors are investing in their businesses to expand heat pump offerings. This is reflected by the substantial increase in the proportion of contractor firms attending HVAC heat pump trainings. The evaluator found that TECH Clean California heat pump training was

[1] DNV. *2019 California Residential Appliance Saturation Survey (RASS)*. July 2021. https://www.energy.ca.gov/sites/default/files/2021-08/CEC-200-2021-005-ES.pdf

[2] TECH Clean California has also received national recognition, winning three national awards since 2021.

[3] Opinion Dynamics. *TECH Clean California: Time 2 Market Assessment Final Report*. May 14, 2025. https://opiniondynamics.com/wp-content/uploads/2026/03/TECH-Time-2-Market-Assessment_Final.pdf

effective and a good investment, and employers valued the skills learned: nearly half (43 percent) of attendees received a promotion within six months.[4] Contractors increasingly report that they value technicians with heat pump experience when making hiring decisions, and a growing share of their staff now works on heat pump projects. Contractors' self-reported confidence working with HVAC heat pumps has grown in recent years.[5] Most importantly, contractors report that heat pumps and heat pump water heaters make up a growing share of their installations. In the evaluator's 2024 survey of 115 contractors, respondents reported that, on average, 62 percent of their HVAC jobs in the prior year involved heat pumps, a 26-percentage point increase from the Baseline Assessment. Surveyed contractors also reported comparable growth in heat pump water heater installation share, from 16 to 40 percent of reported water heater installations.[6]

Overall, TECH Clean California participants have been very satisfied with their heat pumps. Ninety percent of heat pump water heater participants reported being "very" or "somewhat" satisfied with their equipment, reflecting consistently positive customer experiences. Satisfaction with heat pump HVAC systems was similarly high: 91 percent for ducted and 97 percent for ductless systems.[7] These strong satisfaction levels indicate that heat pump technologies are meeting customer expectations for comfort and performance, helping build confidence in broader market adoption. The most common customer concerns include excessive noise and increased cold air near their heat pump water heater units and a higher than desired need for troubleshooting, repair, or replacement. However, the evaluator has found that contractor installation practices may be improving customer experience over time.[7] Furthermore, as customers acclimate to their new equipment, their perception of the value of the equipment increases.

Customers value heat pumps' comfort and cost savings benefits, while customers with environmental motivations and those with existing solar make up important early-adopter segments. The vast majority of both heat pump HVAC (93 percent) and heat pump water heater (89 percent) customers rated their purchase as a "good" or "great" value. The top reasons were financial (long-term cost savings, rebates,

> *"With the rebates, [the heat pump water heater] was an excellent deal! Without rebates, it would have been very expensive, and I probably would have gotten a different type of water heater."*
>
> ***TECH Clean California Customer***

[4] Opinion Dynamics. TECH Post-Training Level 3 Behavior Survey Findings Memorandum. February 28, 2023. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Contractor_Six-Month_Post-Training_Findings_Memo.pdf

[5] Opinion Dynamics. *TECH Clean California: Time 2 Market Assessment Final Report*. May 14, 2025. https://opiniondynamics.com/wp-content/uploads/2026/03/TECH-Time-2-Market-Assessment_Final.pdf

[6] Opinion Dynamics. *TECH Clean California: Time 2 Market Assessment Final Report*. May 14, 2025. https://opiniondynamics.com/wp-content/uploads/2026/03/TECH-Time-2-Market-Assessment_Final.pdf

[7] Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction Wave 2*. March 27, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

equipment efficiency, existing solar), comfort (HVAC only), and environmental. Among the minority of customers who did not view their heat pump as a "good" or "great" value, high upfront cost and high utility bills are the top two reasons. [8]

TECH Clean California's single-family participants have disproportionately been early adopters, as evidenced by the high penetration of rooftop solar (27 percent) compared to the general population (10 percent).[9] The discrepancy is particularly evident among heat pump water heater adopters, where TECH Clean California internal program data shows that 45 percent of participants have existing solar. Among TECH Clean California HVAC customers without solar, nearly a third of them reportedly plan to install solar in the near future. The evaluator also found that solar customers reported higher satisfaction with their heat pumps than non-solar customers, and they were overwhelmingly likely to report that their monthly utility bills went down when they installed a heat pump water heater.[10]

As heat pumps scale and become more mainstream, their core value will increasingly center on low upfront costs, customer bill savings, and comfort. This underscores the need to narrow upfront cost gaps with gas appliances and advance rate reforms that strengthen customer bill savings.

TECH Clean California energy impacts, greenhouse gas (GHG) emissions, and bill impacts vary among climate zones, measures, and customer segments such as those on CARE or FERA rates. The impacts are sensitive to baseline home attributes such as existing central air conditioning and rooftop solar.[11] The evaluator's estimates of customer bill impacts are shown in Table 1. The analysis included over 10,000 participating TECH Clean California projects completed between July 2021 and July 2023, including all incentivized technologies across both HVAC and water heating end uses and including all customers with and without pre-existing solar, as evidenced by their NEM tariff.

[8] Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction Wave 2*. March 27, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

[9] Opinion Dynamics. *TECH Population-based Pathway Impact Report.* November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

[10] Opinion Dynamics. *TECH Clean California Heat Pump Equipment: Insights into Customer Experience and Satisfaction*. September 15, 2023. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Customer_Experience_and_Satisfaction_Final_Report_9.15.23.pdf

[11] Opinion Dynamics. *TECH Population-based Pathway Impact Report.* November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

Table 1. Evaluator's estimates of bill impacts from installing a heat pump; all TECH customers.

Measure	Electric Estimate	Gas Estimate	Annual Net Change
Annual Average Impact	$333	-$344	-$11
Winter	$316	-$222	$94
Summer	-$33	-$24	-$56
Shoulder	$50	-$99	-$49
Impacts by Technology			
Central Heat Pump	$289	-$314	-$25
Ductless Heat Pump	$459	-$387	$72
HPWH	$177	-$362	-$184

The evaluation yielded an average annual impact across the portfolio of projects that was close to break even. In general, customers were estimated to save on their bills during summer and shoulder seasons, with winter bill increases due to new electric heating loads. Central heat pumps and heat pump water heaters showed positive bill savings, whereas ductless heat pumps were associated with net annual bill increases. However, there is significant variation underlying these averages, and it is important to note the causal factors of this variation, which includes climate zones, the presence of existing air conditioning, existing solar, electric and gas utility rates, and whether the customer was on a CARE or FERA rate, among other factors.

The implementer focused its analysis on three primary types of retrofits within the initiative, each having distinct outcomes:

- heat pump HVAC of an existing furnace and air conditioner.
- heat pump HVAC replacement of an existing furnace in a home (without an existing air conditioner).
- heat pump water heater replacement of an existing gas water heater.

Non-solar customers with existing air conditioning achieved average bill savings of $304 per year, while those without existing cooling saw an average bill increase of $69 per year but gained cooling. Non-solar heat pump water heater customers had an average bill reduction of $97 per year (see Table 2).

Table 2: Implementer analysis of average bill impacts by primary project types[12]

Average Annual Bill Impacts	HVAC, AC Detected	HVAC, No AC Detected	HPWH
Electric	$246	$583	$340
Gas	$-551	-$514	-$437
Combined	**$-304**	**$69**	**$-97**

Heat pump HVAC impacts varied widely by geographic region, while heat pump water heater impacts were more consistent across climate zones. The factors driving HVAC savings variability are not strictly random; rather, it is possible to predict with some confidence whether a customer is likely to save on future bills, based on the customer's baseline energy consumption patterns, climate, and heat pump technology choices. For example, TECH Clean California's implementation team's analysis identified that non-solar customers with existing air conditioning in inland and desert climate zones achieved three times the summer peak demand savings than those in coastal or northern climate zones.[13]

Customers on income qualified rates, such as CARE/FERA, typically experience more bill savings from fuel substitution than market rate customers: This is primarily driven by the higher discount on electric rates (30–35 percent) relative to the gas rate discount (20 percent). The TECH Clean California evaluator results for a combined heat pump HVAC and heat pump water heater portfolio found an average $75 improvement in bill impacts for CARE versus non-CARE customers.[14]

Changes in electricity and natural gas tariffs will affect bill impact outcomes of installing building electrification measures. For example, the addition of Base Service Charges is expected to improve bill outcomes for all TECH Clean California customers. Based on utility rates in effect in 2022 and 2023, the implementer forecast that median bill savings could improve by an estimated $91–104 per year for non-solar customers installing a heat pump HVAC project without prior AC,

12 Based on implementer analysis of non-solar customers using 2022–23 energy and rates data. Negative values represent annual bill savings; positive values represent a bill increase. While average values are instructive, there is significant variation due to climate zone, utility, presence of solar, income qualified rates, and household energy consumption patterns. This is based on a sample size of 1,515 non-solar projects.

13 The Coastal/Northern climate region includes CEC Climate Zones 1–9, while Inland/Desert includes Climate Zones 10–16.

14 Opinion Dynamics. *TECH Population-based Pathway Impact Report*, Figure 3. November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

enough to shift median impacts from a bill increase to bill savings.[15] Median bill impacts for heat pump water heaters and HVAC with prior AC were estimated to decrease bills by approximately $42–54. Future analyses could refresh these results with more recent rates and a larger project portfolio to yield results by utility.

Replacing inefficient air conditioning with heat pump HVAC is an especially effective approach for simultaneously advancing building decarbonization and improving energy affordability. While building decarbonization and heat pump adoption can benefit from lower electricity rates, there are significant opportunities in the current moment under existing rates. In particular, targeting air conditioner replacements in hot climates offers the greatest opportunity to advance building decarbonization and energy affordability per dollar invested. Replacing inefficient air conditioning units with heat pumps delivers strong participant and ratepayer benefits per program dollar by reducing participant bills, lowering summer peak demand, and adding off-peak load that spreads fixed grid costs across more electricity sales. The TECH Clean California implementation team's analysis found focusing on air conditioner replacement can achieve five times the peak demand savings, 67 percent greater customer bill savings and 13 percent higher GHG savings versus an untargeted HVAC approach. Customers with both existing air conditioning and above median existing energy consumption, such as homes in hot, inland parts of the state, could achieve 10 times the peak demand savings, 2.7 times utility bill savings, and 40 percent higher GHG savings, while serving more customers in disadvantaged communities than an untargeted approach. Optimizing future programs around replacing existing air conditioning in hotter parts of the state could deliver substantially greater customer and ratepayer benefits, all for the same amount of funding invested, and under current utility rates.

Increased incentives for customers based on income are an important way to serve customers equitably.[16] Since the July 2025 launch of TECH Clean California's dedicated equity bonus incentives, equity customers have received 62 percent of incentives, significantly above TECH Clean California's current goal of 50 percent.[17] The rapid uptake of TECH Clean California's higher incentives for income-qualified single-family customers, such as those with incomes at or below 80 percent area median income, underscores a substantial need, and demonstrates that appropriately sized equity incentives can help low-income households adopt heat pumps. Moreover, numerous contractors are creating dedicated business models to serve this specific demographic.

In addition, a partnership with the San Joaquin Valley Disadvantaged Communities Pilot, TECH Clean California has field tested approaches for serving financially distressed households in need of

[15] At the time of analysis, there were insufficient heat pump water heater projects to effectively model BSC impacts for customers, although future efforts may include them.

[16] Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction Wave 2*. March 27, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

[17] TECH Clean California. 16th Quarterly Stakeholder Meeting. February 12, 2026. https://techcleanca.com/about/reporting/

remediation and minor home repairs prior to home electrification. Likewise, TECH Clean California's collaboration with the Energy Savings Assistance Program has tested approaches for transitioning to heat pump technologies in lieu of like-for-like gas appliance replacements. Both efforts point to a pathway for expanding home electrification services for income-qualified households via existing weatherization programs.

Multifamily building electrification requires a distinct approach tailored to its needs, including dedicated funding and technical assistance, electrification readiness, and infrastructure support. Multifamily buildings house roughly half of low-income households, making this sector critical for achieving equitable, large-scale decarbonization. To date, TECH Clean California has served over 15,000 multifamily units, with 77 percent of the projects focused on water heating, reflecting the sector's unique load profile. The multifamily sector requires a purpose-built program design that differs substantially from single-family approaches since it must account for the sector's longer planning horizons, complex decision structures, and substantial infrastructure limitations. TECH Clean California's Multifamily Pilot projects showed considerable variation in project scope. Projects ranged from single unit upgrades for individual apartment units to the replacement of large central systems that served multiple units at once. Eleven out of 13 properties participating in the pilot needed upgraded infrastructure to support electrification, and seven projects were able to avoid electrical upsizing due to the Pilot's investment in monitoring and engineering analysis.

Incentive layering—combining TECH Clean California incentives with weatherization assistance, tax credits, and owner capital—has proven crucial for closing funding gaps and supporting full electrification. With limited reserves in most low-income properties, property owners rely on outside funding to bring out-of-pocket costs down to less than 10 percent—or in most cases, $0—for projects to move forward. After layering eligible incentives from other programs, the multifamily pilot provided an average of $6,600 per unit to cover the funding gap for participating properties to fully electrify.

The Multifamily Pilot has found that providing electrification readiness support can resolve a major barrier to multifamily electrification due to the challenge of replacing equipment at unit turnover or burnout on a property that is not undergoing a large capital improvement scope of work. Phasing an electrification scope has the benefits of reducing the capital burden on the property owner by spreading project-related expenses across longer timelines and reducing the likelihood of needing to temporarily relocate residents if major upgrades occur in the dwelling units all at once. It also gives the property owner greater flexibility to secure additional funding sources, such as low-income housing tax credits and utility incentives. Tailored technical assistance, readiness planning, and dedicated funding have emerged as essential support areas for successful multifamily electrification.

Comparatively simple program requirements, long and flexible timelines, and a contractor open-market model have all facilitated owner participation and allowed projects to proceed despite permitting, technical, or financing challenges.

The single most consistent feedback the TECH Clean California team has received from market actors is the need for program consistency and predictability, which enables the supply chain to shift their business models toward heat pumps. The elimination of incentive starts-and-stops would have a cascading effect to encourage broader participation by reducing the administrative costs and contractor business risk of short program funding windows. The California Heat Pump Partnership Blueprint and the California Energy Commission's Draft Building Energy Action Plan have similarly highlighted the need for longer-term stability.[18,19] Additionally, in support of its air quality regulation of natural gas-fired water heaters, the Bay Area Air Quality Management District's 2024 Implementation Report has called for continuation and expansion of initiatives like TECH Clean California that reduce costs for heat pump water heater installation.[20]

> *"Simplicity and stability, even if that means lower rebate amounts…that's always been what we've wanted."*
>
> ***Participating Contractor***

Program simplicity is key to success. In both formal and informal feedback, the most common improvement suggestion from contractors is to simplify TECH Clean California and make it easier to participate, particularly for smaller businesses who don't have time and capacity to navigate the intricacies of program requirements.[21] [22] TECH Clean California is subject to a range of requirements that fall into three primary categories: funding source requirements, which limit how specific funds can be leveraged; state requirements, which govern how projects must be implemented; and programmatic requirements, which define eligibility and participation requirements.

While the intent behind these requirements is understandable, an accumulation of constraints can create friction and implementation challenges that deter participation and increase administration costs. The cumulative complexity of these requirements manifests in the form of increased application approval timelines, higher rejection rates for minor errors, and elevates contractor soft costs—this can strain the capacity of firms to participate, particularly small businesses, and

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[18] California Heat Pump Partnership (CAHPP). *California Heat Pump Partnership Blueprint.* March 2025. https://heatpumppartnership.org/blueprint

[3] California Energy Commission. *California Building Energy Action Plan (Draft).* December 19, 2025. https://www.energy.ca.gov/sites/default/files/2025-12/CEC-400-2025-001-CMD.pdf

[20] Bay Area Air Quality Management District. *Staff Report Informational Update Regarding Regulation 8, Rule 6: Nitrogen Oxides Emissions from Natural Gas-Fired Water Heaters less than 75,000 BTU/hr.* December 2024. https://www.baaqmd.gov/~/media/dotgov/files/rules/reg-9-rule-4-nitrogen-oxides-from-fan-type-residential-central-furnaces/2021-amendments/documents/20241127_board-report-dec-2024-pdf.pdf?rev=f9b89cc7ceb54588b5c505d6f20635e3&sc_lang=en

[21] Opinion Dynamics. *Process Evaluation of the TECH Clean California Initiative*. May 2, 2025. https://www.calmac.org/publications/TECH_Process_Evaluation_Final_Report.pdf

[22] Opinion Dynamics. *Interim Process Evaluation: Technology and Equipment for Clean Heating (TECH).* November 7, 2022. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Interim_Process_Evaluation_Final_Report.pdf

discourage contractor and customer engagement. Contractor satisfaction with TECH Clean California grew 29 points from June 2022 to June 2024,[23] in large part due to the simplification of program rules and an 18-month period where heat pump HVAC incentives were continuously available.

Evaluating the cost-benefit trade-off of program requirements can be challenging. The benefits of a requirement may be relatively easier to quantify during the regulatory or initial scoping process, while the operational and participation costs of additional requirements may not become fully apparent until the program is implemented.

Conclusions and Recommendations

A substantial multiyear funding commitment is critical to delivering the program consistency and predictability that the market needs. Program incentive funding is still critical for advancing the heat pump market to meet California's goals. Over time, as the heat pump installation market matures, market gains can be locked in via codes and standards, and program resources can shift to focus more narrowly on high impact opportunities such as full phaseouts of air conditioners in favor of heat pumps, zonal electrification, and serving those customers at risk of being left behind in the clean energy transition.

Focus program investments on high-value opportunities that deliver outsized customer bill savings, peak demand reduction, GHG reductions, and Total System Benefits (TSB), with the goal of leveraging building decarbonization as an investment engine to accelerate affordability gains for both participants and all ratepayers.

Programs should offer income-qualified bonus incentives to encourage heat pump retrofits in low-income households and ensure equitable electrification.

Continue investment in workforce education and training to support heat pump market development and capacity building while standardizing workforce requirements across programs. Individual-level credentialing, curriculum standardization, and targeted training can support existing and income workforce as well as their ability to participate in programs. Trainings should be organized in a progression so that subsequent training builds on what was learned in prior ones, with the express goal of encouraging program simplicity.

Offer multifamily properties dedicated funding and technical assistance, electrification readiness, and infrastructure support to meet the sector's broad needs to adopt heat pumps and electrify.

Continue advancing analysis to better understand how energy, greenhouse gas, and bill impacts of residential space and water electrification vary across different subpopulations, and how ongoing changes in utility rates and other factors may shift project economics over time. When

[23] Opinion Dynamics. *Process Evaluation of the TECH Clean California Initiative*. May 2, 2025. https://www.calmac.org/publications/TECH_Process_Evaluation_Final_Report.pdf

designing future electrification policies and programs, California policymakers should recognize that these impacts vary significantly across customer segments. Subpopulations defined by climate zone or other attributes (e.g., CARE/FERA status) may experience outcomes that differ substantially from population-wide averages.[24] In addition, both natural gas and electric utility tariffs continue to evolve, which may further influence project economics across these groups. Ongoing analysis is essential to ensure policy and program decisions remain aligned with—and informed by—these shifting market dynamics.

Future programs and policy direction should explicitly incorporate simplicity as a core guiding principle to ensure it is prioritized. Because simplicity is one of the most important in achieving strong participant satisfaction, it must be given priority consideration during policy, program design and implementation phases.

Adopt a portfolio approach that balances scale, simplicity, equity, and market development needs. TECH Clean California intentionally focused its initial program design at the contractor level in order to influence contractor decision making and collect program data that would help inform California's long-term building decarbonization strategy. Looking forward to how a future building decarbonization program might be designed to reflect the four years of lessons learned thus far, the TECH Clean California implementation team believes there would be value in eventually shifting market rate incentives to distributors or retailers to more effectively scale. A certain level of market maturity would facilitate this approach. Incentives for customers requiring more in-depth support, such as low-income customers and multifamily, would remain for contractors since these services are not effectively applied at the distributor or retail level.

In a broad view, this creates a three-pronged building decarbonization approach to incentive design and market development, since these needs do not always perfectly align within a single program:

1. **Statewide distributor and retail point of sale incentives,** focused narrowly on cost-effective achievement of the state's climate and grid resiliency goals, with attention to customer economics, simplicity, and expanding participation.
2. **Statewide or regional contractor-based program, comprised of:**
    - **Single family income-qualified incentives** to deliver program benefits broadly to equity households.[25]
    - **Multifamily incentives and market support** to deliver benefits to equity households and renters.

[24] Opinion Dynamics. *TECH Population-based Pathway Impact Report.* November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

[25] An "equity" customer or household includes disadvantaged communities as defined by CalEnviroScreen 4.0, hard-to-reach customers, and those that qualify based on income. TECH Clean California has defined goals related to certain equity criteria and metrics.

3. **Statewide or regional direct install programs,** such as the Equitable Building Decarbonization and Energy Savings Assistance programs, serving the most financially distressed households that need full subsidies and concierge program services to move forward.
    - Transition the Repair and Replacement program under Energy Savings Assistance to deliver electrification services as standard practice for replacing gas appliances.
    - Offer whole-house or partial electrification upgrades to the most financially distressed households, particularly those that require some form of remediation assistance as a precondition for electrification.

These core electrification programs can be complemented as needed with supplemental market development support, as well as local or regional programs to capture locally concentrated opportunities or stack additional grid benefits that are not fully realized within the core portfolio.

2. Introduction

2.1 TECH Clean California Origin

Electrifying buildings is one of the least cost pathways to achieving California's climate goals.[26] The Technology and Equipment for Clean Heating (TECH Clean California) initiative was established by the California Public Utilities Commission (CPUC) Decision 20-03-027, in keeping with legislative direction from California Senate Bill 1477 (Stern, 2018). The initiative was designed to help advance the state's goal to achieve carbon neutrality by accelerating the market of low-emissions space and water-heating technologies for existing single-family and multifamily residential homes, with the guiding principles of equity, cost-effectiveness, regulatory simplicity, and market transformation.[27]

TECH Clean California launched in December 2021, with $120 million in funding from the gas allowances of the California Air Resources Board's Cap and Trade program. Assembly Bill 179 (Ting, 2022) allocated an additional $50 million in General Fund money for TECH Clean California to use across all of California beginning in 2023. TECH Clean California also received an additional $95 million from the Greenhouse Gas (GHG) Revenue Fund in 2023 through Senate Bill 101 (Skinner, 2023) and $40 million in targeted funding from the Aliso Canyon Settlement Fund (Assembly Bill 157, Gabriel, 2024). In addition to these legislative allocations, the program also received a one-time allocation of $80 million in the Self-Generation Incentive Program (SGIP) to support demand-flexible heat pump water heaters. TECH Clean California has had significant contractor and customer participation, with more than 75,000 heat pumps installed and 1,600 contractors participating across 54 of the state's 58 counties.[28] The need for five additional funding allocations over four years is a testament to the popularity of the program, as funding is quickly exhausted when it is made available.

2.2 Program Design Intent

TECH Clean California's theory of change is that program interventions can catalyze market transformation through a three-phase evolution. We assess that heat pump market transformation efforts are currently in Phase 2.

- **Phase 1 Initial Deployment**: At the outset of market transformation activities, program incentives drove contractor and consumer demand and catalyzed tens of thousands of project

[26] California Energy Commission Energy Research and Development Division. *Deep Decarbonization in a High Renewables Future: Updated Results from the California PATHWAYS Model*. CEC-500-2018-012. June 2018. https://www.energy.ca.gov/sites/default/files/2021-06/CEC-500-2018-012.pdf

[27] California Public Utilities Commission. *Decision Establishing Building Decarbonization Pilot Programs*. R.19-01-011, Decision 20-03-027. March 26, 2020. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M331/K772/331772660.PDF

[28] TECH Clean California has also received national recognition, winning three national awards since 2021.

installations. These early projects generated empirical evidence needed to document market responses to program interventions and quantify costs, outcomes, and meter impacts that inform program refinement.

- **Phase 2:** Lessons learned from Phase 1 are informing the development of a long-term decarbonization framework, including rigorous performance measurement to quantify the impact and value of the clean energy resources that heat pumps provide (e.g., GHG reductions, peak load impacts, participating customer bill savings, additional non-peak electric load, etc.). In Phase 2, we expect to start seeing incremental cost reductions due to product and installation efficiencies as the market gains more experience and competition increases.[29]
- **Phase 3:** A maturing market will enable the establishment of clear policy direction and a long-term heat pump investment structure, which drives economies of scale. Performance measurement will transition heat pumps and electrification into an investable clean energy resource, where continued public investments can be tied to the underlying value of the resource, and where a functional market develops—one that values heat pumps' societal and customer benefits.

To drive market transformation through these three phases, TECH Clean California has organized its interventions around three pillars.

Pillar One: Spur the Clean Heating Market for Electrification through Statewide Strategies

- **Focus on contractors to prime the market:** TECH Clean California concluded that a focus on contractors would have the greatest impact since they most directly influence customers' heating, ventilation, and air conditioning (HVAC) and water heater purchase decisions. However, contractors are often hesitant to break away from their existing profitable sales model and invest time and effort to sell and install nascent technologies with yet-to-be proven demand. To address these concerns, the program emphasizes contractor training on the technology, value proposition, and business model aspects of electrification and motivates contractors to sell heat pump technologies via contractor incentives.
- **Provide heat pump water heater and heat pump HVAC incentives for both single-family and multifamily residences:** Incentives attract consumer and contractor attention, address upfront cost barriers and impart a sense of urgency to act. Incentives for multifamily properties help the initiative reach renters who typically lack control of infrastructure upgrade decisions.
- **Leverage existing marketing infrastructure to inform consumer decision making:** To inform customer decisions and drive demand, TECH Clean California integrates with and enhances the Building Decarbonization Coalition's (BDC) electrification website, The Switch Is On, as well as their broader consumer inspiration campaign. This resource provides information for

[29] Assessing changes in incremental cost has been challenging due to higher-than-expected volatility, inflation and supply chain shocks since TECH was designed in 2020.

every step of the customer journey, including electrification guides and resources to find qualified contractors and available incentives.

Pillar Two: Create Scalable Models for Market Transformation through Regional Pilots and Focused Outreach

- **Test solutions through regional pilots and Quick Start Grants (QSGs):** Six regional pilots and 26 QSGs have been designed to test innovative solutions to heat pump adoption barriers in a small-scale, targeted fashion. Successful pilot approaches can then demonstrate an approach that can be scaled.
- **Target low-income, hard-to-reach, disadvantaged communities (DACs):** Investments in impacted communities help fuel economic recovery and respond to the needs of those hit hardest by historical environmental and social inequities. TECH Clean California has a goal to invest 40 percent of program incentives in low-income households and DACs.

Pillar Three: Inform Long-Term Building Decarbonization Framework

- **Public reporting informs policy:** TECH Clean California provides program data for California through its public reporting website, www.techcleanca.com, offering market transparency with program information on installation details, project prices, deployment progress, and meter impacts. TECH Clean California also presents relevant program insights and data at its quarterly stakeholder meetings and other webinars. TECH Clean California data supports regional and statewide agencies pursuing building electrification policies by providing real market data to inform these policy decisions.
- **Quantify the value of decarbonization:** Through rigorous interval meter data analysis to quantify gas and electric load impacts, GHG savings, customer bill savings and other decarbonization benefits, TECH Clean California intends to create an actuarial level of understanding of how specific drivers influence outcomes. This ability to forecast outcomes and investment strategies can then be used to optimize public and private investments and support large-scale project finance and deployment, similar to the wind and solar industry.

2.3 Evaluation of the TECH Clean California Initiative

In 2021, Opinion Dynamics was selected as the embedded evaluator for both Building Initiative for Low-Emissions Development Program (BUILD) and TECH Clean California Initiative.[30] Opinion Dynamics uses its Whole Independent Systems Evaluation (WISE™) framework in its TECH Clean California evaluation, which applies a combination of traditional process, impact, and market transformation evaluation methods, starting at the very beginning of the initiative instead of waiting until the end. This approach allows for more timely insights to stakeholders and immediate

[30] Embedded Evaluation is based on the principles of Developmental Evaluation as defined by Dr. Michael Quinn. It is an approach to insert evaluation within the program design, implementation, and reporting processes to support evidence-based decision-making as well as informed ongoing decision-making.

feedback that the program implementer can leverage to refine the initiative and optimize its outcomes.

The Value of Embedded Evaluation

Embedded evaluation has provided valuable suggestions for modifications that the implementation team can act upon quickly. For example, rapid feedback enabled the implementation team to troubleshoot application data quality issues with participating contractors. Similarly, timely data collection around baseline costs for gas appliances proved useful for informing both incentive design and policymaking.

Embedded evaluation also enabled real-time participant research that resulted in above-average response rates and more representative samples. Collecting insights from larger sample sizes closer to the time of the intervention provided greater confidence in the validity of the findings and a stronger ability to uncover variations among participants. The evaluator also followed up with customers at multiple points in time, yielding longitudinal data on how customers' perspectives of heat pump equipment change as they gain experience with it. Having robust data is particularly important for pilot programs to inform the most effective strategies for scaling, which aligns with the vision of Senate Bill 1477.

The full array of third-party evaluation results can be accessed via the Opinion Dynamics TECH Clean California Initiative Research Index.

2.4 Guide to the Remainder of This Report

The purpose of this report is to provide a high-level summary of program lessons learned through four years of implementation and evaluation. This report seeks to:

1. Assemble evidence supporting or refuting the underlying theory of change.
2. Provide insights for future implementers regarding best practices that should be integrated into decarbonization programs.
3. Offer guidance to policy makers for policy approaches to pursue and avoid when considering how to advance the state's building decarbonization goals.

The following section, Section 3. Program Design Best Practices address portfolio design for optimizing across multiple policy objectives; the importance of simplicity in program design and implementation; cost-containment strategies around electric service rightsizing; approaches for addressing remediation needs for low-income customers; lessons learned around customer engagement; and the role of data and analytics.[31]

The next section, Section 4. Supporting Sectors and Strategies dives into complementary capacity-building strategies, with a focus on supply chain engagement; contractor engagement; workforce

[31] An additional best-practices section, *Measure-specific best practices*, can be found in the Appendix.

education and training; opportunities to align with customer needs via solar partnerships; and electrification readiness support.

While these first two sections are retrospective, Section 5. Achieving Scale: Long-Term Vision looks forward to how the lessons learned so far can inform continued efforts to scale building decarbonization. It views this topic through the lens of the California Heat Pump Partnership Blueprint, which distills the consensus recommendations from California state agencies and the private sector into 11 strategies for scaling California's heat pump market to six million installed units by 2030.[32]

2.5 Note on Methods and Data Sources

The data in this report comes from a wide range of TECH Clean California activities and reports completed by the TECH Clean California implementation team and TECH Clean California evaluator, including:

- **TECH Clean California evaluator reports.** The studies included process evaluations conducted with enrolled contractors and property owners who received incented equipment; impact evaluations measuring portfolio-wide energy impacts, peak demand reductions, GHG reductions, and bill impacts; market assessments with general population homeowners and contractors; and evaluations of TECH Clean California's workforce development efforts. These studies and others, including Key Performance Indicator Assessments, and an evaluation of the initiative's pilot and QSG strategy, can be found at https://opiniondynamics.com/tech-clean-california-research-index/.[33]
- **TECH Clean California implementation team findings**, which include many published reports covering pilots and QSGs, 16 quarterly stakeholder meetings, three annual reports, and a number of webinars, conference presentations, published program resources, and internal analyses to inform future program design—all of which can be found at: https://techcleanca.com/ . It also includes formal and informal feedback provided by participating customers, contractors, distributors, and manufacturers. In addition, based on the evaluator findings of widespread variability across customers and need to better understand specific project types such as customers with and without existing air conditioning,[34] the Implementation Team developed an internal analysis of project meter-based impacts to inform refinements to program design. Implementation team internal

[32] California Heat Pump Partnership (CAHPP). *California Heat Pump Partnership Blueprint: Scaling California's Heat Pump Market: The Path to Six Million.* March 2025. https://heatpumppartnership.org/wp-content/uploads/2025/03/CAHPP_Blueprint_2025.pdf

[33] Opinion Dynamics evaluated the TECH Initiative with the exception of the program activities funded by the Self Generation Incentive Program (SGIP), which was conducted by Verdant.

[34] Opinion Dynamics. *TECH Population-based Pathway Impact Report.* November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

analyses cited in this report were not independently verified by the TECH Clean California evaluator.

It is important to note that bill impacts were calculated using the rate schedules and magnitudes in place during the first reporting year for each customer, largely during 2022–2023. Utility tariffs continually evolve, and electric and gas rates have experienced significant volatility in the past four years. Thus, these numbers should be used to understand general directionality of outcomes and not a static value proposition. Future analyses will incorporate updated meter and rates data and will more accurately reflect the present moment.

In some cases, there may be some differences in analysis outcomes between the implementation and evaluation teams; because each team had different research purposes, they used different methods and sampling. For example, when conducting energy impacts analyses, the evaluator took a comprehensive program perspective, including all customers and both end uses to assess program portfolio impacts. The implementers analyzed drivers of outcomes to provide granular insights and enable forecasting and thus focused more on customer segmentation. While these findings are directionally similar, when multiple sources are cited, we attempt to describe the fundamental purpose and differences influencing the various outcomes.

3. Program Design Best Practices

3.1 Integrated Program Offerings

A. Designing a Portfolio Strategy that Maximizes Synergies around Customer Savings, Greenhouse Gas Emissions, and Grid Benefits to Utilities and Non-Ratepayers

Senate Bill 1477 called for the establishment of the TECH Clean California initiative to promote the use of low-emissions space and water heating equipment, specifically to help the state meet its GHG emissions reduction targets. Accelerating the market for such equipment requires a compelling value proposition for participating customers (referred to here as private benefits), while recognizing their full value to society (i.e., their public benefits)—not just their role in reducing greenhouse gases. Programs that clearly understand both customer and societal benefits can more successfully leverage these advantages to drive cost-effective adoption of new measures while supporting larger state policy goals.

From a customer benefit perspective, heat pump technologies must offer customers one or more advantages relative to gas appliances. Toward this end, TECH Clean California has sought to intervene in the markets to advance four customer-facing value propositions:

1. Little or no incremental cost of installation
2. Favorable operating costs (i.e., positive bill savings relative to what one would have spent to operate the gas alternative)
3. Non-energy services (e.g., health, comfort, safety, reliability) equal to or better than gas alternatives
4. Minimal hassle factor relative to gas alternatives during both equipment installation and operation

TECH Clean California has also sought to maximize the following societal benefits:

1. Maximize GHG reductions overall while achieving those reductions at minimum cost.
2. Reduce peak electric loads, improve demand flexibility, or avoid adding grid infrastructure costs.
3. Distribute decarbonization benefits equitably across California households.

The balance of this section reviews program impacts across multiple objectives and discusses how program design can be optimized across sometimes conflicting priorities. **The TECH Clean California implementation team's internal analysis has shown that the outcomes tied to different policy objectives are not always correlated; that is, designing to maximize outcomes for one objective may undermine efforts to accomplish other objectives.** Nevertheless, an intentional program design approach can reconcile and balance multiple program goals.

B. Valuing the Customer Benefits of Heat Pumps

UPFRONT INSTALLATION COSTS

Takeaways:

- **The higher incremental cost of heat pump equipment is a barrier to heat pump adoption.**
- **Incentives that cover incremental cost are highly effective.**

Key Outcome: **Market Acceleration**

TECH Clean California's primary goal was to accelerate the market for low-emissions space and water heating equipment, in service to California's GHG emissions reduction goals. As such, the initiative was not optimized for maximum direct GHG reductions, but designed to pilot approaches that would address key barriers to enable broader, long-term heat pump adoption (see *2.2 Program Design Intent*).

The higher incremental cost of heat pump equipment is a barrier to heat pump adoption. A 2022 survey of 1,583 TECH Clean California customers found that over 90 percent of respondents noted that incentives were "somewhat important" or "very important" in their heat pump purchase.[35] Achieving cost parity or better with baseline equipment addresses the important first-cost barrier. Replacing an air conditioner or air conditioner and furnace is already close to cost parity when replacing that equipment with a more efficient heat pump HVAC unit. However, a heat pump HVAC unit is significantly more expensive than a furnace-only replacement. Heat pump water heater costs are cost-competitive with tankless gas water heater installations, but proportionally high compared to like-for-like gas storage water heater replacements.[36,37]

Incentives that cover incremental cost are highly effective. To maximize the impact of the TECH Clean California incentive budget, the initiative has been able to reduce heat pump space conditioning incentives over time to align more closely to the incremental cost of an air conditioner to heat pump replacement (AC to heat pump), while maintaining high participation levels. This approach encourages participation from AC-to-heat-pump projects, and still facilitates furnace-only replacements, while declining to offer the high incentives that would be required to achieve cost parity with a furnace-only replacement. For heat pump water heaters, the TECH implementer has been able to reduce incentives over time below the incremental cost as markets mature: for example, the initiative reduced incentives in Southern California from an initial high of $3,100 to $2,100 while

[35] Opinion Dynamics. TECH Customer Post-Install Survey Topline Findings. September 2023. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Single-Family_Customer_Post-Install_Survey_Topline_Findings_Q4_2022.pdf

[36] Opinion Dynamics. *TECH Clean California: Incremental Cost Study Final Phase 1 Findings*. February 12, 2024. https://opiniondynamics.com/wp-content/uploads/2025/06/TECH_Cost_Study_-_FINAL_Phase_I_Findings_2.12.24_2.pdf

[35] Opinion Dynamics. *TECH Clean California: Gas Baseline Incremental Cost Study*. September 25, 2025. https://opiniondynamics.com/wp-content/uploads/2026/01/TECH-Incremental-Cost-Study-Final-Report.pdf

maintaining strong volume. For more discussion on incentive design, reference 2.2 Program Design Intent.

The program's analysis of HVAC and water heating cost drivers has found that certain technology features contribute to higher project costs while improving other customer value propositions, including bill savings and quality of energy services. The program design team has thus had to weigh trade-offs between increased installation costs versus other value propositions, such as greater GHG reductions, customer bill savings, and reduced peak demand. These are described further in **Appendix A: Measure-Specific Best Practices** and **3.2 Simplifying Program Design to Reduce Costs and Burdens.**

Expanding TECH Clean California contractor enrollment has created downward pressure on overall project cost. TECH Clean California found that all else equal, projects in counties served by 100 or more TECH Clean California–enrolled contractors cost $1,031 less on average than projects in counties served by just 10 contractors.[38] Furthermore, the TECH Clean California implementer's preliminary analysis of customer return on investment (ROI)—which integrates both lifetime bill savings and incremental upfront cost—indicates that the number of contractors serving a county is one of the top drivers of improving ROI for both heat pump water heater and heat pump HVAC customers. This also implies that simplifying program processes and creating stable incentives, which increases contractor participation, can result in improved affordability and lower project cost.

High incentives can contribute to price inflation when set above median installation cost. When incentives are set higher than the median installation cost, contractors may adjust their bids to match the incentives. This was more commonly observed for heat pump water heaters than for heat pump HVAC, since incentives represent a higher fraction of overall project cost. This pattern was most evident for Self-Generation Incentive Program (SGIP) HPWH) equity incentives, which had a maximum equity incentive of $8,885—far above the median heat pump water heater project cost.[39] When set lower than the median cost, inflation is less apparent. Three factors in combating price inflation are 1) contractor competition as discussed above; 2) program simplicity, which reduces contractor soft costs of program participation; and 3) customer willingness to pay. For market-rate customers, willingness to pay is typically compared to a new air conditioning unit for HVAC and a gas tank water heater. For lower income customers, willingness to pay is significantly lower, which tends to keep downward pressure on project costs. Aside from SGIP HPWH project costs, we did not observe price inflation for equity projects.

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[38] Sarkisian, Dylan, Energy Solutions; Kirwan, Desmond, Sean Parker, Abigail, Hotaling, and Michael Fink, VEIC. *TECH Clean California: Heat Pump HVAC Cost Drivers*. October 3, 2023. https://techcleanca.com/documents/2641/Heat_Pump_HVAC_Retrofit_Cost_Drivers_v4W3bW0_kiFU8k4.pdf

[39] The SGIP heat pump water heater incentive levels were fixed in the CPUC Decision authorizing SGIP heat pump water heaters and could not be adjusted by the TECH Clean California team without a modification to the decision itself—a multi-month process. Going forward, it is recommended that specific program implementation details, such as incentive levels, are omitted from regulatory decisions, thus enabling implementers sufficient flexibility to respond to changes in the market. Reference *Section 3.2B Simplify Program Requirements Where Feasible.*

CUSTOMER BILL SAVINGS AND AFFORDABILITY OF ENERGY SERVICES

Key Takeaways:

- **Customers with existing air conditioning have the strongest bill savings from heat pump projects.**
- **TECH Clean California's energy impacts, GHG emissions, and bill impacts vary among climate zones, measures, and customer segments such as customers on CARE or FERA and TOU rates. The impacts are sensitive to baseline home attributes such as existing central air conditioning and rooftop solar.**1
- **Low-to-moderate income (LMI) customers on California Alternate Rates for Energy (CARE)/ Family Electric Rate Assistance Program (FERA) rates realize greater bill savings value from heat pump projects, due to the greater discount on electric rates over gas rates.**
- **Since energy bills take up a larger proportion of the income of LMI customers, programs focused on energy affordability should prioritize LMI customers and ensure they see real savings.**
- **Changes in electricity and natural gas tariffs will affect bill impact outcomes. For example, the Base Service Charges is expected to improve bill outcomes for all customers.**

Both the evaluator and implementer analyses observed a wide distribution of bill savings outcomes for TECH Clean California incentive recipients. Evaluator results are shown in Table 3.[40] The analysis included over 10,000 participating TECH Clean California projects completed between July 2021 and July 2023, including all incentivized technologies across both HVAC and water heating end uses and including all customers with and without pre-existing solar, as evidenced by their NEM tariff.

Table 3. Evaluator estimates of customer bill impacts by season, all customers.

Measure	Electric Estimate	Gas Estimate	Annual Net Change
Annual Average Impact	$333	-$344	-$11
Winter	$316	-$222	$94
Summer	-$33	-$24	-$56
Shoulder	$50	-$99	-$49

[40] Opinion Dynamics. *TECH Population-Based Pathway Impact Report*. November. 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

The evaluation yielded an average annual impact that was close to break even. In general, customers were estimated to save on their bills during summer and shoulder seasons, with winter bill increases due to new electric heating loads.

Heat Pump HVAC Bill Impacts: Evaluator estimates for HVAC bill impacts are shown in Table 4.[41]

Table 4. Evaluator estimates of customer bill impacts from HVAC measures.

Measure	Electric Estimate	Gas Estimate	Annual Net Change
Central Heat Pump	$289	-$314	-$25
Ductless Heat Pump	$459	-$387	$72

Heat pump-only results showed projects installing central heat pumps savings $25 per year, on average, whereas ductless heat pumps added an average of $72 to annual bills. This result may reflect the fact that almost 70 percent of ductless systems were installed in homes with no prior air conditioning, whereas central systems replaced an existing central AC system more than 60 percent of the time.

The differential bill impacts experienced by customers with and without air conditioning are also reflected in customer responses to the evaluator's 2022 customer satisfaction survey. Nearly half of those with air conditioning before reported a decrease in their bills, while fewer than one-third without air conditioning prior experienced a decrease. One-fifth of customers without air conditioning before (40 of 190; 21 percent) reported higher monthly energy bills since having their HVAC heat pump installed.[42]

The above interpretation is corroborated by the implementation team's finding that the greatest bill savings opportunities were concentrated among those customers with high summer cooling bills. The implementer analyzed 1,515 projects for customers with no pre-existing solar, completed

[41] Opinion Dynamics. *TECH Population-Based Pathway Impact Report*. November. 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

[42] Opinion Dynamics. TECH Clean California Heat Pump Equipment: Insights into Customer Experience and Satisfaction. Sept. 15, 2023. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Customer_Experience_and_Satisfaction_Final_Report_9.15.23.pdf

between July 2021 and January 2023. The analysis focused on three technology portfolios: "HVAC, AC Detected;" "HVAC, No AC Detected;" and "Heat pump water heater" (see Figure 1, below).[43, 44]

Customers with existing AC typically experienced modest or negative savings on winter bills but accrued additional savings during summer months. Heating bill impacts depend on the magnitude of gas heating bill savings, compared to heating electric bill increases. Summer electricity savings come from the increased cooling efficiency of the new heat pump relative to their previous equipment. Overall, the implementation team's analysis of non-solar customers with existing AC indicated average bill savings were $304 per year (median savings were $260 per year) based on 2022-2023 rates, and 67 percent of adopters experienced positive bill savings.[45]

The energy bill savings from furnace-only replacements are derived exclusively from winter gas bill savings relative to electric bill increases. Those savings are generally modest or in some cases negative due to the high electricity-to-gas price ratio in some service territories and the addition of new cooling loads. Heat pump HVAC retrofits replacing a gas furnace in homes without existing cooling loads show a small average annual bill increase of $69 per year and a median increase of $35 per year, counterbalanced by a gain in cooling functionality and extreme heat protection.

Heat pump water heater bill impacts: The evaluator's analysis of heat pump water heater impacts are shown in Table 5.[46]

Table 5. Evaluator estimates of customer bill impacts from heat pump water heaters

Measure	Electric Estimate	Gas Estimate	Annual Net Change
HPWH	$177	-$362	-$184

[43] The implementation team's ability to analyze differential impacts across technologies, project attributes, and customer demographics was constrained at this stage by the small population of projects with sufficient post-retrofit energy consumption data. Future iterations of this analysis will have access to a much larger project population, supporting more granular analysis.

[44] Bill Impacts. Source: 2025 ACEEE Hot Water & Air Forum. Session 8A: Measured Impacts of TECH Heat Pump Installations. https://drive.google.com/file/d/1oju5s-S4zltvkv5rzDFuDu6k3ftKujPT/view.

[45] The impact of AC on customer bills was also corroborated in customer self-report responses to the TECH Clean California evaluator's customer satisfaction survey (Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction Wave 2*, March 27, 2025). More than half of those with air conditioning before reported a decrease in their bills (236 of 445; 53 percent), while two-fifths of customers without air conditioning prior experienced a decrease (76 of 189). heat pump water heater adopters perceived that their bills declined or stayed the same 71 percent of the time.

Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction Wave 2*. March 27, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

[46] Opinion Dynamics. *TECH Population-Based Pathway Impact Report*. November. 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

As expected, the results show substantial gas savings, offset by an increase in electric water heating costs.

The TECH Clean California implementation team's analysis found that heat pump water heater retrofits replacing gas water heaters achieve average savings of $97 dollars per year and a median savings of $6 per year. Again, results vary significantly by utility rate, income status, and household energy consumption.

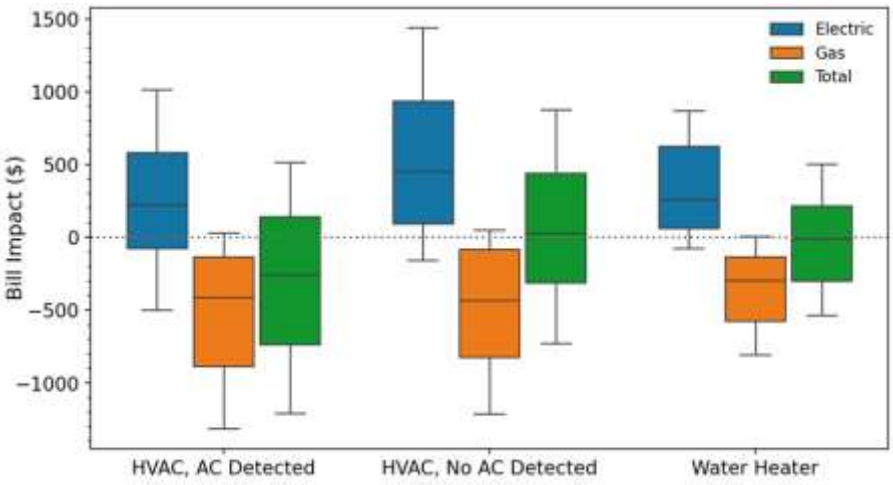

Figure 1: Median annual bill impacts by project type.[47,48]

Customer perceptions of bill impacts. Perhaps more important than the bill impacts themselves is customer perceptions of those impacts. In response to the evaluator's satisfaction survey, more than 93 percent of heat pump HVAC adopters rated their purchase as a "good" or "great" value. Cost savings were the most frequently cited reason for customers who viewed their heat pump as a valuable investment. Likewise, 90 percent of heat pump water heater adopters rated their purchase as good or great value. Over one-fourth of those customers said they valued the monthly and long-term reduction in their energy bills.[49]

Bill savings are highly variable. As Figure 1 from the implementer's internal analysis illustrates, almost 50 percent of heat pump HVAC projects with no prior AC nevertheless produced positive bill savings. That fraction is almost exactly 50 percent for heat pump water heater and climbs to two-

[47] Scheer, Adam. Recurve. "Measured Impacts of TECH Heat Pump Installations" from the 2025 Hot Water & Hot Air Forum. March 6, 2025. https://drive.google.com/file/d/1oju5s-S4zltvkv5rzDFuDu6k3ftKujPT/view

48 Analysis based on a sample size of 1,515 non-solar projects. The implementation team's ability to segment by technology, project attributes, customer demographics, and utility was constrained by the sample size. As more incentivized projects accrue a full year of post-retrofit energy consumption data, more detailed analysis will become possible.

[49] Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction Wave 2*. March 27, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

thirds for heat pump HVAC with preexisting AC. Results vary widely by climate, utility rate, income status, and household energy consumption patterns.[50] Climate exerts a smaller influence on heat pump water heater compared to heat pump HVAC.

Customer utility electricity and gas rates are a major driver of bill impacts. The role of utility rates was most evident in the comparison of bill impacts observed between Sacramento Municipal Utility District (SMUD) and Pacific Gas and Electric (PG&E) customers. The Implementer analysis estimated that the median SMUD customer saved $516 per year for heat pump HVAC replacements with preexisting AC and $102 per year for heat pump water heater replacement. By comparison, the median PG&E customer saved $276 per year for heat pump HVAC replacements with preexisting AC, while heat pump water heater replacement increased bills by $57.[51] The differences were attributable both to lower electric bill increases for SMUD customers, tied to lower rates, and higher gas bill savings for SMUD customers, possibly driven by higher heating needs and larger homes around the Sacramento area. The evaluator did not report customer bill savings by utility.

A related value proposition that is harder to quantify is the hedge against future rate increases and price volatility that heat pump technologies may afford. The hedge is most clear-cut in the case of future gas rate increases, which building electrification mitigates. Customers can extend the hedge to future electric rates by combining building electrification with rooftop solar and battery storage. This combination allows the customer to produce and self-consume at a known and fixed electricity cost for the life of the solar and storage system, while minimizing gas charges or avoiding them entirely. This value proposition may help explain the popularity of heat pumps and heat pump water heaters among customers with preexisting solar arrays. In future analyses, it would be important to further segment solar and non-solar customers to better understand this difference.

Customers on income qualified rates, such as CARE/FERA, experience more bill savings from fuel substitution than market rate customers. Analyses by both the Evaluator and the implementor bill indicated that customers on a CARE or FERA rate experience more HVAC bill savings from fuel substitution than non-CARE or FERA customers. This increase is primarily driven by the higher discount on electric rates (30-35 percent) relative to the gas rate discount (20 percent). Evaluator results for a combined heat pump HVAC and heat pump water heater portfolio found an average $75 improvement in bill impacts for CARE versus non-CARE customers (annual savings of $109 versus $34).[52]

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[50] Opinion Dynamics. *TECH Population-based Pathway Impact Report.* November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

[51] Electricity and gas rates have changed significantly since this analysis was completed, and thus these values should be interpreted as directional outcomes that will shift based on changes to fluctuations in electricity and gas rates.

52 Opinion Dynamics. TECH Population-based Pathway Impact Report, Figure 3. November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

Table 6. Evaluator analysis of CARE or FERA and Non-CARE or FERA annual bill impacts

Low-Income Status	Electric Estimate	Natural Gas Estimate	Annual Net Change
CARE or FERA	$95	-$205	-$109
Non-CARE or FERA	$327	-361	-$34

The Implementor found that non-solar CARE and non-CARE customers with AC achieved virtually the same average annual bill savings, while non-solar CARE customers without AC would see an average improvement of $116. Median savings improved for both measure portfolios.

Table 7. Implementer analysis of annual electric, gas, and total bill impacts by canonical portfolio and CARE rate

			Electric		Gas		Total	
Portfolio	CARE	Projects	Mean	Median	Mean	Median	Mean	Median
HVAC, AC	False	541	$270	$234	-$527	-$378	-$256	-$199
HVAC, AC	True	84	$126	$160	-$377	-$325	-$251	-$240
HVAC No AC	False	373	$634	$506	-$549	-$470	$85	$46
HVAC, No AC	True	29	$121	$140	-$153	-$54	-$31	-$64

The addition of Base Service Charges is expected to improve bill outcomes for all customers. Based on utility rates in effect in 2022 and 2023, the implementer forecast that median bill savings could improve by an estimated $91–104 per year for non-solar customers installing a heat pump HVAC project without prior AC, enough to shift median impacts from a bill increase to bill savings.[53] Median bill impacts for heat pump water heaters and HVAC with prior AC were estimated to decrease bills by $42–54 per year. Future analyses could refresh these results with more recent rates and a larger project portfolio that can yield utility-specific results.

[53] At the time of analysis, there were insufficient HPWH projects to effectively model BSC impacts for customers, although future efforts may include them.

Bill savings for heat pump water heaters could be further improved through the adoption of baseline consumption allowances. To explore this possibility, the implementer modeled a hypothetical baseline allowance for PG&E customers, set at the average measured increase in electricity consumption for heat pump water heaters, which was 2.4 kWh per day in the summer and 4.0 kWh per day in the winter. The change was sufficient to improve median bill savings by $96 per year and transition from negative to positive savings.

Subsequent analysis can support more granular results. Going forward, the continued growth of completed projects with more than one year of post-install data offers an opportunity to address gaps in the above analysis and improve rigor across the board, by utility, climate zone, and technology, and to isolate specific drivers to understand how they individually contribute to outcomes. For example, considering the large observed energy impact differences for CARE and non-CARE customers, it will be necessary to further investigate the differences between these groups to better isolate the effect of the CARE program on electrification bill impacts. The implementer analysis sample of CARE customers was just 113 projects, so revisiting this analysis when more projects are available is advisable. Among other enhancements, increased data availability could shed light on utility variation. Likewise, the Implementer did not estimate heat pump water heater or solar customer bill impacts due to small sample size. With continued growth in the TECH Clean California's project portfolio, these gaps may be addressed in a subsequent analysis.

NON-ENERGY SERVICES: CUSTOMER COMFORT, HEALTH, AND RESILIENCE

Key Takeaways:

- **Customer comfort and reliability are drivers in customer heat pump purchasing decisions.**
- **Heat pump HVAC adoption amongst customers who previously lacked air conditioning can provide customers in hot climate zones better resilience to extreme heat events.**

Comfort is the key energy services benefit customers derive from their heating-cooling systems: Customers purchase heat pumps to heat and cool their homes or provide hot water and, as such, comfort and reliability are critical considerations from the customer perspective. Customers identify reliability, performance, and cost as the most important factors when replacing their HVAC equipment, and over 80 percent rated heat pumps as very effective at both heating and cooling their

homes (8 out of 10 or higher).[54,55] heat pump water heaters are effective at meeting customer demand, with 71 percent of customers always having sufficient hot water to meet their needs, and 23 percent had sufficient hot water "most of the time".[56]

Upsize heat pump water heaters to achieve energy service parity with gas storage water heaters. Technical limitations around the first hour rating for heat pump water heaters can be resolved by upsizing the tank by at least 20 percent compared to the existing tank. TECH Clean California added a bonus incentive to encourage contractors to adopt these best practices and this is now standard practice (See Appendix A: Measure-Specific Best Practices). In 2022, only 34 percent of projects upsized the new heat pump water heater, while in Q3 2025 over 90 percent of projects did so.[57]

Heat Pumps Strengthen Climate Resilience. Heat pumps for customers who previously lacked air conditioning significantly improves resilience in hot climate zones by enabling households to better withstand extreme heat events. When paired with solar and battery storage, heat pumps further enhance preparedness during extended power outages, particularly when considering that modern gas appliances rely on electricity to operate. Although not a primary benefit, a number of customers have anecdotally noted the value of heat pump water heaters in providing additional cooling in their garage space, the most common location for a heat pump water heater.

While climate resilience naturally improves customer health, TECH Clean California is not primarily designed to maximize or measure health outcomes. Nonetheless, these secondary value streams remain important to understand from a customer value perspective.[58]

[54] Opinion Dynamics. *Technology and Equipment for Clean Heating (TECH) Initiative Baseline Market Assessment*. July 15, 2022. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Baseline_Market_Assessment_Final_Report_8AHwAxk.pdf

[55] Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction Wave 2*. March 27, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

[56] Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction Wave 2*. March 27, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

[57] TECH Clean California. 15th Quarterly Stakeholder Presentation. October 30, 2025. https://techcleanca.com/documents/5673/TECH_15th_Quarterly_Stakeholder_Meeting_IPTFwGx.pdf

[58] Notably, indoor air quality improvements that come from heat pump adoption are generally limited to installations that replace unvented gas appliances in the conditioned space (e.g., wall furnaces and unvented water heaters). Electrification of gas cooking is an ineligible program measure, even though it would improve health outcomes for the broadest cross section of participants. See "Clearing the Air: Gas Stove Emissions and Direct Health Effects" Environ Health Perspective. 2024 Feb 28;132(2):022001. doi: 10.1289/EHP14180 https://pmc.ncbi.nlm.nih.gov/articles/PMC10901287/

HASSLE FACTOR, TRANSACTION FRICTION

Key Takeaways:

- **Heat pump installations are significantly more hassle than installing a replacement gas unit.**
- **Program requirements can add significant hassle to the transaction.**
- **There are opportunities to reduce the inherent work complexity of heat pump projects.**

While heat pumps offer significant value to individual customers, the hassle factor of installing a heat pump as compared to a replacement gas appliance can be a significant deterrence to customer adoption. Transaction friction for heat pump installations comes from three primary sources:

- Program requirements associated with incentive applications
- Differential enforcement of state laws such as building permit requirements that apply to all appliance installations, but are consistently enforced only on program participants
- Inherent work scope complexity compared to gas alternatives

For opportunities to address the first source of friction, see **Section 3.2 Simplifying Program Design to Reduce Costs and Burdens** for a discussion of lessons learned and best practices. The second source of friction, differential enforcement of state laws, will remain an issue until regulators and policy makers resolve the differential enforcement issue more broadly.

Emerging opportunities to mitigate project complexity. As for the third source of friction, there has been some progress in reducing the inherent complexity of heat pump installations. In some cases, technology innovations have succeeded in simplifying project work scopes, particularly related to duct design and wiring upgrade requirements. Mini splits, for example, have greatly simplified the task of retrofitting HVAC in a home that lacks preexisting air ducts. TECH Clean California has seen positive market response to the introduction of 120V heat pump water heaters, which mitigates the need for expensive wiring upgrades. Similar technologies promise to do the same for induction cooking. Since TECH Clean California was launched, developments in power-efficient design have reduced the need for service panel upsizing.

While new technologies have succeeded in resolving some points of work scope friction, other sticking points remain, particularly when an appliance needs to be relocated or when a service panel upgrade cannot be avoided. The points of friction can multiply when the extra work scope complexity triggers additional permit requirements.

CONSIDERATION OF OTHER CUSTOMER PREFERENCES

While this section focuses extensively on the economic value and customer cost of heat pump retrofits, humans rarely make decisions in perfect accordance with economic theory. Meeting a customer's financial thresholds may be a necessary precondition to heat pump adoption, but an array of other value propositions also comes into play, including impacts on social status and

alignment with personal values and beliefs. Moreover, the way those value propositions affect program uptake can be expected to change as participation moves beyond "early adopters" to include "early majority" customers.

For example, heat pump water heaters are clearly in an "early adopter" stage, and heat pump water heater customers were much more likely than heat pump HVAC customers to list "solar/electrification" or "environmental" reasons for moving forward with a heat pump or have functioning equipment but searching for an alternative as opposed to emergency replacement. In contrast, heat pump HVAC is in the "early majority" stage of market adoption, and thus retrofit drivers are more consistent with standard business practices. Sixty-four percent of heat pump HVAC customers reached out to a contractor because their equipment was old, malfunctioning, or broken, whereas only 42 percent of heat pump water heater customers had those reasons.[59] These evolving customer needs are best addressed through thoughtful design of marketing and outreach campaigns.[60]

C. Valuing the Societal Benefits of Heat Pumps

GREENHOUSE GAS EMISSIONS (GHG) IMPACTS

Key Takeaways:

- **Building electrification can deliver cost-effective greenhouse gas reductions, and these emissions reductions will only improve as the grid further decarbonizes.**
- **Fully decommissioning furnaces as part of heat pump HVAC installs results in substantially higher GHG savings than projects that retain their furnace.**

Building electrification can deliver cost-effective greenhouse gas reductions. The primary source of greenhouse gas emission reductions comes from decommissioning gas appliances. While the new electric heating load from heat pumps contributes GHG emissions, those emissions are substantially lower (74 percent) than the gas heating emissions they replace.[61] These heating-related electricity emissions are expected to decline as electricity generation continues to decarbonize to meet California's commitment for a fully decarbonized grid by 2045 (as required by Senate Bill 100, 2018). The implementer found that heat pump HVAC emissions are even lower when replacing a furnace-

[59] Opinion Dynamics. TECH Customer Post-Install Survey Topline Findings. September 2023. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Single-Family_Customer_Post-Install_Survey_Topline_Findings_Q4_2022.pdf

[60] Opinion Dynamics. *TECH Clean California: Time 1 Market Assessment Final Report*. February 29, 2024. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Time_1_Market_Assessment_Final_Report_4.22.24.pdf

TECH Clean California. The Roadmap to Scale: Using Analysis of Heat Pump Installations to Inform the Next 20 Million Projects. 2024 ACEEE Hot Water & Hot Air Forum. March 13, 2024. https://drive.google.com/file/d/1YrcUEcHaTh3Cw3dTrMpa5WuqttSSK967/view

air conditioner combination because the heat pump reduces summer cooling loads and associated emissions. The TECH Clean California implementation team analyzed GHG savings at a measure level (see Table 8 below).

Table 8. Implementer estimates of average lifecycle GHG emissions impacts by primary project type[62],[63]

	Average Lifecycle GHG Impacts per Participant (Tons CO2e)		
Portfolio	Electric	Gas	Total
HVAC, AC	7.8	-27.0	-19.2
HVAC, No AC	13.0	-25.8	-12.8
Water Heater	7.6	-21.4	-13.8

Across the portfolio, the evaluator calculated GHG emissions reductions to be 16.42 tons of CO2e across the measure lifetime.[64] In addition to estimating the overall emissions impacts, the evaluator also estimated the program cost per avoided metric ton of CO_2-e.[65] The evaluator estimated that streamlined program implementation would deliver CO_2-e reductions at an average cost of $240 per ton.[66] This value is close to the California Air Resources Board's 2035 estimated cost for reducing a metric ton of CO_2-e via building decarbonization ($235).[67] It should be noted that the evaluator results were derived from the cohort of projects completed between July 2021 and July 2023. During that time frame, the HVAC heat pump incentive decreased from $3,000 to $1,000 per unit in May 2022, so an updated analysis should show lower incentives per installed unit. Likewise, the

[62] Scheer, Adam. Recurve. Scheer, Adam. 2025 ACEEE Hot Water & Air Forum Presentation "Measured Impacts of TECH Heat Pump Installations". March 6, 2025. https://drive.google.com/file/d/1oju5s-S4zltvkv5rzDFuDu6k3ftKujPT/view

63 For TECH Clean California electrification projects installed in 2021 and 2022. Negative values denote GHG emissions reductions.

[64] Opinion Dynamics. *TECH Population-Based Pathway Impact Report*. November. 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

[65] Opinion Dynamics. *TECH Population-based Pathway Impact Report*. November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

[66] "Streamlined implementation" excludes administrative and incentive costs related to both pilots and quick start grants and workforce training and development activities. The intent is to show potential impacts for a full-scale program in a more mature market.

[67] California Air Resources Board. *2022 Scoping Plan for Achieving Carbon Neutrality*. December 2022. https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf

Implementer's internal analysis has identified opportunities to maximize GHG reductions along with other policy priorities. These opportunities are currently being operationalized. In short, there is ample reason to believe that a well designed and implemented program in a maturing market could achieve reductions at a cost well below $235 per metric ton.

Furnace decommissioning for heat pump HVAC projects generates substantially higher GHG savings than projects that do not. Internal analysis by the implementation team found that median GHG savings for heat pump HVAC electrification projects where the furnace was fully decommissioned are 63 percent greater than median GHG savings for projects where the furnace was left in as backup heat, even when the furnace was reported to be commissioned to operate in emergency scenarios only.[68]

PEAK LOAD REDUCTIONS, AVOIDED COSTS OF GRID INFRASTRUCTURE

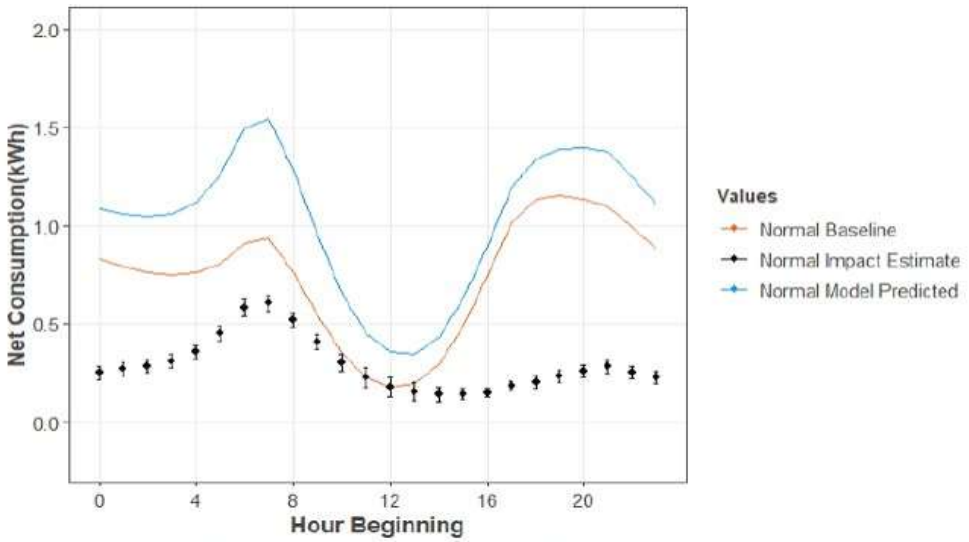
Key Takeaways:

- **Building electrification measures add electric load to the grid, though largely during off-peak or partial peak hours.**
- **Beyond peak load reductions, building electrification contributes a suite of benefits that avoid costs of grid infrastructure and add up to positive Total System Benefits.**
- **AC to heat pump replacement is a key opportunity to reduce overall electric demand.**
- **Water heating electrification does not meaningfully increase household peak demand.**
- **Integrated Demand Side Management (IDSM) programs can provide significant value to the grid and to customers by shifting load to off-peak hours; however, numerous demand flexibility requirements in programs can significantly hinder customer adoption and market actor participation.**

Even though building electrification measures add electric load to the grid, they can achieve significant peak demand reductions and support demand flexibility. Building decarbonization and electrification of space and water heating has potential to improve energy affordability, by adding load natively to the grid largely during off-peak and partial-peak hours.[69] This enables fixed costs, which represent the majority of the customer electric bill, to be spread across more kWh, thereby putting downward pressure on electric rates. As the evaluator has found and in-house analysis has confirmed, adding heat pumps for either space conditioning or water heating produces a morning winter peak, which is still small compared to the summer peak and existing grid capacity (Figure 2).

[68] Sarkisian, Dylan. Energy Solutions. "The Roadmap to Scale: Using Analysis of Heat Pump Installations to Inform the Next 20 Million Projects" Slide 11. 2024 ACEEE Hot Water & Hot Air Forums. March 13, 2024. https://drive.google.com/file/d/1YrcUEcHaTh3Cw3dTrMpa5WuqttSSK967/view.

[69] Scheer, Adam. 2025 ACEEE Hot Water & Air Forum Presentation "Measured Impacts of TECH Heat Pump Installations". March 6, 2025. https://drive.google.com/file/d/1oju5s-S4zltvkv5rzDFuDu6k3ftKujPT/view



Note: Normal weather estimates based on fixed-effects D-in-D panel regression analysis of TECH participant and matched nonparticipant interval electricity consumption data. Error bars show 95% confidence intervals.

Figure 2. Average winter weekday electric load shape and impacts

Beyond peak load reductions, building electrification contributes a suite of benefits that avoid costs of grid infrastructure and add up to positive Total System Benefits. The implementer's internal analysis has quantified a suite of public benefits from heat pump technologies, as shown in Figure 3. Of note, the biggest contributions result from reducing gas, and include reduced environmental impacts, avoided fuel costs, and avoided distribution infrastructure costs. The benefits of reducing gas are offset to a small degree by some incremental electric costs, although AC to heat pump replacements ("HVAC, AC Detected") do result in increased grid capacity.

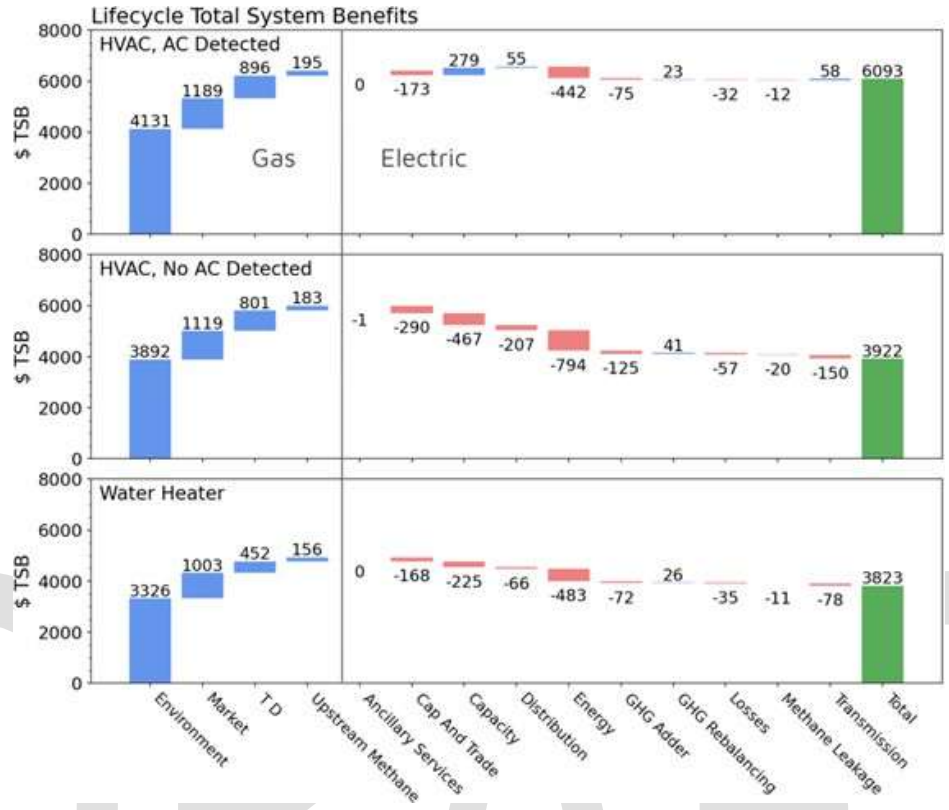


Figure 3: Lifecycle total system benefits for three technology portfolios[70]

AC to heat pump replacement is a key opportunity to reduce peak demand. Heat pumps that replace inefficient air conditioning with high summer cooling loads produce substantial permanent reductions in summer peak—no load shifting required—whereas heat pumps for furnace-only replacements add summer peak loads (Figure 4).

[70] Scheer, Adam. Recurve. "Measured Impacts of TECH Heat Pump Installations" from the 2025 Hot Water & Hot Air Forum. March 6, 2025. https://drive.google.com/file/d/1oju5s-S4zltvkv5rzDFuDu6k3ftKujPT/view

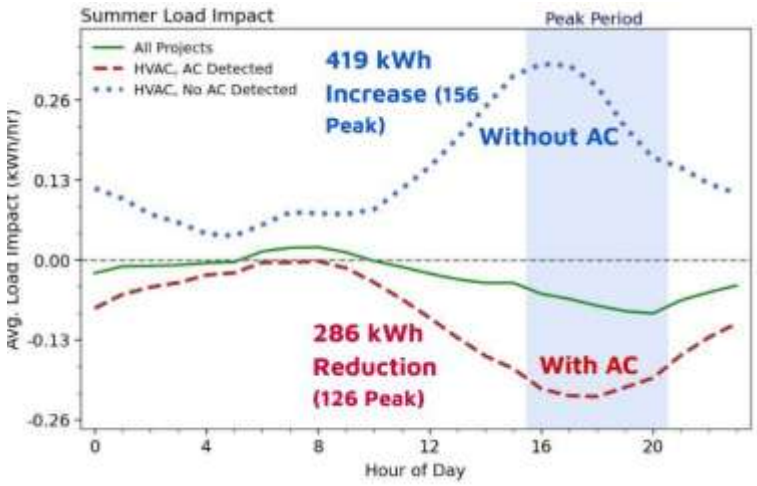


Figure 4. Average Summer Load Impact from Heat Pump HVAC Retrofits.[71]

Water heating electrification does not meaningfully increase household peak demand. The TECH Clean California evaluator found that the peak impact during the Resource Adequacy window from 4:00 p.m. to 9:00 p.m. on summer weekdays from heat pump water heaters was less than 0.01 kW, a finding which the Implementer's analysis corroborated.[72]

[71] Recurve. Scheer, Adam. 2025 ACEEE Hot Water & Air Forum Presentation "Measured Impacts of TECH Heat Pump Installations". March 6, 2025. https://drive.google.com/file/d/1oju5s-S4zltvkv5rzDFuDu6k3ftKujPT/view

[72] Opinion Dynamics. *TECH Population-based Pathway Impact Report*. November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

While Integrated Demand Side Management (IDSM) program design can provide significant value to the grid and to customers by shifting load to off-peak hours, numerous demand flexibility requirements in programs can significantly hinder customer adoption and market actor participation. SGIP HPWH launched incentives for heat pump water heaters (with demand flexibility requirements) under the TECH Clean California brand in October 2023. Figure 5, from the upcoming SGIP HPWH interim evaluation by SGIP HPWH evaluator Verdant Associates, demonstrates the substantial amount of load shed during peak periods from JA13-enabled sites (those that participated in the SGIP HPWH program).

However, complex or numerous demand flexibility requirements can introduce logistical and administrative burden that may create barriers to achieving other program goals (see ***Section 3.2. D. Simplifying Program Design to Reduce***

Self-Generation Incentive Program Heat Pump Water Heater Program (SGIP HPWH Program)

Key Outcome: ***Load Shifting***

Heat pump water heaters are an eligible measure for California's Self-Generation Incentive Program due to their ability to shift load from peak to off-peak time periods. D.20-01-021 established a budget allocation for heat pump water heaters specifically. The SGIP HPWH Program has been implemented under the umbrella of TECH Clean CA, enabling the program to utilize the TECH Clean CA program infrastructure, though the goals and outcomes of SGIP HWPH funding were more narrow and the SGIP HWPH program is evaluated on the reduction in customer

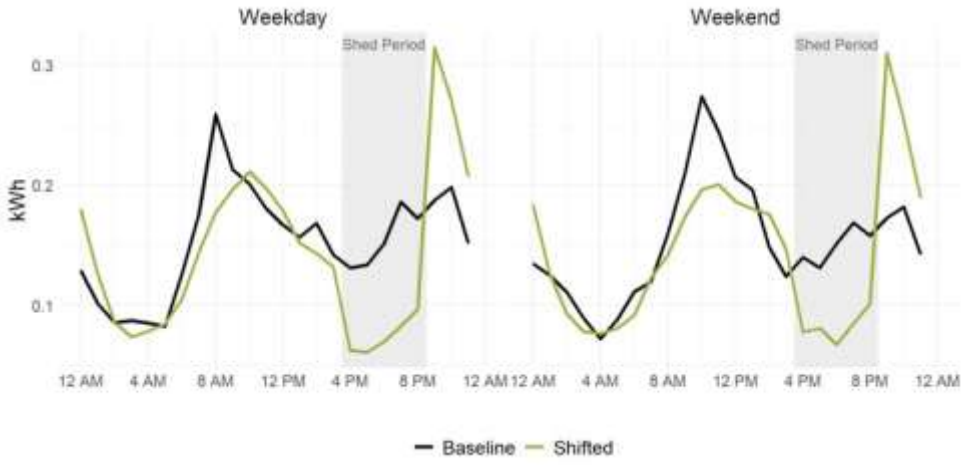


Figure 5. Average Hourly Load Profile, JA13 Enabled Sites[73]

[73] Upcoming Interim Evaluation Report for SGIP HPWH [not yet published] by program evaluator Verdant.

ADVANCING ENERGY EQUITY

Advancing energy equity via building decarbonization programs is best achieved by serving the customer segments that benefit most from building decarbonization measures. Low-income customers in hot climate zones stand to benefit the most from building decarbonization.

CARE customers are more likely to realize bill savings from heat pump installations than market rate customers. As previously discussed, CARE customers are more likely to achieve positive annual utility bill savings following heat pump installation than market-rate customers. (See *Customer Bill Savings and Affordability of Energy Services).* Data analytics can be employed to screen for customers most likely to save on their bills, thereby amplifying bill savings opportunities and mitigating any concerns about pushing income-qualified customers to make home upgrades that then result in higher energy bills.

Equity communities and bill savings opportunities are both concentrated in hot climate zones. In California, a significant proportion of disadvantaged communities and income-qualified customers are concentrated in hot interior climate zones with high cooling loads. Customers in those areas stand to benefit the most from heat pump adoption.

To ensure equitable distribution of benefits, TECH Clean California learned that a focus on A/C replacement to drive bill savings and grid benefits should be balanced with enabling access to cooling for added customer health, comfort, and safety benefits. This includes customers who have existing window units or cooling systems that are underused due to cost impacts and therefore may not show up as having cooling loads.[74,75]

[74] Rachel Etherington, Irina Krishpinovich, and David Ortiz, The Ortiz Group LLC; Meghan Harwood, Becky Schaaf, Ben Staub, and Asa Parker, VEIC. *Pilot Project Final Report: Low-Income Leveraging Pilot*. December 15, 2025. https://techcleanca.com/documents/5705/8.2_Low_Income_Leveraging_Pilot_v260105.pdf

[75] Forthcoming TECH Clean CA Multifamily Pilot Report.

D. Program and Portfolio Design Optimization and Strategies

Building decarbonization programs can deliver significant benefits to utilities, the grid, and customers. In many cases, these benefits are interrelated—but they do not automatically align without intentional program design. As the TECH Clean California evaluator noted, "The TECH Clean California energy impacts, GHG emissions, and bill impacts vary between climate zones, measures, and customer segments such as customers on CARE, FERA.[76] The variations in these program metrics show varying degrees of correlation, which opens an opportunity to optimize across multiple metrics.

This section summarizes how the Implementer investigated how different objectives relate to one another and the relative tradeoffs in prioritizing different metrics. These analysis results point to opportunities to optimize program design across multiple policy priorities rather than trade off one priority for another. In particular, the Implementer found that it is possible to improve program performance around its core mission of reducing greenhouse gas emissions without compromising ratepayer affordability or ignoring equity considerations—in fact, all three policy priorities can be enhanced in tandem.

Embracing a multivariate approach to building decarbonization. As part of its program strategy optimization, the implementation team analyzed the relationships among six key program metrics. Table 9 illustrates the varying levels of synergies that exist between TECH Clean California's goals.[77] For customers in single-family homes, total system benefits (TSB) show strong alignment with GHG emissions reductions (GHG impact) and reasonably good alignment with the goals of maximizing customer bill savings (annual bill impact) and maximizing peak period load reductions (peak MWh impact). If these four impact metrics were the only program goals, then it would be straightforward to optimize program design around maximizing TSB, knowing that the program would also score well on the other three metrics. Equity related metrics (Low-income, hard-to-reach county, and disadvantage community) have a slightly negative correlation to the four TSB-related goals, meaning that while they are not in opposition to the other metrics, they would not be achieved on their own without specific, intentional program support. This analysis informed the TECH Clean California decision to offer dedicated equity incentive kickers to advance energy equity. For full methodology, reference Appendix E: .

[76] Opinion Dynamics. *TECH Population-based Pathway Impact Report*. November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

[77] 2025 ACEEE Hot Water & Air Forum Presentation "Measured Impacts of TECH Heat Pump Installations". https://drive.google.com/file/d/1oju5s-S4zltvkv5rzDFuDu6k3ftKujPT/view.

Aside from TECH Clean California, this strategy for program optimization has been used by the Equitable Building Decarbonization team to support outreach to candidates most likely to benefit and with high alignment with the program's GHG objectives.[78]

Table 9: TECH Clean California goal correlation matrix for single family customers[79]

Correlation Matrix	Low Income	HTR County	Disadvant. Comm.	GHG Savings	TSB	Annual Bill Savings
Peak MWh Savings	-0.02	0.16	0.02	0.10	0.51	0.54
Annual Bill Savings	-0.02	0.14	0.06	0.39	0.68	
TSB	-0.09	0.11	-0.06	0.88		
GHG Savings	-0.12	0.04	-0.11			
Disadvant. Comm.	0.24	0.28				
HTR County	0.13					

APPLYING MULTIVARIATE OPTIMIZATION TO SINGLE FAMILY PROGRAM DESIGN

As TECH Clean California has collected program data, a clear program design strategy has emerged to maximize both the customer (private) as well as societal (public) benefits from building decarbonization in single-family homes. A primary focus on ***Air Conditioner Replacements in Hot Climates*** is compelling to the customer because they have (1) a reduced incremental cost of installation; and (2) better customer bill savings; and they have substantial societal benefits from (3) peak load reductions and avoided costs of grid infrastructure, (4) improved GHG reductions, (5) Total System Benefit (TSB) and (6) improved equity outcomes, more often located in equity communities.

Customer segmentation and targeting can drastically improve critical impact metrics. Table 10 demonstrates a segmentation analysis of the key benefits of TECH Clean California incentivized heat pump HVAC projects. Homes with A/C and on-peak electricity use above the median had:

- Much higher bill savings ($423/year);
- Lower total project costs (approximately $300 less than "all heat pump retrofits").
- Greater societal benefits (over $2,000 in additional lifecycle total system benefit than "all heat pump retrofits," nearly 30 percent more GHG savings, and nearly 10 times the on-peak electricity savings compared to "all heat pump retrofits."

[78] Diana Maneta, California Energy Commission. CPUC Building Decarbonization Best Practices and Future Pathways Workshop; "Equitable Building Decarbonization Direct Install Program". January 22, 2026. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/building-decarb/bdworkshop20260122updatev2-pdf.pdf

79 Note that a comparable correlation analysis for multifamily customers might show different relationships between program goals, pointing to different targeting solutions.

- Were more often located in disadvantaged communities.

Table 10: Applying machine learning model findings to real data.

Targeting Tier	Heat Pump HVAC Retrofit Customer Targeting Strategy	Sample size (# TECH projects)	On-Peak Electricity Savings (kWh)	Annual Utility Bill Savings [1] ($)	Lifecycle [2] GHG Savings (MT CO2e)	Lifecycle [2] Total System Benefit ($)	Total Project Cost (2022 $)	Percentage of Projects in DACs [3]
0	**None** - All HP HVAC Retrofits	1,918	32	155	15	5,219	18.0k	12 percent
1	**Reference case** - Target only homes with air conditioning	1,270	155	259	17	5,962	17.2k	16 percent
2	Target homes with A/C **and** on-peak electric use above the median (1 MWh)	789	311	423	21	7,582	17.7k	16 percent

Table 10 illustrates the value of preferentially steering heat pump HVAC incentives to projects in homes with existing air conditioning and high on-peak electricity consumption.[80] As a first step, TECH Clean California **has increased the incentive for customers with preexisting air conditioning** by $500 (a fraction of the additional TSB these projects achieve). The intent is to signal to contractors the value of focusing on these opportunities. Going further, programs could identify and preferentially market to communities with a high concentration of homes in "Tier 2" (existing AC and on-peak electricity use exceeding one MWh).

Targeting via geographic propensity is more scalable than segmentation targeting. TECH Clean California has also experimented with narrowly targeted marketing campaigns to specific customer segments with high savings opportunities, regardless of their geographic concentration. However, TECH Clean California's targeted marketing efforts have not produced efforts that can be scaled

[80] 2025 ACEEE Hot Water & Air Forum Presentation: "Threading the Electrification Needle: Finding Peak Demand Savings Drivers for Heat Pump HVAC Retrofits with Machine Learning". https://drive.google.com/file/d/1T8jK6xCAMFWOwSpWdcHvmaUio69YDiep/view

statewide. (See Section 3.5 A. Progress Towards Building Customer Awareness and Positive Perceptions of Heat Pump Technologies.) Instead, the TECH Clean California implementation team recommends geographic targeting of areas in which there is a higher concentration of homes with attributes that correlate with higher savings opportunities. For example, between 55–60 percent of TECH Clean California heat pump projects have replaced an air conditioning unit, and a marketing effort that could increase the percentage of AC to heat pump conversions amongst all participants without constraining eligibility would substantially increase the benefits of installed projects while still enabling projects which add cooling for health and comfort when appropriate (furnace-only heat pump HVAC replacements).

Looking forward, the implementation team intends to replicate the above optimization approach for heat pump water heating, which makes up 23 percent of single-family projects and 64 percent of multifamily projects. One can expect that climate variation will be less important as a savings driver, whereas factors such as tank upsizing, utility rates, and the presence of solar may prove more important in project outcomes.

MULTIFAMILY HOME PROGRAM DESIGN OPTIMIZATION

California's multifamily sector is important to address, both from an overall impact perspective and from an equity perspective. While program lessons learned generally apply to both single-family and multifamily, there are nevertheless important differences between the two customer segments that necessitate a different optimization solution.

While the implementer has not yet conducted the multivariate optimization analysis for multifamily that was described for single family, it is reasonable to expect that such analysis would produce substantially different results. For one thing, given the demographics of multifamily residents, a multifamily initiative would disproportionately benefit low-income households and renters even in the absence of income eligibility requirements. Thus, there may not be the same tension between equity and environmental outcomes that the Implementer observed in the single-family sector (See Table 1).

Multifamily housing in California by the numbers

1. Multifamily housing represents 28 percent of California's housing stock
2. 91 percent of multifamily units are rentals.
3. Approximately half of low-income households in California live in multifamily properties.
4. 25 percent low-income households live in subsidized affordable housing.
5. 75 percent in market-rate properties referred to as "Naturally Occurring Affordable Housing" (NOAH)

Another salient difference is that water heating is the dominant multifamily end use: of the 16,000+ multifamily apartment units served by TECH Clean California, 77 percent of them were for heat

pump water heater installations.[81] Water heating represents the biggest opportunity for GHG reductions, bill savings, and grid benefits in the multifamily sector. Water heating loads are less seasonal than space conditioning, so there is not the same additional value from targeting hot climates that one sees for single family customers. In fact, multifamily housing tends to be concentrated coastally in large urban areas.

The complexity of the multifamily sector necessitates consideration of additional design elements to maximize adoption and impact. Multifamily electrification requires a holistic problem-solving approach to address multiple barriers. It must account for long planning horizons, a diverse mix of sometimes complex technologies, complex finance structures, a variety of ownership models, multiple decision-makers, and more variable decision criteria. TECH Clean California's lessons learned for this segment are discussed throughout the report and inform our recommendations for achieving scale. See the following sections: Simple Programs Improve Uptake and Reduce Administrative Burden, Right-Sizing in the Multifamily Sector, Multifamily Engagement and Buy-In, and Electrification Readiness for Multifamily Properties.

SCALABLE SOLUTIONS TO SERVING EQUITY CUSTOMERS

Existing Weatherization Programs Offer an Opportunity to Support Decarbonization for Income-qualified Customers.

TECH Clean California has pursued equity investments for the dual purpose of serving equity populations and demonstrating the value of reorienting the larger energy efficiency and weatherization programs around decarbonization goals. California's primary direct install programs, Energy Savings Assistance (ESA) and the Low-Income Home Energy Assistance Program (LIHEAP), account for a combined annual $40 million of gas appliance installations for low-income customers.[82] ESA program restrictions on fuel substitution replacements have inhibited heat pump adoption in favor of like-for-like gas appliances, thus leaving this vulnerable group of residents behind in the transition to clean energy.

TECH Clean California's collaboration with the ESA programs of two investor-owned utilities points to opportunities to refine the ESA program in ways that better integrate California's equity and climate policy priorities. In support of equity-related single-family installations, TECH Clean California partnered with the San Joaquin Valley (SJV) Pilot and the ESA programs of Pacific Gas and Electricity (PG&E) and Southern California Edison (SCE). With funding support from TECH Clean California to cover incremental costs, these ESA programs have been able to replace aging

[81] TECH Clean California. 16th Quarterly Stakeholder Meeting. February 12, 2026. https://techcleanca.com/documents/5720/TECH_16th_Quarterly_Stakeholder_Meeting.pdf

[82] TECH Clean California. *TECH Clean California Annual Report 2022-2023. Year Two: September 2022-August 2023.* March 14, 2024. https://techcleanca.com/documents/4324/TECH_Annual_Report_2022-2023_v230212.pdf

furnaces and gas water heaters with high-efficiency heat pumps in 520 homes.[83] Incorporation of methods and results from TECH Clean California's billing impacts analysis could further support building decarbonization in the context of the program's customer affordability priorities. Going forward, while the process could be simplified for a decarbonization program to inject appliance incentive funding into an existing weatherization program, the simpler solution from an implementation perspective would be to reorient the weatherization program scope to include decarbonization as a core design principle.

Incentives for income-qualified customers offered through TECH Clean California

Higher income-qualified incentives have been an important factor in TECH Clean California's ability to allocate 46 percent of its incentive spending to equity households to date.[84] TECH Clean California introduced higher incentives for income-qualified customers and households, which boosted the heat pump HVAC incentive for qualified households from $1,000 to $3,500. TECH Clean California now forecasts 56 percent of incentives will be spent toward equity households across funding sources through the life of the program. The inclusion of income-qualified incentives has been instrumental in putting TECH Clean California on track to achieve Governor Newsom's goal of directing at least 50 percent of incentives to disadvantaged communities.[85] The market response to the bonus has illuminated several important lessons:

- **A number of contractors have turned their attention to serving equity households and have been successful in bringing equity customers into the program**. Of particular note, some contractors have even found solutions for serving residents of mobile home parks. Many of these contractors do not currently participate in income-qualified direct install programs, showing that there is an opportunity for broader contractor engagement that complements existing direct install programs.
- The strong market response to the higher equity incentives demonstrated that **there is a sizable income-qualified customer segment willing and able to pursue equipment upgrades even without 100 percent subsidies**. This finding suggests that California can serve more equity households faster if direct install programs are complemented by an enhanced equity incentive offer that can contribute less than 100 percent of the project cost.
- **Simplifying the income verification process remains an important program design challenge.** Income verification has also resulted in multiple points of customer frustration. Firstly, a recurring misconception among both contractors and customers is that completing

[83] Rachel Etherington, Irina Krishpinovich, and David Ortiz, The Ortiz Group LLC; Meghan Harwood, Becky Schaaf, Ben Staub, and Asa Parker, VEIC. *Pilot Project Final Report: Low-Income Leveraging Pilot*. December 15, 2025. https://techcleanca.com/documents/5705/8.2_Low_Income_Leveraging_Pilot_v260105.pdf

[84] TECH Clean California. 16th Quarterly Stakeholder Workshop. February 12, 2026. https://techcleanca.com/documents/5720/TECH_16th_Quarterly_Stakeholder_Meeting.pdf

[85] Office of the Governor. Letter to Liane Randolph, Chair of the California Air Resources Board. July 22, 2022. https://www.gov.ca.gov/wp-content/uploads/2022/07/07.22.2022-Governors-Letter-to-CARB.pdf

income verification automatically reserves funding, which it does not. Furthermore, income verification adds another element in which errors can be introduced into processing applications, thereby increasing the chance a claim is rejected. Yet another challenge is that contractors who engage with low-income customers may encounter barriers such as limited English proficiency and limited internet or email access.

- **A dedicated multifamily initiative is critical for comprehensively serving low-income customers.** From the outset, TECH Clean California emphasized the importance of addressing the multifamily sector as part of a comprehensive equity focus. TECH Clean California's approach to multifamily has been iterative, starting with basic incentives and pilot offers, which have informed a subsequent round of more comprehensive incentive offers and technical assistance. Specific best practices are discussed under Appendix A: Measure-Specific Best Practices and in Section 4.5 Electrification Readiness for Multifamily Properties and Portfolios.

3.2 Simplifying Program Design to Reduce Costs and Burdens

A. Program Design Decisions and Incentive Delivery Channels

An array of program design decisions impacts the simplicity and impact of the final offering. Each decision entails trade-offs between costs and benefits and sometimes between competing policy priorities. The decisions are often interconnected, such that the answer to one design question constrains the available choices to resolve another question. The big-picture design decisions generally relate to eligibility criteria for (1) technologies, (2) customers, (3) projects, and (4) installers.

- **Which technologies are eligible?** A broader menu of eligible technologies gives consumers more flexibility to mix and match, depending on their particular needs, while a narrower menu can be more targeted to specific policy goals. Technology specifications that set performance thresholds above industry standards can improve impacts at the expense of narrowing choices and perhaps increasing costs. Overly detailed or prescriptive requirements for eligible technologies may unnecessarily constrain technology innovation.
- **Which customers are eligible, and how does the program offer vary across customers?** Customer eligibility may vary by multiple factors, including geography, income, and utility service. Beyond the threshold eligibility question, the program offer could vary across different customer segments. Narrowing the range of eligible customers can have the effect of narrowing viable communication channels while multiplying the number of offer permutations adds complexity and cost.
- **Which projects are eligible?** In addition to explicit eligibility criteria around project attributes such as building type, program requirements applicable at the project level can indirectly impact which projects are feasible. For example, requirements that result in extended project timelines are generally incompatible with emergency replacement scenarios.
- **Who is eligible to install qualifying technologies?** Answers to this question could range from "anyone" at one extreme to "only the program's hand-picked installers" at the other. In

addition to decisions that directly address installer eligibility, a broader range of decisions may indirectly impact installer participation, thereby acting as de-facto eligibility restrictions.

Program design choices (and program goals) have direct implications for the optimal program delivery channel. Depending on market maturity, incentive availability, and policy priorities, delivery channel options include:

Point of Sale (Distributor and Retail)

- **Pros:** Point-of-sale incentives enable all contractors to benefit from the program and gives them maximum flexibility for how they integrate the incentives into their service offerings. The speed and simplicity support emergency equipment replacements, and the lack of installer requirements, accommodate "do-it-yourself" installations, which make up over 50 percent of water heater replacements in California.[86] Wholesale-level incentives generate a multiplier effect by reducing retail markups. It enables administrators to collect sales data for market tracking.
- **Cons:** In a Point-of-Sale delivery model, it is difficult to enforce permit verification, tenant protections, professional training and credential requirements, and other downstream program requirements. The model offers limited ability to track project characteristics or prioritize individual equity customers. Finally, to drive true market adoption, an upstream delivery model needs sufficient incentive availability to serve a broad market over an extended period.

Contractor Open Market (e.g., the current TECH Clean California model)

- **Pros:** Incentives are targeted at contractors, with any contractor meeting minimum eligibility able to participate. The program can offer higher, more narrowly targeted incentives based on customer-specific data (income, energy usage, etc.). The approach can accommodate more complex requirements such as professional training, credential requirements, and project eligibility requirements.
- **Cons:** Compared to distributor/retailer incentives, this channel involves higher "transaction friction" and administrative costs, which can limit participation from small businesses. It is less suited for emergency replacements, and "do-it-yourself" (DIY) projects are excluded entirely.

Contractor Closed Market

- **Pros:** In this variation on the contractor model, a limited set of contractors is selected through a competitive process based on pricing and qualifications. These contractors provide a "concierge" experience, managing the project from scope to installation. This

[86] Opinion Dynamics. *California Water Heating Market Study: Contractor Building Models, Training, and Electrification*. March 29, 2024. https://opiniondynamics.com/wp-content/uploads/2025/07/Water_Heater_Market_Characterization_Study_PDA_Final_9_18_2024.pdf

approach is well suited for a deep equity focus with high-touch support and 100 percent program subsidies (i.e., Direct Install). It resolves multiple barriers (upfront cost, language, community distrust, and landlord-tenant split incentives) and enables a whole-home approach, delivering health, safety, and bill savings to those who otherwise could not afford any retrofit. Installation costs can be negotiated at the portfolio level rather than project by project.

- **Cons:** High per-project costs associated with full subsidies can limit total volume and reach/market acceleration impacts of the program. The "program monopoly" approach does little to transform the broader, non-subsidized home improvement market and requires longer timelines for enrollment as well as project evaluation and scoping.

Direct to Consumer.

- **Pros:** Incentives targeted directly to consumers enable downstream project eligibility requirements and the collection of site-specific data.
- **Cons:** Rebate applications need to be done by each individual customer. Few households actually utilize downstream rebates due to the amount of paperwork. High friction application processes do not help customers with emergency replacements. Downstream programs also require relatively high administration costs versus more upstream models where participants number in the tens or hundreds. Finally, downstream rebates have lower incentive leverage due to markups throughout the supply chain.

Senate Bill 1477 (Stern, 2018) established that TECH Clean California shall advance the market for low-emission space and water heating equipment through "upstream market development" as well the "the provision upstream and midstream incentives." The Commission defined upstream and midstream market development in Decision 20-03-027:

- Upstream market development: Program elements aimed at encouraging manufacturers to make the most GHG-reducing equipment available at competitive prices.
- Midstream market development: Program elements that provide incentives to wholesale distributors, retailers, e-commerce companies and/or contractors to stock and/or sell more efficient products.

In practice, TECH Clean California has been delivered via a "contractor open market" structure. Several factors informed this choice:

- Statutory requirements and regulatory guidance that necessitated project-specific eligibility criteria.
- The ability to focus on the contractor as the key source of influence in customer decision-making.
- The ability to collect project characteristics and track meter-based outcomes to fill an information void about building decarbonization best practices.

As the market matures, the last two factors become less critical for market acceleration. Contractors are becoming more familiar with heat pumps, and, as customer awareness and adoption rates

ratchet up, peer-to-peer word of mouth is expected to gain importance as a source of influence. Conversely, once we have gathered enough project data and conducted enough analysis to address information gaps, the marginal value of additional project-specific data should decline. In short, a simpler point-of-sale delivery model should become increasingly viable.

The remainder of this chapter examines the opportunities, challenges, and lessons learned while weighing cost/benefit trade-offs of different design choices in the context of sometimes competing policy priorities.

B. Program Complexity Has Practical Implications for Incentive Layering

Over the course of its implementation, TECH Clean California has served as a platform for several additional programs with their own funding streams and program administrators by virtue of the program's unique role as a state-wide initiative.

- SGIP HPWH was administered through TECH Clean California with a primary goal of positive grid impacts and GHG reductions through the market acceleration of equipment that reduces peak load.
- California's Home Electrification and Appliance Rebates (HEEHRA) Program was administered by the CEC through TECH Clean California.
- Funding from the Aliso Canyon Recovery Account was allocated to TECH Clean California via AB 157 (2024) with a priority of reducing winter natural gas demand from the Aliso Canyon natural gas storage facility.
- Incentives from regional programs such as the BayREN Heat Pump Water Heater Incentive Program and 3CE Electrify Your Home were also administered via the TECH Clean California platform.

Leveraging the mature TECH Clean California infrastructure promised much quicker deployment of these additional funds and streamlined the experience for customers. However, each funding stream carried distinct programmatic and contractual requirements, along with differing priorities and expected outcomes. These differences created several "programs" all under TECH Clean California umbrella, and because these programs each have different, typically inflexible requirements, it limited the extent to which true alignment and administrative efficiencies could be realized.

Incentive layering is most effective when aligning requirements across programs. TECH Clean California's initial single-family offering was designed to encourage incentive layering directly, with an enhanced measure structure in regions where a partner program existed. The incentive structure set up three distinct methods of layering with another incentive on a single claim submission. These included:

1. Stacking both incentives on a single claim form, with a single check paid to participants.
2. Stacking both incentives on a single claim form, while incentives were paid out separately by each program.
3. Operating both programs separately, but data was shared on the backend between program implementers to reduce participant burden.

TECH Clean California discontinued the third option of integration as it proved to be an administrative burden that did not significantly reduce participant burden.[87]

In practice, the feasibility of layering incentives from two different programs has hinged on the degree of alignment around program requirements pertaining to (1) technologies, (2) customers, (3) projects, and (4) installers. Layering opportunities can be characterized as follows:

- **Best:** Program requirements are completely aligned across all four sets of requirements, facilitating unified workflows, information systems, etc.
- **Good:** For a requirement category with less than complete alignment, the requirements for one program are a subset of the other program requirements, such that the program with fewer requirements can function as a base offering, with the stricter requirements acting as an optional higher threshold. For example, program A might offer an incentive for a code-compliant heat pump, whereas program B might contribute a bonus incentive for variable speed models.
- **Also good:** Program requirements are non-overlapping; for example, program A might incentivize heat pump HVAC while program B incentivizes heat pump water heater.
- **Poor:** Incompletely overlapping and conflicting requirements. In this case, the resulting offer with layered incentives becomes more complex than either program individually. The compounded complexity adds administrative burden and project costs while thwarting customer participation.

The need for incentive layering is particularly acute in the multifamily sector. Multifamily heat pump water heater projects were often funded through a variety of incentive sources, in addition to TECH Clean California incentives. These additional funding sources included BayREN incentives, federal tax credits, and California's Low-Income Weatherization Program (LIWP), as well as other means such as HOA fees or rental income. In contrast, multifamily HVAC heat pump projects were generally funded using the property owner's own funds, such as financial reserves, capital expenditure budgets, or rental income.[88] In both cases, TECH Clean California incentives played a significant role, with some property owners indicating they would have been unlikely to purchase the equipment without these incentives.[89]

After layering eligible incentives from other programs, the multifamily pilot provided an average of $6,600 per unit to cover the funding gap for participating properties to fully electrify. With limited

[87] TECH Clean California. *TECH Clean California Annual Report 2022-2023. Year Two: September 2022-August 2023*. March 14, 2024. https://techcleanca.com/documents/4324/TECH_Annual_Report_2022-2023_v230212.pdf

[88] Opinion Dynamics. *Process Evaluation of the TECH Clean California Initiative*. May 2, 2025. https://www.calmac.org/publications/TECH_Process_Evaluation_Final_Report.pdf

[89] Opinion Dynamics. *Interim Process Evaluation: Technology and Equipment for Clean Heating (TECH)*. November 7, 2022. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Interim_Process_Evaluation_Final_Report.pdf

reserves in most low-income properties, property owners rely on outside funding to bring out-of-pocket costs down to less than 10 percent—or in most cases, $0—for projects to move forward.

More generally, simplicity and flexibility are essential ingredients to multifamily incentive program success, where incentives must align with long-term planning horizons driven by complex financing structures, engineering challenges, and business decisions. Multifamily pilot projects showed considerable variation in project scope. Projects ranged from single unit upgrades for individual apartment units to the replacement of large central systems that served multiple units at once. Most multifamily projects required upgrades to electrical infrastructure, including upgrades to the building's electrical panel, electrical service, or transformer, or upgrades to panels in individual units.

TECH Clean California's multifamily success has been largely driven by its comparatively simple process and the relative ease with which it can be layered with other funding sources. TECH Clean California originally set a project deadline of one year for multifamily projects but has seen projects take years longer than anticipated.

C. Avoid Incentive Funding "Starts and Stops", which is Critical to Market Actor Engagement

TECH Clean California comprises three core segments, each with their own funding allocation and budget: single-family heat pump HVAC, single family heat pump water heater, and multifamily. However, within each funding tranche, there may be specific geographic or equity requirements that further split the funding into smaller subprograms. When considering all the individual subprograms, TECH Clean California incentive funding has been depleted 27 times over the past four years of implementation.

> *"I don't know what zip codes or what jurisdictions the rebate is still available for, so that's the biggest problem. [We] don't know where money is available for customers so we don't want to sell a customer on [the incentive] and then them not get it."* ***Statewide Contractor***

Sustained incentive funding is crucial to market transformation. The number one strategy in California's Heat Pump Partnership Blueprint is to "Support long-term, stable incentives to provide market certainty." Similarly, the first recommendation in the Draft 2025 California's Building Energy Action Plan, is to "continue to prioritize funding for incentives to achieve GHG targets." Crucially, both documents recognize the importance of the ***stability*** of incentive funding for market transformation. Market transformation initiatives are successful when they provide supply chain actors assurances that the program will last long enough to justify their participation in the program and invest in changing their business model towards enabling building decarbonization. Funding consistency is therefore a key component of effective incentive design.

Incentives have been effective at driving heat pump sales. TECH Clean California incentives have clearly a significant impact on heat pump adoptions both for space conditioning and for water heating. Many surveyed contractors (88 percent) observed an increase in their heat pump sales since they began participating in TECH Clean California and cited the initiative's incentive in driving this increase.[90] Likewise, many contractors reported a negative impact on their heat pump sales during periods when TECH Clean California funding was paused.[90] Periodic disruptions to incentive availability have been cited repeatedly as sources of transaction friction, confusion, increased cost and complexity, and contractor reluctance to engage with the program.

> *"TECH HVAC initially started giving $3,000 per outdoor unit, HVAC outdoor unit. Cool. That was a little too good to be true, and it turns out it was, so [the TECH Initiative] ran out of money pretty fast. Then they slimmed it down to $1,000, and that, we've seen more longer-term benefits from the $1,000 than the $3,000. So, less money that, to encourage stability, seems to be better, leads to long-term, much better results. So, simplicity and stability, even if that means lower rebate amounts, that's always been what we've wanted."* ***TECH Clean California Contractor***

Program funding interruptions have negative effects for a spectrum of key market actors. Interruptions in program funding negatively affect market actors in various ways:

> *"This uncertainty doesn't just affect us; it affects every single contractor and customer involved in this process. It is creating a black eye on programs that should be celebrated, making it harder to get buy-in from contractors who would otherwise be eager to participate."* ***TECH Clean California Contractor, describing the effects of Funding Pauses***

- **Distributors and retailers**. Upstream market actors make stocking decisions on two- to three-month cycles. Volatile program conditions such as abrupt funding "stops and starts "disrupt demand forecasting for program-eligible technologies and reduce distributors and retailers' willingness to stock heat pump HVAC systems and heat pump water heaters. These interruptions also create hesitation around staff training and marketing investments. The decision of distributors and retailers have downstream effects: suppliers' ability to keep these technologies in stock is critical for contractors who participate in the program and plan their business operations around the installation of program-eligible technologies such as heat pumps HVAC units and heat pump water heaters.
- **Contractors**. Participation in incentive programs also requires an investment from contractors to provide their installers and sales staff with training, understand and keep up-to-date with incentive requirements, purchase qualifying equipment, and adjust marketing strategies. To justify these business costs, contractors also rely on program consistency and stability over longer timeframes. While contractor participation in TECH Clean California has grown over

[90] Opinion Dynamics. *Process Evaluation of the TECH Clean California Initiative*. May 2, 2025. https://www.calmac.org/publications/TECH_Process_Evaluation_Final_Report.pdf

time, participation program data reveals a level of churn in contractor participation that is attributable to disruptions in incentive availability.[91] Both the TECH Clean California implementer and evaluator have received reports of contractors who invested significantly in marketing for heat pumps only for incentives to run out weeks afterwards.

- **Local organizations supporting electrification, such as utilities, CCAs, and regional energy networks**. Local organizations provide critical on-the-ground support tailored to the needs of their local community. A multi-year statewide program would provide these organizations with the planning certainty they need to develop complementary services to support the needs of their communities. Numerous CCAs, utilities and other organizations offer local heat pump incentives layered on top of TECH Clean California, as well as customer and contractor engagement. While TECH Clean California's incentive support has helped drive heat pump adoption, the lack of long-term consistency makes it difficult for other local stakeholders to plan and assume that TECH Clean California funding will still be available, or at least replenished on a consistent, annual timeline. Consistency will help the many organizations supporting electrification plan and coordinate efforts more effectively.
- **TECH Clean California implementation team**: Inconsistent funding creates a dilemma for TECH Clean California planning itself, particularly regarding market development activities. Consumer education campaigns, workforce initiatives, pilots, and marketing efforts all lose effectiveness when incentive availability fluctuates. Outreach strategies tied to incentive availability are delayed or diluted, reducing overall program impact. The periodic interruption in incentive availability triggered the need for extra incentive administration processes during each start/stop, including:
    - Project preapplications and preapprovals to reserve incentives in advance
    - Public-facing incentive dashboard to show incentive availability in real time
    - High-frequency cadence of contractor communications regarding incentive availability

As the TECH Clean California evaluator has observed, "TECH Clean California's supply of incentives that make their way to end-use customers should be more stable to ensure continued heat pump installations .....The fluctuating availability of incentives introduces uncertainty into contractor business practices and undermines their confidence that incentives will be available at a given time. If we want to keep installations at a steady or growing pace, incentives must continually be available."[92] While TECH Clean California has been able to minimize disruptive impacts to some degree by reducing per unit incentives, this approach has inherent limitations, especially if premium incentives are needed to compensate contractors for managing complex program requirements or supporting equity kicker incentives.

[91] TECH Clean California. *TECH Clean California Annual Report Year 3. July 2023-June 2024.* November 21, 2025. https://techcleanca.com/documents/5689/TECH_Annual_Report_2023-2024_v251114.pdf

[92] Opinion Dynamics. *TECH Clean California: Key Performance Indicator Assessment.* July 18, 2024. https://www.calmac.org/publications/TECH_Clean_California_Key_Performance_Indicator_Assessment.pdf

D. Simplify Program Requirements Where Feasible

Programs are most successful when the participation process is simple and predictable. Market transformation efforts can be undermined if the mechanisms designed to address barriers create new barriers for customers, contractors, or supply chain actors.

As a market transformation program created by legislation, TECH Clean California has had a significant degree of flexibility in designing its approach and the solutions that have enabled its success. While program results are reported, the program is not subject to strict cost-effective requirements and in many ways has had flexibility to adapt to a changing market. This flexibility has, in large part, enabled many of the successes of the program. Even so, while TECH has more latitude than more other programs, there are opportunities to further improve the participant experience and increase participation.

LAYERED REQUIREMENTS DISRUPT THE CONTRACTOR AND CUSTOMER EXPERIENCE

TECH Clean California is subject to a range of requirements that fall into three primary categories: funding source requirements, which limit how specific funds can be leveraged; state requirements, which govern how projects must be implemented; and programmatic requirements, which define eligibility and participation requirements. Each requirement has operational implications, often adding processing time, adding complexity to the participation process, or segmenting program funding. While the intent behind these requirements is understandable, an accumulation of constraints can create friction and implementation challenges that deter participation.

- **Funding Source Requirements**: These come from the funding source or legislation itself. For example, TECH Clean California's original funding was from gas IOU cap and trade funding, which required incentive funding to be allocated exactly along gas IOU proportions (PG&E: 42.34 percent, SoCal Gas 49.26 percent, SDG&E 6.77 percent, Southwest Gas 1.63 percent), effectively creating four different program budgets to manage.
- **State Requirements**: These requirements come from existing statewide law, such as construction permit requirements.
- **Programmatic Requirements**: These requirements may come from the Regulatory Decisions associated with the specific funding tranche, or the program team itself:
- **Eligibility:** Program eligibility requirements include customer income verification, equipment eligibility requirements, etc. For example, SGIP heat pump water heater funding required enrollment in a "qualifying" demand response program as defined in the Decision. However, "qualifying" demand response programs were not available to customers of publicly-owned utilities until the CPUC issued a revised Decision. Until that point, those customers were ineligible. Thus, to keep statewide consistency, incentives for those customers needed to come from a different source.

- **Process Requirements**: The SGIP HPWH program had a requirement for confirming time-of-use enrollment prior to the implementer paying an incentive. This requirement involved contacting the utility for confirmation prior to incentive payment, adding weeks to the payment timeline.

Table 11: Example requirements at each level for TECH Clean California

State/Funding Requirements	Programmatic Requirements
Permitting	Time of Use Verification
Tenant Protections	Demand Response Enrollment
Geographic Allocation	JA 13 Compliance
	Specific Incentive Amounts Written into Policy

While many of these requirements are well intentioned, their cumulative effects manifest in the form of increased application approval timelines, increased number of application errors and rejections, and extended enrollment timelines. These combined impacts strain participating contractors' staffing resources and information systems; add to their soft costs that either reduce profitability or get passed through to customers; and erode both contractor and customer participation.

Evaluating the cost-benefit trade-off of program requirements can be challenging. The benefits of a requirement may be relatively easier to quantify during the regulatory or initial scoping process, while the operational and participation costs of additional requirements may not become fully apparent until the program is implemented. As discussed above, building electrification programs are often expected to achieve multiple objectives simultaneously. When too many specific requirements tied to program objectives are embedded into program rules, the resulting complexity can undermine participation and dilute program impact.

CASE STUDY: DEMAND FLEXIBILITY REQUIREMENTS FOR SGIP HPWH PROGRAM

Demand flexibility of electrified appliances via integrated demand side management (IDSM) can provide substantial value to both customers and the grid (see Section 2.1)

Even though building electrification measures add electric load to the grid, they can achieve significant peak demand reductions and support demand flexibility. The SGIP HPWH program, implemented within TECH Clean California, included several demand flexibility requirements and can inform best practices for large-scale IDSM as part of a broader market transformation strategy. While each requirement had a clear policy rationale, the combination of requirements created administrative complexity and participation challenges.

SGIP HPWH demonstrated progress toward increasing demand flexibility awareness and adoption. Contractors shared positive feedback on program training and support materials about load shifting and demand response and reported mostly moderate or high confidence in their ability to enable JA13 TOU rate-based scheduling.[93] Furthermore, the load shifting requirements significantly increased total enrollments into those programs as compared to direct-to-customer outreach. Load-shifting program enrollment requirements for SGIP HWPH were instituted in Dec 2024; subsequently, over half of 2025 applications to PG&E's WatterSaver program were from TECH and SGIP Heat Pump Water Heater participants. SCE's Smartshift Rewards saw 394 enrollments by the end of 2025, a substantial increase from 2024's 19 enrollments.[93]

These outcomes suggest electrification programs can help move the market toward flexible loads when demand flexibility strategies are integrated with technology deployment. The benefits to the customer and the value of the SGIP HPWH incentivized equipment as a load-shifting resource will be discussed in the upcoming Interim Evaluation Report for SGIP HPWH [not yet published] by program evaluator Verdant. Preliminary results suggest JA13 load shifting shifted 370Wh (weekdays) and 360Wh (weekends) out of the 4:00 p.m. to 9:00 p.m. peak window and *did not* substantially increase overall energy consumption. [94]

Importantly, the daily net energy impact is near zero on weekdays, indicating that JA13 is successfully moving energy consumption without increasing overall energy consumption.

Align program requirements with the capabilities of the installed technology, while maintaining program simplicity. The SGIP HPWH program required incentivized water heaters to function as grid resources by shifting load from peak to off-peak periods. In addition to requiring set up of JA13 TOU controls for load shifting, projects were also required to have customers enroll in demand response programs and verify participation in TOU rates.

Contractors' ability to describe demand flexibility requirements to the customer requires subject matter expertise and administrative effort.[95] Contractors experienced confusion around requirements to participate in distinct "demand response" *and* "load shifting" programs.[96] When the

[93]Upcoming Interim Evaluation Report for SGIP HPWH [not yet published] by program evaluator Verdant.

[94] Preliminary results are based on a limited initial study population that included units from just one manufacturer.

[95] Multiple contractors have mentioned hiring or designating a dedicated staff just to manage the HPWH demand flexibility requirements. One contractor responded, in a winter 2025/26 survey, "We had to hire a separate person just to make sure we had every single thing needed..."

[49] D.23-12-004 requires SGIP HPWH customers enroll in both a CAISO market-integrated *demand response* program and a *water heater load shifting* program. All stakeholders expressed confusion regarding the demand response program being unrelated to the water heater, and some customers attempted to connect their HPWH to OhmConnect instead of the water heater load shifting program.

requirement for participants to enroll in a water heater load shifting program (in addition to an event-based DR program) was added after launch, a separate "water heater rewards program" category was created for program communications to distinguish these programs from event-based demand response. Since load shifting programs are commonly considered DR programs by the industry, the new load shifting requirement led to confusion and miscommunication. While SGIP HPWH provided a wealth of information on its numerous requirements via online program resources and webinars, the volume and intricacies of the requirements necessitated one-on-one email and phone support for participating contractors to identify and resolve points of confusion.[97] Both the TECH Clean California implementer and evaluator have received contractor feedback asking to simplify the application process and program complexity has negatively impacted contractor satisfaction.[98, 99] Additionally, participating contractors ranked "getting the customer to agree to enroll [in a DR program]" as part of TECH Clean California's requirements (49 percent) and "distinguishing the demand response requirement from the required TOU rate plan enrollment and heat pump water heater TOU scheduling requirements" (47 percent) as the most challenging aspects of demand response enrollment requirement.[100]

"Demand Response" programs call for adjustments in energy use in response to prices or to support grid reliability.

"Load Shifting" programs shift energy use on a recurring basis, for example, from peak to off-peak times.

On the administrative side, a provision in the CPUC decision required the implementer to confirm TOU enrollment prior to approving applications. This involved back and forth data sharing with the utilities, and this seemingly minor requirement created weeks of payment delays and frustrated contractors. After SGIP HPWH funds were exhausted, TECH Clean California was able to cease active enforcement of the TOU verification requirement and instead communicate the expectation through program terms and conditions, dramatically reducing implementer and contractor administrative burden, decreasing payment timelines and reducing contractor risk while maintaining the program's demand flexibility objectives.

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[97] This one-on-one support was ranked as the most helpful support resource over two contractor surveys (Summer 2024, 59 responses; Winter 2025/26, 29 responses). More in-depth Summer 2024 survey results are covered in the TECH Load Shifting Pilot Final Report and the Opinion Dynamics *Process Evaluation of the TECH Clean California Initiative* https://www.calmac.org/publications/TECH_Process_Evaluation_Final_Report.pdf. Winter 2025/26 survey results will be discussed in the upcoming Final Evaluation Report for SGIP HPWH [not yet published] by program evaluator Verdant.

[98] Opinion Dynamics. *Interim Process Evaluation: Technology and Equipment for Clean Heating (TECH) Initiative.* November 7, 2022. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Interim_Process_Evaluation_Final_Report.pdf

[99] Upcoming Interim Evaluation Report for SGIP HPWH [not yet published] by program evaluator Verdant.

[100] Opinion Dynamics. *Process Evaluation of the TECH Clean California Initiative*. May 2, 2025. https://www.calmac.org/publications/TECH_Process_Evaluation_Final_Report.pdf

Focus on the "highest value" requirements to balance program impacts complexity. For heat pump water heaters, the primary mechanisms to support load shifting are JA13 TOU rate-based scheduling functionality and participation in connected water heater load shifting programs, where available. Additional demand flexibility requirements, such as separate "qualified" demand response program enrollment and TOU verification, added significant complexity to the participation process while contributing marginal value.

At the same time, demand flexibility technologies and program capabilities continue to evolve. Standards, product features, and program structures are still developing, and the relative benefits and implementation challenges of different approaches may change over time. For this reason, future regulation informing program design should emphasize flexibility and alignment with technology capabilities, rather than prescribing detailed requirements in advance.

CASE STUDY: PREAPPROVAL AND INCENTIVE RESERVATION

Incentive programs benefit from consistent and stable funding. In the absence of stable funding, transparency of funding status and a reservation system alleviates at least some market concerns. The initiative moved through three distinct phases as we refined our strategy to offer more transparency to market actors and mitigate the effect of funding starts-and-stops on the market.

- **Phase 1: "First-Come, First-Serve"** ***(December 2021–May 2023)*****:** TECH Clean California initially launched incentives on a "first-come, first-served" basis with no reservation system. Significantly higher demand than expected led to abrupt funding exhaustion. Contractors often made sales assuming incentives were available, only to be left "holding the bag" when the funding was depleted before their claim was processed and paid out.
- **Phase 2: Claim-Based Reservations** ***(5/2023–11/2024 HVAC; 05/2023–07/2025 Heat Pump Water Heater):*** To provide more assurance to contractors that claims would be paid out, the program allowed "draft claims" to reserve funds. However, since the only required field was an address, and all fields - including the address - could be modified while still reserving the incentive, the system enabled some contractors to submit low-quality or "speculative" claims to secure a "slice of the pie." This system created an inaccurate pipeline and failed to prevent over-subscription in specific funding buckets.
- **Phase 3: Preapproval Reservation System** ***(11/2024-Present HVAC; 07/2025-Present Heat Pump Water Heater):*** TECH Clean California introduced the preapproval system. By requiring project characteristics upfront, which could not be subsequently modified, the program gained a reliable view of the pipeline across diverse funding buckets (e.g., Equity vs. Market Rate for differing utility territories). This system allowed the team to manage a waitlist and communicate "soft landings" before funding was fully exhausted.

Trade-offs for the Preapproval System: The preapproval system has helped to mitigate contractor frustration at funding starts-and-stops, since TECH Clean California only preapproves claims that we have funding for. However, there are some trade-offs. Because preapproval data fields are "locked" upon submission to ensure more accurate budgets, minor clerical errors (in which a pre-

approval does not match a claim) can create issues and necessitate manual staff intervention. While the preapproval process is not mandatory to begin an installation, the perceived financial risk of proceeding without a reservation creates a logistical hurdle that disproportionately impacts smaller contractors. The administrative complexity favors larger, resource-heavy firms. The evaluator's contractor survey showed that most contractors found it easy to address needed updates to incentive applications, although 40 percent found it difficult for heat pump water heater applications and 19 percent had trouble for HVAC.[101]

One of the consequences of increased administrative complexity has been the negative impact on incentive disbursal timelines and contractor cash flows. TECH Clean California recommends that contractors pass through the incentive to customers as an instant discount at the time of sale. However, floating funds to customers while waiting for payment from the initiative can create cash flow issues for smaller contracting firms. The approval process and incentive payment timeline can be further delayed if contractors are not aware that their application has been flagged for corrections. The evaluator reported that many contractors expressed dissatisfaction with the long wait times for receiving incentive payments, attributable to payout timelines from three weeks to three months. The evaluator recommended that the implementation team consider ways to expedite the contractor reimbursement process, such as a mobile payment service.[102]

> *"Don't expect contractors to act as bankers until you folks get around to cutting checks. People calling us "where is their rebate?" drove us nuts. It ruins the satisfaction of getting a rebate if clients (or contractors) have to wait more than 2 or 3 weeks for their payment."* ***Participating Contractor***[103]

Program administrators and implementers must consider the impacts that every incremental increase in application complexity has on program participants and balance the potential participation impacts with benefits.

CASE STUDY: WORKFORCE STANDARDS AND TRAINING

Contractors are crucial participants in midstream program delivery and critical to the achievement of California's building decarbonization goals. The success of building decarbonization programs relies on individual installers that are technically proficient in installing heat pumps to avoid quality

[101] Opinion Dynamics. *Process Evaluation of the TECH Clean California Initiative*. May 2, 2025. https://www.calmac.org/publications/TECH_Process_Evaluation_Final_Report.pdf

[102] Opinion Dynamics. *Process Evaluation of the TECH Clean California Initiative*. May 2, 2025. https://opiniondynamics.com/wp-content/uploads/2026/03/TECH-Process-Evaluation-Final-Report.pdf

[103] Opinion Dynamics. *Interim Process Evaluation Technology and Equipment for Clean Heating (TECH) Initiative*. November 7, 2022. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Interim_Process_Evaluation_Final_Report.pdf

issues. However, California lacks consistent statewide standards essential for ensuring the quality of contractors at scale.

A Fragmented Landscape of Workforce Standards for Heat Pump Installers

Heat pumps are a more technically complex installation than a gas equipment replacement, and at present, there is no federal or state-level mechanism for consumers to verify if a contractor possesses specialized training in heat pump technology. While IOUs and various partnerships offer 62 distinct on-demand heat pump courses, these programs lack a common underlying curriculum or instructor credential requirements.

This fragmentation creates several market failures:

- **Information Asymmetry:** Consumers cannot easily distinguish "trusted" contractors from those without specialized training.
- **Administrative Friction:** Because credentials are held at the company level rather than the individual installer level, even working with a credentialled contractor is not a guarantee that an individual installer is proficient with heat pumps.
- **Contractor Fatigue:** In the absence of a "gold standard," contractors are often forced to navigate a patchwork of training requirements to remain eligible for various regional or utility-led programs.

Leveraging Existing Frameworks

There are existing frameworks that California can leverage as a baseline for statewide building electrification workforce standards. The Department of Energy Skilled program already provides a framework for recognizing training programs and certifications (for example, the HVAC Excellence Heat Pump Installer Credential) that meet modern building science and heat pump installation standards. Another option is the NATE Specialty Heat Pump certification program.

Recommendations for Workforce Alignment

- **Individual-Level Credentialing:** Work with the Contractors State License Board (CSLB) to establish a specialized credential for heat pump installers. This should be tied to the individual technician rather than the contracting company to ensure on-site expertise.
- **Curriculum Standardization:** Mandate a standardized curriculum for all state-recognized heat pump and weatherization training. This curriculum should include electrical panel optimization and require that all instructors hold verified credentials.
- **Cross-Program Reciprocity:** Any installer who achieves the state-recognized credential should be automatically eligible to participate in any state or utility-funded energy program, significantly reducing administrative overhead for those programs.

CONCLUSION: AN OUTCOME-ORIENTED REGULATORY APPROACH WOULD BE MOST EFFECTIVE IN ACHIEVING PROGRAM GOALS.

For the reasons stated above, the TECH Clean California team recommends an outcome-oriented regulatory approach that provides clear policy direction around the intended outcomes while limiting prescriptive implementation requirements. This framework allows program implementers to adapt strategies, refine program design, and respond to market feedback while still meeting policy objectives.

3.3 Right-Sizing Electric Service

Recent innovations in power-efficient design have demonstrated that **service panel upsizing can be avoided for the vast majority of single-family upgrade projects**. The emerging consensus among practitioners is that 100 amps is generally sufficient to fully electrify a single-family home, and 60 amps is sufficient for a multifamily unit.[104] Fournier, et al., (2024), in an analysis of publicly available TECH Clean California data plus other sources, found that less than two percent of TECH Clean California participants had service panels below these thresholds.[105]

A. Right Sizing in the Single-Family Sector

Incentives for service panel upgrades should be narrowly targeted to avoid incentivizing unnecessary upgrades. At launch, TECH Clean California offered bonus incentives for electrical panel upgrades required to accommodate heat pump water heaters, covering up to 50 percent of electrical costs up to $2,000 for projects in select areas. The launch of SGIP HPWH incentives also came with bonus incentives for service panel upgrades. The bonus incentives were discontinued in 2025. A 2024 evaluator analysis identified that only 3 percent (1,004 of 30,630) of households who purchased TECH Clean California incented heat pump equipment required an electrical panel upgrade, consistent with the expectation that upsizing is generally unnecessary.[106]

Panel upsizing is more common for heat pump water heaters than for heat pump HVAC. One hypothesis for this finding is that air conditioner replacement projects can typically reuse an existing circuit, whereas gas water heater replacement projects would more likely need to install a new dedicated circuit.[107]

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[104] See for example: https://powerefficiency.ca/wp-content/uploads/2025/03/electrification-guide-for-retrofits.pdf and https://www.redwoodenergy.net/watt-diet-calculator. While there may be some bias in TECH data since they only reflect projects, the fact that these values were low even when there was an incentive early on in the program suggests that upsizing rates are not particularly high.

[105] Fournier, E. D., Cudd, R., Smithies, S., & Pincetl, S. Quantifying the electric service panel capacities of California's residential buildings. Energy Policy, Volume 192. June 27, 2024. https://doi.org/10.1016/j.enpol.2024.114238

[106] Opinion Dynamics. *Process Evaluation of the TECH Clean California Initiative*. May 2, 2025. https://www.calmac.org/publications/TECH_Process_Evaluation_Final_Report.pdf

[107] TECH Clean California. *TECH Clean California Annual Report 2022-2023. Year Two: September 2022-August 2023*. March 14, 2024. https://techcleanca.com/documents/4324/TECH_Annual_Report_2022-2023_v230212.pdf

Going forward, it may be prudent to offer a bonus incentive for service panel upsizing in single-family homes, narrowly targeted to income qualified households with panels less than 100 amps. Complementary incentives could be offered for power-efficient design solutions for homes with less than 150 amps of service panel capacity.

Continued focus on contractor education is key. Contractors are inclined and incented to reach a simplistic conclusion that 100 Amps is not enough. Good contractor training on system sizing and electric load planning can help contractors learn how to power-efficient design methods can help them reduce project costs, timelines, and other friction points that may jeopardize a project. TECH Clean California has taken several actions to help TECH Clean California participants learn how to avoid unnecessary service panel upsizing, including:

- "Good Stewardship of the Panel" webinar, January 2024
- Right-sizing web page: https://www.switchison.org/electric-panels

Utility coordination and partnership will be crucial. Training should be supported by utilities providing usable information about household demand, as well as existing electrical distribution system capacity and service connections.

B. Right Sizing in the Multifamily Sector

In contrast to the single-family sector, electrical infrastructure upgrades or the studies required to avoid upsizing were the main expense during the multifamily pilot.[108] Eleven out of 13 properties needed upgraded infrastructure to support electrification, and seven projects avoided electrical upsizing due to investment in monitoring and/or engineering and analysis. **Right-sized electrical service in advance of full electrification can lower retrofit costs over time, but electrification readiness must be followed with engagement through to full electrification** (See Multifamily Pilot Final Report).

3.4 Recognizing Remediation Needs

Remediation needs within existing low-income energy efficiency and weatherization programs represent a significant barrier to serving the decarbonization needs of this customer segment in a truly inclusive manner. Our implementation of several pilots designed to better address barriers in equity and low-income communities has generated several lessons learned that can help inform future efforts.

Partnering with existing programs and community-based organizations can be an effective strategy for reaching the subset of income-qualified customers who need extra financial assistance to overcome costly remediation barriers. TECH Clean California's Low-Income Heat Pump Adoption Pilot partnered with the San Joaquin Valley Disadvantaged Community Pilot and the Energy Savings Assistance (ESA) Program to sponsor remediation and minor home repairs for

[108] Defined here as upsizing or upgrades to electrical infrastructure downstream of the meter, including apartment sub-feeders, main breakers, and main and subpanels.

520 households that would have otherwise been excluded from those programs. Likewise, Quick Start Grantee Revalue.io showed how collaboration with home rehabilitation programs helped them identify properties, perform repairs and remediation, and electrify water heating, HVAC, and cooking appliances for an additional 70 homes. Collaboration enabled TECH Clean California to contribute funding through existing program infrastructure.

A portfolio-level budgeting approach enables a program to address the wide diversity of remediation needs at a reasonable average cost without either overpaying on inexpensive projects or excluding the more expensive projects. The ESA program currently caps remediation work at $3,000 per home. By monitoring portfolio-wide spending rather than imposing rigid per-home limits, TECH Clean California was able to accommodate high-cost projects while maintaining an average project cost of $5,197 for single-family homes and $11,203 for mobile homes. Eighty-seven percent of all Leveraging Pilot projects required less than or equal to $10,000 in supplemental remediation work. Non-energy remediation costs are summarized in the Low-Income Leveraging Final Report and in the Revalue Quick Start Grant Final Report.[109]

For partnerships to be effective, the program had to minimize administrative burdens for participating contractors and address customer needs. TECH Clean California offered a $225 incentive and technical support to ESA contractors to participate in and layer with the pilot, which proved effective at addressing this barrier. Revalue found that consumer messaging had to address common health and comfort concerns, such as moisture, mold, asbestos, and drafty spaces, or other comfort, financial, and quality of life concerns. General electrification messaging did not resonate as well.

Non-energy benefits to the participating households were substantial, including restoration of basic access and functionality of air conditioning or water heater systems that deliver health, comfort, and safety in the face of extreme heat and weather events. These benefits were typically delivered via the following types of remediation work:

- **Electrical Panel Upsizing:** 315 (60 percent) Adding circuits to an existing panel to increase capacity or upgrading <100- amp panels to 200 amps to enable heat pump installations. In some cases, panel upsizing could have been avoided by applying panel optimization techniques that have been more recently developed.
- **Heat Pump Water Heater Relocations:** 232 (43 percent) Moving water heaters from non-compliant locations to suitable outdoor or garage installations.
- **Structural Remediation:** 251 (47 percent) Minor wall, roof, or enclosure repairs to allow safe electrification.
- **HVAC System Upgrades:** 236 (44 percent) Removal of gas furnaces, installation of electric heat pump HVAC systems.

[109] See The Ortiz Group and VEIC's Low-Income Leveraging Pilot Final Report for more information. https://techcleanca.com/documents/5705/8.2_Low_Income_Leveraging_Pilot_v260105.pdf

Some remediation issues, particularly asbestos, have limited or no funding sources available to fund repairs. In some cases, the presence of existing unpermitted work posed an additional legal and financial obstacle to project completion.

Going forward, pilot results point to the continuing need for direct install programs with full or nearly full subsidies and concierge services to the most financially distressed households, particularly those that require remediation and minor home repair needs as a precondition to home electrification. It is the implementation team's hope that the lessons learned from this pilot can point to solutions that further integrate electrification and remediation services into core direct install weatherization programs.

3.5 Excelling in Customer Buy-In

While contractors play an influential role in the property owner's consideration of a new space conditioning or water heating system, their willingness to prioritize heat pumps goes up when their customers are aware of heat pumps and asking for them. TECH Clean California has thus taken a combined "push-pull" approach, promoting both contractor supply and customer demand.

A. Progress Towards Building Customer Awareness and Positive Perceptions of Heat Pump Technologies.

EVALUATION RESULTS

Customer experience plays an important role in shaping perceptions of heat pump technologies and influencing broader market adoption through word-of-mouth. The TECH Clean California evaluator conducted multiple market assessments and customer experience surveys to track changes in awareness and perceptions of heat pump equipment in California and inform program optimization.

California homeowners' awareness of heat pumps has been improving since the baseline assessment in 2022, reaching 60 percent for HVAC heat pumps in 2024 (11 percent increase) and 37 percent for heat pump water heaters (5 percent increase). The evaluator also observed that homeowners' perspectives on heat pumps are changing to view them as increasingly reliable and efficient heating and cooling technologies. However, familiarity is still lacking; about half of homeowners still did not know the benefits and drawbacks of HVAC heat pump systems, despite being generally aware of them.

TECH Clean California's single-family participants have disproportionately been early adopters, as evidenced by the high penetration of rooftop solar (27 percent), compared to the general population (10 percent).[110] The discrepancy is particularly evident among heat pump water heater adopters, where TECH Clean California internal program data shows that 45 percent of heat pump water heater participants have existing solar.

In fact, the evaluator found that solar PV is a key driver of the choice to install a heat pump, satisfaction with it, and the perceived value of the investment.[111] Being able to take advantage of solar power contributed to customers rating their purchase as a good or great value and the majority of customers who were extremely likely to recommend their heat pump had solar. As discussed elsewhere in this report, when programs can capitalize on the complementarity between solar and heat pumps, it enhances customer satisfaction with the technology.

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[110] Opinion Dynamics. *TECH Population-based Pathway Impact Report*. November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

[111] Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction Wave 2*. March 27, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

Satisfaction rates exceed 90 percent for heat pump technologies, which is a necessary precondition for positive word-of-mouth. The vast majority of customers surveyed by the evaluator perceive heat pump HVAC and heat pump water heaters as a "good" or "great" value, with existing solar being a major positive driver. Heat pump HVAC had particularly strong perceived value, with 96 percent of ductless HVAC and 92 percent of ducted HVAC systems rating it a "good" or "great" value. This figure was 89 percent for heat pump water heaters.[112]

We found that many surveyed customers' perception of the value of their investment in their heat pump HVAC improved over time, which suggests that customers need time to adjust to living with their heat pump HVAC, and that initial concerns are likely to attenuate. Nevertheless, a few pain points were noted in the responses:

- Ductless heat pump users, in particular, require more support for their thermostats to enhance system efficiency and customer satisfaction. About one-third of ductless heat pump adopters found their ductless thermostat harder to use than their prior thermostat.112 They also reported adjusting their thermostats more frequently than ducted heat pump customers, which is a less efficient way of operating the equipment.112
- Heat pump water heater noise and vibration issues affected one-third of customers (100 of 300), and it bothered most of them (73 of 100). Vibration was an issue for an additional 12 customers.

It will be important for contractors to install heat pump water heaters in ways that minimize customer complaints if the technology is to become more common.

Customer satisfaction data indicates that heat pump water heaters and HVAC heat pumps are poised to become more mainstream. However, as discussed elsewhere, customer bill savings are an important factor in customers' perceptions of the value of their investment and likelihood of recommending the equipment to others. Programs that can reduce the upfront cost of the equipment or target customers who are likely to realize energy bill savings can improve the customers' sense of cost-effectiveness, improve their satisfaction, and increase positive word of mouth.

LESSONS FROM THE FIELD

TECH Clean California partnered with Switch Is On to build customer awareness, cultivate positive perceptions, and connect customers with both incentives and trained contractors. Through multiple iterations of testing, deploying, and refining, the following lessons have emerged:

- **Use real stories to build trust:** Poll after poll indicates that the strongest messengers are neighbors, family, and friends. Programs should use testimonials from customers and contractors to increase credibility, reduce perceived risk, and help normalize heat pump adoption in local communities.

[112] Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction, Wave 2*. March 27, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

- **Invest in upstream education across multiple channels:** Programs should use layered, consistent messaging across paid, owned, earned, and in-person channels to normalize heat pump technologies and prime customers *before* equipment replacement becomes their near-term priority.
    - Paid ads are essential for driving general awareness, but they are not good for conversions.
    - Paid search is great for people who are looking for things, so they have good conversions but do less to reach new audiences.
    - Earned is effective at achieving both, but very hard to quantify because the web traffic is not trackable.

- **Optimize the digital experience for conversions:** A predictable customer journey has emerged: Awareness → Incentive Search → Contractor Search → Consultation → Installation. Programs should make incentive discovery simple and prominent, seamlessly connect incentive tools to a high-quality contractor directory, and make it easy to request consultations and obtain three bids. Similarly, contractors should be encouraged to respond quickly to new leads and invest in a strong web presence.
- **Support customers through the contractor selection experience:** The variability within bids can be paralyzing for people who do not have a sense of urgency to replace a broken piece of equipment. Addressing this barrier can help increase the rate of planned replacements. Programs should help customers understand the differences between bids so that they can make informed, confident decisions.
- **Fully fund incentive programs:** Incentives are the primary behavioral nudge that moves customers from seeking information to acting. However, the constant starts and stops have fueled confusion and frustration for both customers and contractors. Policy makers should prioritize regulatory certainty and sustained funding.

TECH Clean California's pilots and QSGs have shed additional light on best practices for engaging income-qualified customers and disadvantaged communities.

- **Focus on both cost savings and increased comfort and health.** Communications with prospective participants should include clear and factual expectations around potential bill impacts, while also highlighting other benefits to participants, such as adding cooling or increased comfort.
- **Community-based organizations (CBOs) are effective outreach partners for building momentum in historically underserved communities**. As one example, The Energy Coalition QSG enlisted a local CBO to lead outreach and enroll homeowners for a free water heater "tune up" service and assessment. These early interactions built trust and credibility with residents that opened up opportunities to offer more comprehensive retrofits. The Sacramento QSG showed how neighborhood-specific outreach at existing meetings and events can be an efficient way to scale recruitment beyond broad-based marketing campaigns.

LESSONS FROM CUSTOMER TARGETING ANALYSIS

Both the innovative Customer Targeting Pilot (in partnership with Southern California Edison (SCE)) and the Inclusive Utility Investment Pilot (in partnership with Silicon Valley Clean Energy (SVCE)) **leveraged historical energy consumption data and advanced analytics to identify and market to households most likely to benefit from heat pump retrofits**. The design intent was to both (1) pinpoint tens of thousands of homes in which transitioning to heat pumps is likely to yield substantial utility bill savings and broader energy benefits and (2) avoid promoting heat pump retrofits in cases where electrification might increase energy burdens or exacerbate grid stress. The resulting marketing campaigns targeted just a small fraction of the residential customer base: approximately 22 percent of the SCE customer base and 30 percent of SVCE customers.

Customer Targeting can be highly effective in identifying and achieving strong project outcomes. While there was limited uptake in the SCE customer targeting pilot, Implementation Team analysis identified that customers who did participate achieved:

- 71 percent greater median greenhouse gas savings
- 493 percent great median annual utility bill savings
- Over 1,100 percent great median peak demand electricity savings[113]

The primary challenge is targeting customers who are both: 1) good candidates and 2) in the market for new equipment. The need to avoid marketing to the majority of customers placed a substantial constraint on the market channels and methods that could be employed. In contrast to the best practice cited above to "invest in upstream education across multiple channels," both pilots relied almost exclusively on direct email marketing campaigns to a subset of customers who were good candidates, but not necessarily in the market for new equipment. The campaigns could not build general awareness about the benefits of heat pumps, or the program offers. In practice, the pilots were trying to identify the overlap between two already small customer segments: (1) those customers who would benefit financially from electrification, and (2) those customers in the market to upgrade their gas appliances to heat pumps soon. At any given point in time, only one percent of households are actively looking to replace their equipment.[114] As a result, both marketing campaigns experienced low uptake—between one and four out of 10,000 targeted customers.

Recommendations for future applications

- Going forward, performance-based targeting analysis may be most applicable to **identify geographies where customers with promising bill savings opportunities are sufficiently concentrated** to support sustained, multi-channel communication.

[113] TECH Clean California. 14th Quarterly Stakeholder Meeting. July 23, 2025. https://techcleanca.com/documents/5623/TECH_14th_Quarterly_Stakeholder_Meeting_Xt3e3vj.pdf

[114] Assuming equipment is replaced on burnout every 15-20 years and a 2-month customer decision window.

- A **"Customer Lookup Tool"** could empower contractors to identify candidates with high savings potential and communicate potential benefits to customers, thereby amplifying the impact of the targeting approach.
- While infeasible for short-term pilots, mature programs **should consider combining digital marketing with physical outreach**, e.g., mailers and bill inserts. Programs could also pursue partnerships with solar installers to increase reach to customers with a high propensity to adopt heat pumps and generally favorable project economic impacts.

B. Multifamily Engagement and Buy-in

- **It is prudent to treat multi-family and single-family customer engagement initiatives separately, as multifamily has distinct customer journeys, technologies, and workforce needs.**
- **Multifamily engagement is a long-term process to gain trust among the multiple stakeholders in the process, including owners, operators, engineers, contractors, and maintenance staff.**
    - Currently, there are few technical or workforce resources to support this trust-building over time.

Multifamily properties have an entirely different customer journey than single-family – different contractors, different technologies, different timelines. This merits future programs to focus on multifamily through a separate and dedicated initiative. Based on pilot results, key attributes of multifamily engagement strategy should include:

- Program delivery through a "contractor open market" model that enables property owners to choose their own contractors and work with their in-house property maintenance teams
- Long and flexible incentive timelines that allow for extended planning horizons and diverse upgrade strategies, ranging from gut rehabilitation to incremental upgrades of housing units upon tenant turnover.
- Simple incentive requirements that enable funds to be combined from multiple sources.
- Planning assistance, resources, and decision tools to help project sponsors map out an electrification readiness strategy that accommodates upgrades over time and across large project portfolios.
- Strong technical assistance, including training, case studies, and design best practices to address technical challenges with multifamily central heat pump water heater retrofits and electrical infrastructure evaluation. Programs may need to provide project-specific design consulting in some instances.
- Emphasis on capacity building, including knowledge transfer to contractors, engineers, maintenance personnel, and other decision-makers.[115]

[115] Forthcoming TECH Clean California Multifamily Pilot Final Report.

C. Opportunities and Challenges of Serving Rental Housing

Supporting rental housing remains an important segment, particularly supporting the emerging portable heat pump market to address. TECH Clean California's Quick Start Grant with 350 Bay Area piloted an approach to give renters control over their energy usage, health, and comfort, while bypassing the need to engage landlords around expensive building upgrades.[116] The pilot deployed window heat pumps and air purifiers as a solution for renters who lack air conditioning to address both extreme heat days and particulate matter (PM) pollution from transportation, industrial activities, and wildfires. The Energy Coalition is also testing a similar approach in Pomona, California, with a full suite of portable heat pumps, electric cooking appliances, air purifiers, portable batteries, fans, and energy management plugs and apps.[117]

- **Current designs of portable heat pumps require professional skill to install. Manufacturers should simplify and improve the window interface to facilitate customer installation.**
- **Programs should plan to provide initial installation assistance and remain available for repairs throughout the project.** Education and ongoing support, from installation through maintenance and operation, are critical to ensuring effective use of these technologies. Programs should plan to provide language-appropriate, one-on-one assistance.
- **Ongoing support from trusted, well-established community groups is essential for low-income communities to ensure the long-term success of clean energy initiatives.**

[116] Neish, Laura. 350 Bay Area; Higbee, Emily. Redwood Energy. *Quick Start Grant Final Report: Fast Path to Clean Indoor Air*. September 25, 2024. https://techcleanca.com/documents/5555/TECH_Quick_Start_Grant_350_Bay_Final_Report_v250204_R50VvSK.pdf

117 See https://www.bayren.org/sites/default/files/documents/2025/04_Direct-to-Renter%20-%20BayREN%20Q2%20Forum%20-%20June%2010%202025%20%28final%29.pdf

3.6 Role of Data and Analytics in Supporting Heat Pump Adoption

Data and analytics have played a foundational role in planning, assessing progress, and driving market transformation. TECH Clean California has produced the nation's first large-scale dataset on the real impacts of heat pump installations. The combination of data on the installed equipment, project, home, and energy consumption has yielded a robust and comprehensive dataset that enables analysis of energy savings, contractor performance, project costs, and demographic and geographic trends. Having objective data and analytics embedded in TECH Clean California operational infrastructure has allowed for responsive adaptation to drive success. Embedded data analytics has helped the implementer identify cost drivers and market responses in weeks and months rather than years. D. Program and Portfolio Design Optimization and Strategies TECH Clean California prioritized assembly of three data sets: **Project Data**, **Meter-Based Consumption Data**, and **Evaluation Data**. These data can be combined and utilized to inform program strategy as well as state goals (see *Figure 6. TECH Clean California Data Stream Overview*). Insights from TECH Clean California's data analysis have been incorporated throughout this report.

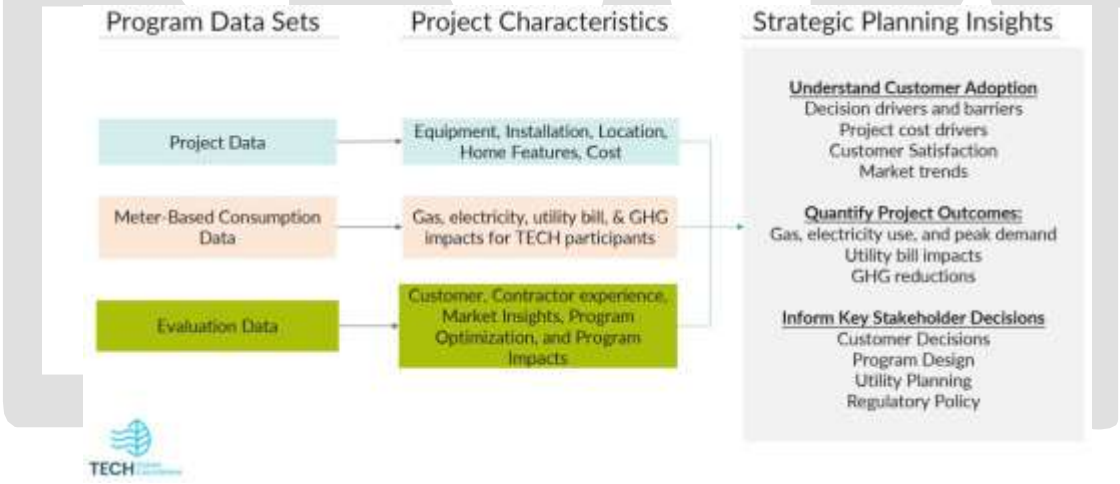

Figure 6. TECH Clean California Data Stream Overview[118]

A. Overview of TECH Clean California Data Streams

- **Project Data enables detailed documentation of heat pump retrofit project components and costs.** Energy Solutions' Iris database tracks project data from incentive applications. Capturing detailed project-specific information about costs, baseline equipment and technology specifications for more than 75,000 project installations, the database has afforded visibility into project costs, cost drivers, benefits, and market responses to program design changes.
- **Weather-normalized energy consumption data supports advanced targeting and screening strategies to maximize both customer and societal benefits.** CPUC D.21-11-002 established data

[118] Kisch, Teddy. Leveraging Data to Inform Building Decarbonization Strategy. January 21, 2026. https://www.cpuc.ca.gov/about-cpuc/divisions/energy-division/building-decarbonization/building-decarbonization-workshops

sharing requirements for TECH Clean California and set clear expectations on data accessibility for program optimization, not just evaluation. Crucially, the guidance supported combining both gas and electric utility metered consumption data to track the fuel switching impacts on both energy sources.

The TECH Clean California team member Recurve leads meter-data-based targeting and analytics. Recurve's FLEX platform provides weather-normalized calculations of changes in customer energy consumption resulting from heat pump adoption. It has been used for end-use detection (AC and PV presence) and for a granular assessment of baseline usage to inform targeted customer outreach and resource deployment (see ***Section 3.1 B. Valuing the Customer Benefits of Heat Pumps***). Additionally, the platform integrates the aforementioned project data, enabling the implementation team to identify key drivers of outcomes and inform incentive design for TECH Clean California and other decarbonization initiatives, as described in ***Appendix F: Driver Analysis and the Importance of Site-Level Granularity***.

- **Evaluation Data generates a wealth of information, from how TECH Clean California has impacted market assessments to customer and contractor experienced actors across the supply chain.** Repeated surveys with end-users revealed the customer experience with their TECH Clean California contractor and heat pump equipment, identifying opportunities for improvement. Opinion Dynamics' impact evaluation demonstrated GHG reductions, peak demand reductions, as well as energy and customer bill impacts. Surveys and interviews with contractors provided feedback on trainings promoted by TECH Clean California, what contractors learned, and how they applied those learnings on the job. The market assessments measured changes in customer awareness and familiarity with heat pump equipment, and contractor confidence with selling, sizing, and installing heat pumps including differences between the single-family homes and multifamily buildings. Interviews with manufacturers and distributors assessed how TECH Clean California incentives influenced their stocking and production processes. Finally, the Technology and Policy Briefs showcased trends in technology advancements and summarized relevant policies affecting manufacturers and equipment performance.

B. Scaling Market Transformation Impacts through Policy

TECH Clean California's data and analyses have served as a jumping off point for the next generation of electrification initiatives in the state, reducing duplication, improving efficiency, and accelerating impacts. The internal data analysis and results have supported the TECH Clean California's comments and insights informing regulatory proceedings focused on building decarbonization, the future of gas, the Energy Savings Assistance program, and the energy efficiency portfolio.[119] TECH Clean California team's robust program implementation experience and understanding of likely outcomes for customers, driven by customer-level analysis and complemented with evaluation reports, have contributed best available information and best practices for programs across the state, and beyond (see sidebar for highlights).

TECH Clean California Informing Policy

TECH Clean California brings program insights and data to inform the California's building decarbonization policy and program design. Highlights include:

- Generated written or verbal comments in six proceedings and presented as panelists at multiple agency workshops or conferences
- Participated as a Technical Expert for CARB's zero-emission appliance standards rule development
- Participated in the Implementation Working Group for Bay Area Air District standards for zero-emission space and water heating appliances, as well as South Coast Air Quality Management District Working Group for their proposed rules.
- Participated and provided data analysis to CPUC Working Groups working on technical analysis of viable electric alternatives to gas appliances

Publicly Accessible Data Accelerates Market Transformation

A cornerstone of the TECH Clean California strategy is the secure, public sharing of anonymized project and contractor data via techcleanca.com, along with progress reports and research results. By providing downloadable datasets for single-family and multi-family projects alongside interactive analysis and visualization tools, TECH Clean California has lowered the barrier to entry for stakeholders across the country to understand heat pump market dynamics.

The transformative value of TECH Clean California's data is best evidenced by its broad utilization by governmental agencies across the state. The California Public Utilities Commission, California Air Resources Board, California Energy Commission, Bay Area Air District, and South Coast Air Quality Management District have not only cited TECH Clean California results in key reports but have also conducted independent analyses of the public data to drive their own policy decisions.

[119] TECH Clean California. *TECH Clean California Annual Report 2022-2023: Year Two: September 2022-August 2023*. March 14, 2024. https://techcleanca.com/documents/4324/TECH_Annual_Report_2022-2023_v230212.pdf

TECH Clean California also illustrates the power of shared data infrastructure to accelerate decarbonization through inter-agency collaboration. Primary research funded by the California Energy Commission on end-use detection of air conditioning was used by the TECH Clean California team to conduct granular segmentation analysis of heat pump installations in homes with and without air conditioning. Customer bill impacts and GHG impacts were notably different between each cohort and that variability allowed the implementation team to modify incentive and outreach strategies toward customers most likely to see bill reductions, increased GHG impacts, and reduced summer grid constraints. (See **Appendix F: Driver Analysis and the Importance of Site-Level Granularity**). In short, the multivariate optimization framework has turned the TECH Clean California meter data into an operational tool for designing and targeting electrification portfolios that simultaneously support decarbonization, affordability, system value, and equity.) This granular analysis has in turn been used by the Equitable Building Decarbonization team to screen for customers that will benefit most and drive program goals.

Data Access Barriers. While the data access guidelines outlined by the Commission in D.21-11-002 were clear about the need and intent for data sharing, some barriers have emerged, and TECH Clean California has identified and tested solutions. It is critical for utilities to understand their customers' electricity *and* gas consumption patterns to target homes most likely to benefit from electrification, especially of space heating. However, single-fuel utilities generally can only access one type of consumption data. Sharing combined gas and electricity consumption data with single-fuel utilities has been limited due to privacy and liability concerns. TECH Clean California has identified strategies to share valuable dual-fuel consumption insights with a single-fuel utility *without* disclosing private information across utilities. A strategy tested by the TECH Clean California Customer Targeting Pilot was to aggregate consumption data into four groups based on quartiles: low, medium, high, and very high. Sharing this aggregated data enabled effective customer targeting without exposing individual consumption data. Alternatively, in shared savings or carbon credit scenarios, it would make sense to establish agreements between parties to allow utilities to see the combined impacts at the customer level. The implementer and evaluator also created a standardized data request delivered to the IOUs and other Program Administrators in the state to facilitate sharing of personally identifiable information. This standardized form allows us to identify when one customer layers incentives across programs, understand what fields each program collects, and inform data policy updates.

CASE STUDY: IMPROVING PERMITTING IN MOBILE HOME AND SPECIAL OCCUPANCY PARKS

As an example of TECH Clean California's data and program insights informing policy, the TECH Clean California provided comments into the Department of Housing and Community Development (HCD)'s rulemaking related to regulations for mobile home parks (title 25, chapters 1, 2, and 2.2) as it related to heat pump water heater installations in September 2025. The TECH Clean California team submitted comment based on the program's experience with that sector—in particular related to the Low-Income Leveraging Pilot and AESC Quick Start Grant - which both elevated permitting inconsistencies and challenges for heat pump water heater installations. HCD's

updated language published in October 2025 directly reflected the TECH Clean California team's comments and initial feedback, and specifically accepts split systems for both heat pump water heaters and heat pump HVAC, alongside allowing other water heating equipment (i.e. unitary heat pump water heaters in an outdoor enclosure), if installations follow manufacturer guidelines. Critically, this outcome allows program administrators to evaluate what type of heat pump equipment is the best fit for an individual mobile home project - enabling flexibility based on the unique space constraints we oftentimes see within mobile homes (both internal space constraints as well as external space constraints).

C. Leveraging Program Data to Inform Incentive Design

TECH Clean California has evolved and refined its incentive design over time, in order to incorporate new insights driven by program data. Table 12 lists select changes to TECH Clean California incentives, and the rationale. These changes were made to incentivize installations with the greatest value to both customers and the public (reference *Section 3.1 Integrated Program Offerings*).

Table 12. Non-exhaustive list of modifications to TECH Clean California's Incentive Design and Rationale[120]

Category	Change	Reason
HP HVAC	Increase incentive for projects that **fully replace furnace and air conditioner** (as of Nov. 2024)	- 3x greater utility bill savings - 25 percent greater GHG emissions savings - Peak demand **reduction** of 20 percent
HP HVAC	Require **multi-** or **variable-speed compressors** (as of Nov. 2024)	- 9x greater utility bill savings when replacing air conditioner - 2x greater peak demand reduction when replacing air conditioner
HPWH	Increase incentive for heat pump water heater with **≥55-gallon tank** (as of Oct. 2023)	Projects that up-sized the water heater tank by at least 20 percent had 20 percent greater GHG savings

The changes to incentive structure had a demonstrative effect on the types of installations incentivized by TECH Clean California, demonstrating the influence that incentives can have in

[120] TECH Clean California. 15th Quarterly Stakeholder Meeting. October 31, 2025. https://techcleanca.com/documents/5673/TECH_15th_Quarterly_Stakeholder_Meeting_IPTFwGx.pdf

driving market change. Figure 7 illustrates the change in percentage of installations aligned with the increased incentives or requirements for each of the three changes described in Table 12. Non-exhaustive list of modifications to TECH Clean California's Incentive Design and Rationale Higher incentives for >55-gallon HPWHs went into effect in October 2023; the higher incentive for fully decommissioned furnace and previous AC went into effect in November 2024, and the requirement for variable or multi-speed compressors occurred in November 2024. Note that projects that are under contract when the rules change can continue to receive incentives under previous rules, which explains why variable speed compressor projects do not amount to 100 percent of projects even after the requirement was implemented.

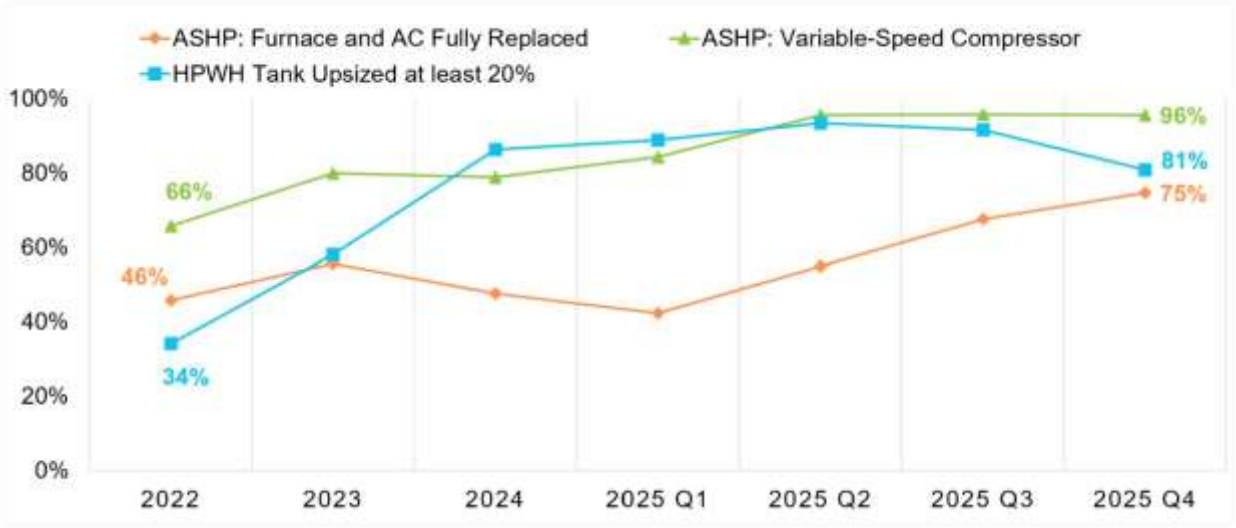

Figure 7: Effects of Incentive Redesign on TECH Clean California Initiative Participation (Single Family Heat Pump Water Heating).[121]

[121] TECH Clean California. 15th Quarterly Stakeholder Meeting. October 31, 2025. https://techcleanca.com/documents/5673/TECH_15th_Quarterly_Stakeholder_Meeting_IPTFwGx.pdf

4. Supporting Sectors and Strategies

This section describes TECH Clean California's various approaches to engaging the market actors to realize "win-win" scenarios and create a cohesive and effective strategy for building decarbonization in concert with market actors.

Key takeaways:

- **Engage Market Players:** Actively involve manufacturers and distributors in the development and implementation of building decarbonization programs to ensure the program is aligned with market.
- **Support Contractor Participation:** Contractors are the most critical influence in a customer's heating and cooling equipment replacement journey. Prioritize the training and support of contractors to encourage participation in heat pump installations.
- **Invest in Workforce Education**: Continuously invest in workforce education and training to maintain installation quality and expand career opportunities for contractors.
- **Adopt Inclusive Approaches**: Implement inclusive strategies, such as supporting DIY installations and focusing on high-unemployment areas, to ensure broader participation and equity in the program.
- **Implement Phased Electrification**: Promote the benefits of a phased approach to electrification. Allow property owners to spread project-related expenses over time and reduce the need for immediate, large-scale upgrades.

4.1 Upstream Market Development Efforts

Engagement with Equipment Manufacturers Accelerates Market Transformation. TECH Clean California has been implemented as a mid-stream program focused primarily on contractors. Nevertheless, the program's engagement with equipment manufacturers and distributors has contributed welcome momentum to market transformation efforts. Manufacturers engaged heavily in the development of the California Heat Pump Blueprint,[122] so manufacturers and the program have aligned interests around Blueprint implementation.

Manufacturers are "trusted messengers" in workforce development efforts. Contractors cite manufacturers and distributors as their preferred training sources, particularly via in-person

[122] The California Heat Pump Partnership (CAHPP) is a private-public partnership to rapidly scale heat pump adoption in California. The "Blueprint" outlines near-term strategies to address technical, market, and policy barriers to heat pump adoption in service to reaching the California's goal of six million heat pumps installed by 2030. https://heatpumppartnership.org/blueprint/

training.[123] Manufacturers have already invested heavily in training contractors on proper installation and maintenance procedures for their products. TECH Clean California's engagement with manufacturers on Workforce Education and Training has built on those prior investments with good results. Programs should consider how to work with manufacturers and other trusted partners to enhance their training efforts.

> *"California overall and its TECH program is one of the largest markets for HPWHs. Our distributors are well stocked with HPWHs, and all pure-bred plumbing distributors are supporting HPWHs in California today."* ***- Heat Pump Water Heater Manufacturer***

Manufacturers are looking at nationwide markets. Heat Pump market acceleration efforts should take a broader lens and coordinate with interstate and regional programs. TECH Clean California's ability to influence equipment technical specifications and form factors is limited unless the program can articulate a market need that extends beyond the program and beyond California. California's influence on technical specifications (like the 120V heat pump water heater) succeeded because advocates successfully signaled a market need that resonated beyond state lines. Without this broader "market case," manufacturers are hesitant to retool production. Coordination of programs to aggregate demand across state borders via multi-state coalitions can lead to faster commercialization of heat pumps that meet the needs of the broader market.

4.2 Contractor Engagement

Contractors play an influential role in the heat pump adoption process. As the TECH Clean California evaluator found in a survey of 500 customers, a recommendation from a professional contractor was one of the three most influential sources when homeowners considered purchasing a new space heating system. More than half of respondents rated it extremely or very important in influencing their decision.[124]

While contractors wield considerable influence in the adoption decision, they are reluctant to exercise that influence in favor of heat pumps if they believe that doing so would risk leaving the customer unsatisfied. Moreover, building electrification can represent a substantial shift to contractor business models, which contractors may perceive as risky. To reverse this dynamic, TECH Clean California has adopted a **suite of tactics to support contractors** in transitioning their business to focus on HVAC and hot water electrification.

[123] Opinion Dynamics. *TECH Clean California: Time 2 Market Assessment Final Report*. May 14, 2025. https://opiniondynamics.com/wp-content/uploads/2026/03/TECH-Time-2-Market-Assessment_Final.pdf

[124] Opinion Dynamics. *TECH Clean California: Time 2 Market Assessment Final Report*. May 14, 2025. https://opiniondynamics.com/wp-content/uploads/2026/03/TECH-Time-2-Market-Assessment_Final.pdf

- **Technical training**. As described in more detail under 4.3 Workforce Education and Training (WE&T), TECH Clean California has offered a full array of technical training opportunities and resources and has collaborated with training partners to integrate electrification content into existing training programs. These efforts have emphasized hands-on experience, with the goal of building contractor confidence in their technical proficiency.
- **Business skill training**, including quality management, effective marketing and sales tactics for heat pump HVAC and heat pump water heaters, and related skills to navigate a gas-to-electrification transition.
- **Demand generation** through active outreach and education to consumers. Contractors perceive that electrification recommendations are less risky if their customers are asking for them. The Switch Is On website has attracted 400,000 to 1 million visitors per year, supported 300,000 to 500,000 searches per year for available incentives.
- **Amplifying contractor visibility** via the Switch Is On Contractor Directory, which features over 2,500 Contractors and generated more than 12,000 leads to contractors in 2025. The directory equips contractors to differentiate themselves via enriched directory profiles and rewards contractors with strong profiles, Google reviews, and quick response rates. In addition to lead generation, contractors have reported valuing directory listings as a tool to confirm program participation and build trust at the point of sale. To complement the directory and reinforce the Switch Is On website as the go-to source for finding a contractor, the website features tools to help customers filter contractor listings and solicit multiple bids. Going forward, the site plans to add a bid comparison feature.
- **Incentives** to help contractors compete on an installed cost basis with gas appliance offers.

TECH Clean California's internal research has identified effective ways to recruit contractors to participate in the initiative. For example, contractor enrollment increases when TECH Clean California implementers partner with trusted and well-known industry organizations to drive interest through their channels. By contrast, the least effective contractor recruitment strategies include cold calls and paid or print advertisements. Contractor recruitment has higher prospects for success when program participation is simple, the program trajectory is predictable, and the value of participation is clear.[125]

While incentives are well-established tools for getting customer attention, spurring a sense of urgency to act, and giving contractors a price advantage over their competitors, **the incentive application process brings its own participation challenges, which has necessitated proactive contractor engagement.** Through experience, the TECH Clean California team has distilled the following lessons learned for effective contractor engagement:

- **Offer a variety of resource formats to meet the needs of a diverse contractor base.** Over time, TECH Clean California has expanded information formats to include contractor support articles, direct-to-customer resources, office hours, and one-on-one support, all of

[125] TECH Clean California. *TECH Clean California Annual Report Year 3. July 2023-June 2024.* November 21, 2025. https://techcleanca.com/documents/5689/TECH_Annual_Report_2023-2024_v251114.pdf

which have contributed to improved contractor engagement and program satisfaction. Going forward, TECH Clean California is expanding the use of text messages to communicate in a timely manner with contractors in the field.

- **Contractors have consistently ranked dedicated, one-on-one contractor support as the most helpful resource.**[126]
- **Proactively reaching out to contractors directly over email and phone** can be highly effective in maintaining contractor participation and satisfaction.
- **A phased approach to deploying and enforcing new program requirements, with simpler provisions required at the outset and more complex provisions phased in later**, allows contractors to evolve their business practices over time. New requirements invariably require a learning curve, and any difficulties in complying with those requirements directly impact the contractor's bottom line.

These interventions appear to be building contractor confidence to shift their business practices and recommend heat pumps to their customers, at least in some regions. More than half of surveyed contractors shared they have experienced an increase in their confidence when working with heat pump equipment or presenting heat pump options to customers, according to Evaluator findings.[127] Ten heat pump water heater contractors in Kern County have been the primary drivers of 1,539 heat pump water heater installations in the county, equivalent to the deployment per capita in Sacramento County and eight times more than Los Angeles County on a per capita basis. Evaluator-conducted interviews captured the following outcomes from TECH Clean California enrolled contractors:

"I have definitely started to push and offer heat pump conversions on a regular basis now, whereas before it was very rarely."

– Attendee of EMH's Residential Space Conditioning and Water Heating Electrification Course

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[126] SGIP HPWH Contractor Surveys. Summer 2024, 59 responses; Winter 2025/26, 29 responses

[127] Opinion Dynamics. TECH Contractor Six-Month Post-Training Finds Memorandum. February 28, 2023. https://opiniondynamics.com/tech-contractor-6-month-post-training-findings/

"Due to the training, I have a much better knowledge base than I did previously. I am better prepared to explain the benefits of transitioning [to a heat pump] from what a customer currently has, even if it may be at a higher cost initially. I now have more tools and resources to expand my standing in the industry, while at the same time increasing my company's ability to conduct meaningful and profitable work."

– Attendee of EMH's Residential Space Conditioning and Water Heating Electrification Course[128]

4.3 Workforce Education and Training (WE&T)

Continued Investments in Workforce Education and Training are Needed for Heat Pump Market Development. Younger workers are needed to replace an ageing workforce that approaches retirement. Improving installation quality remains an additional training priority for delivering promised heat pump benefits to customers. While roughly 90 percent of TECH Clean California customers were "very satisfied" or "somewhat satisfied" with their heat pump project, the TECH Clean California evaluator found that over 20 percent of projects had some issues, many of which stemmed from installation.[129]

Proficiency with Heat Pumps is Linked to Career Advancement. Of the hundreds of contractors that TECH Clean California has trained, 62 percent of those with a change in work responsibilities following the training reportedly earned a promotion (18 of 29).[130] Moreover, schools and other training centers offering heat pump trainings supported by TECH Clean California report that available training slots fill quickly, and that almost all students trained are finding employment immediately.[131] Reassuringly, HVAC Contractors surveyed in 2024 noted that at least half of their staff had worked on HVAC heat pumps in the past year – a 14 percent increase over 2023. Only 16 percent of contractors surveyed in 2024 reported no heat pump water heater experience – a

[128] Opinion Dynamics. TECH Contractor Six-Month Post-Training Finds Memorandum. February 28, 2023. https://opiniondynamics.com/tech-contractor-6-month-post-training-findings/

[129] Opinion Dynamics. *TECH Clean California: Insights into customer Experience and Satisfaction Wave 2*. March 31, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

[130] Opinion Dynamics. TECH Post-Training Level 3 Behavior Survey Findings Memorandum. February 28, 2023. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Contractor_Six-Month_Post-Training_Findings_Memo.pdf

[131] TECH Clean California. *TECH Clean California Annual Report Year 3. July 2023-June 2024.* November 21, 2025. https://techcleanca.com/documents/5689/TECH_Annual_Report_2023-2024_v251114.pdf

significant decrease since the 2022, when 28 percent of surveyed contractors had no heat pump water heater experience.[132]

Eliminating Enrollment Friction Maximizes Participation. Initially, TECH Clean California training was only open to contractors participating in the program. Beginning in 2024, TECH Clean California has opened training events to all contractors, not just TECH Clean California enrolled contractors. Enrollment now simply requires one's name and email address.

Targeted Training in "Electrification Deserts" is Essential for Program Equity

Installation data from TECH Clean California has revealed regions with disproportionally low project installs ("electrification deserts"), including portions of the Central Valley and Inland Empire. These "electrification deserts" overlap significantly with hard-to-reach communities and/or disadvantaged communities, as designated by CalEnviroScreen 4.0. To address this issue, TECH Clean California has focused its contractor training efforts on high-unemployment zones. As a result, nearly 55 percent of participants in TECH Clean California's trainings in the 2023-2024 program year represented high-unemployment areas.[133]

Leveraging Existing Training Infrastructure is More Effective Than Standing Up Specific Training. Capacity building is most successful when it amplifies existing efforts. For example, the program's "Heat Pump Ready" initiative has coordinated closely with manufacturers and distributors to get working heat pump units into training programs to give trainees hands-on experience with the equipment before they go into the field. TECH Clean California has provided training equipment to 32 training centers across the state. More generally, TECH Clean California is working with 20 trade schools, both union and non-union.

A Fragmented Training and Credentialing Ecosystem Creates Inconsistency in Quality of Installs. Despite current successes, workforce education remains fragmented across utilities, CCAs, and unions. Curriculum developers have varying degrees of understanding of industry needs. There is a particular lack of credentialing at the individual level. Credentials tend to be assigned at the company level but then changes in personnel can undermine the basis for those credentials.

4.4 Solar + Electrification Opportunities

Solar is a key driver influencing customer decisions to install HVAC heat pumps and heat pump water heaters. As previously noted, solar owners make up 27 percent of TECH Clean California participants overall and 45 percent of heat pump water heater adopters, compared to 10 percent of

[132] Opinion Dynamics. *TECH Clean California: Time 2 Market Assessment Final Report*. May 14, 2025. https://opiniondynamics.com/wp-content/uploads/2026/03/TECH-Time-2-Market-Assessment_Final.pdf

[133] TECH Clean California. *TECH Clean California Annual Report Year 3. July 2023-June 2024.* November 21, 2025. https://techcleanca.com/documents/5689/TECH_Annual_Report_2023-2024_v251114.pdf

the general population.[134] Customers with solar are overwhelmingly likely to report that their monthly utility bills went down when they installed a heat pump water heater. The combination of solar and heat pumps also appears to improve customer satisfaction with their heat pump decision.[135]

Going forward, a number of research questions merit consideration to inform how solar adoption can accelerate heat pump adoption and cost-effective attainment of California's decarbonization goals:

- What are the customer bill impacts of combining heat pumps with rooftop solar and battery storage? Can the combination produce positive bill savings for customers who would otherwise experience bill increases from heat pump-only adoption?
- What are the pros and cons of combining heat pumps with rooftop solar and battery storage from a demand flexibility perspective?
- What are the pros and cons of promoting distributed solar and storage from the perspective of alleviating grid bottlenecks, avoiding grid infrastructure costs, and avoiding delays for transmission interconnections to industrial-scale renewable energy projects?
- How might financing solutions unlock heat pump plus solar plus storage opportunities for income-qualified households and disadvantaged communities?
- What new opportunities can solar and battery storage unlock to pursue whole-house electrification, either as stand-alone projects or as part of zonal decarbonization initiatives?

The TECH Clean California evaluator has produced results based on an impact analysis of more than 10,000 TECH Clean California projects installed between July 2021 and July 2023. For example, the analysis showed that NEM 1.0 and 2.0 participants experienced a 14 percent decrease in average hourly demand during the resource adequacy (RA) window from 4:00 p.m. to 9:00 p.m. on summer weekdays, compared to a one percent decrease for non-NEM participants.[136]

Further analysis of the project data that TECH Clean California may provide additional insights to some of these questions, particularly as the program dataset begins to include customers on the Net Benefit Tariff and more customers combine solar with battery energy storage.

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[134] Opinion Dynamics. *TECH Population-based Pathway Impact Report*. November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

[135] Opinion Dynamics. *TECH Clean California Heat Pump Equipment: Insights into Customer Experience and Satisfaction*. September 15, 2023. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Customer_Experience_and_Satisfaction_Final_Report_9.15.23.pdf

[136] Opinion Dynamics. *TECH Population-based Pathway Impact Report*. November 27, 2024. https://opiniondynamics.com/wp-content/uploads/2025/12/TECH-Population-Pathway-Impact-Analysis-Report-FINAL.pdf

4.5 Electrification Readiness for Multifamily Properties and Portfolios

One of the major barriers for multifamily electrification is the challenge of replacing equipment at unit turnover or burnout on a property that is not undergoing a large capital improvement scope of work. Phasing an electrification scope has the benefits of reducing the capital burden on the property owner by spreading project-related expenses across longer timelines and reducing the likelihood of needing to temporarily relocate residents if major upgrades occur in the dwelling units all at once. In addition to the replace-on burnout scenario, electrification readiness can also facilitate building electrification when:

- **Navigating utility upgrades**: Undertaking the scope of work feasible without triggering the need for electrical infrastructure upgrades.
- **Preparing for low-income tax credit scope**: Completing electrification readiness work so that electrification measures are cost competitive with like-for-like replacements in an upcoming tax-credit funded scope of work.
- **Layering financing and incentives**: Strategically deploying incentives funding so that more flexible sources of funding could be used for readiness measures and allow deeper decarbonization.
- **Planning upgrades over time**: Completion of readiness work at a "cash poor" property with good prospects for electrification due to existing on-site solar but expecting to rely on available incentives for future electrification.

One of TECH Clean California's Multifamily Pilot Activities tested the impact of providing building owners with electrification readiness support, including technical assistance, site assessments, and electrical analysis to develop a detailed plan for how to electrify all appliances and equipment in a property over time. Plans included scopes of work for electrical upgrades for full electrification, appliances to be installed today, and readiness measures for future appliances. In addition, the pilot team collaborated with affordable housing portfolio owners to create roadmaps that guide electrification across their portfolios, including prioritizing properties. Taken together, these initiatives produced important insights for accelerating electrification in the multifamily sector.

- **The pilot activity demonstrated that electrification does not have to be taken on all at once**, offering both affordable and market-rate owners different ways to phase electrification in this resource-constrained sector. This can also provide a pathway for easier compliance with future regulations such as Zero-NOx emissions.
- **Funding sources must be widely available to pay for electrical infrastructure**, other electrification readiness measures, and the engineering analysis to either implement or avoid electrical infrastructure upgrades. Eligible measures should be defined broadly to include measures such as ventilation and space modifications needed to fully enable future installation of electric appliances.
- **Easier access to demand data and/or monitoring data, coupled with proper professional training**, is necessary to undertake electrification readiness and achieve the benefits. Analysis efforts were hindered by ineffective utility request processes, lack of options from municipal utilities, and/or time-consuming efforts that exceeded staff capacity. This analysis

approach for full electrification, utilizing demand data and/or appropriate NEC calculations, should be used to enable full electrification all at once when possible.

- **Approaching these projects in a phased approach requires extensive and ongoing engagement with property owners, engineers, and contractors**. Electrification readiness can reduce or avoid retrofit costs over time, but since this brings no immediate energy savings value, there needs to be continued engagement with project decision makers to move forward when funding becomes available.

5. Achieving Scale: Long-Term Vision

In 2025, the California Heat Pump Partnership published a Blueprint proposing 11 strategies for scaling California's heat pump market to six million installed units by 2030.[137] To align with this established public-private consensus, the TECH Clean California team has utilized the Blueprint as a framework for applying our "lessons learned" to future decarbonization policy. A few Blueprint strategies are outside of TECH Clean California's purview, but the following relate directly to our work:

Improve Customer Economics

- *Support long-term, stable incentives to provide market certainty.*
- *Direct 50 percent of program funds to low-income and disadvantaged communities, ensuring all Californians are included in the heat pump transition.*
- *Target near-term, high value opportunities for appliance retrofits, especially AC replacements in warm climates and water heater retrofits in regions with forthcoming appliance standards.*

Streamline Sales and Installation Processes

- *Simplify incentive program design to ease customer accessibility.*

Accelerate Market Adoption

- *Supercharge heat pump marketing efforts, with a two-pronged focus on consumers and contractors.*
- *Develop a comprehensive workforce engagement campaign to address gaps, provide essential training and sales tools, and position contractors as key advocates for heat pump adoption.*

With these strategies in mind, the implementation team offers the following suggestions for scaling building decarbonization, based on our accrued experience.

5.1 Improve Customer Economics

The customer economics of heat pump installation comprises two major factors: upfront and ongoing costs. Strategies for improving customer economics include 1) reducing upfront costs using incentive programs, so that heat pumps are competitive with baseline equipment on a first cost basis, and 2) improving operating cost economics (rates), so that customer bill savings make heat pumps a compelling investment case.

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[137] **The California Heat Pump Partnership (CAHPP)** is a public-private partnership that brings together state policy leaders, heat pump manufacturers, retailers, distributors, utilities, and other key market stakeholders to rapidly scale California's heat pump market and achieve Governor Newsom's goal of installing six million heat pumps in California's buildings by 2030. California Heat Pump Partnership (CAHPP). *California Heat Pump Partnership Blueprint.* March 2025. https://heatpumppartnership.org/blueprint

A. Reducing Upfront Costs through Incentives:

The single most consistent feedback the TECH Clean California team has received from market actors is the need for program consistency and predictability, which enables the supply chain to shift their business models towards heat pumps (see ***Section 3.2 C. Avoid Incentive Funding "Starts and Stops", which is Critical to Market Actor Engagement***). The CEC's first recommendation in the Draft 2025 California's Building Energy Action Plan is to "continue to prioritize funding for incentives to achieve GHG targets." The California Heat Pump Partnership recommended the establishment of a long-term, stable incentive program to meet the state's goals. An investment of this magnitude would support the predictability and stability of incentives that market actors have repeatedly signaled they need. Avoiding incentive starts and stops would reduce administrative complexity and cost and remove a source of confusion and frustration for contractors.

When establishing a long-term program, consider the following best practices:

- Enable the program administrators to set predictable incentive phases, with any changes to availability or amounts communicated to the market in advance.
- Offer point-of-sale rebates through retailers and distributors to simplify the process, with contractor-level efforts reserved for specific hard-to-reach customer types.
- Aim for upfront cost parity with gas appliances and air conditioner replacements.
- Support low-income households and the contractors that serve them through dedicated bonus incentives.
- Continue incentives even after appliance standards are in place; at least for income-qualified customers.
- Narrowly target panel upgrade incentives to encourage panel optimization best practices.

B. Improve Customer Operating Cost Economics

Over the long term, customer economics of building electrification can improve in response to other policy and regulatory levers, in particular, electrification-friendly rates.[138, 139] While rate design falls outside TECH Clean California's scope, aligning rates (heat pump specific or otherwise) closer to the actual marginal cost of delivering energy (for example, by shifting the fixed costs of the grid to base charges and aligning time-of-use rates with actual marginal costs) is one of the potential solutions for improving the customer economic value proposition of electrification. The current focus on energy affordability in California is well justified, and building decarbonization can be part of the solution mitigating increasing energy bills (*see* ***Section 3.1 B. Valuing the Customer Benefits of Heat Pumps***).

[138] ACEEE. Electricity Rates that Keep Bills Down after Electrification of Home Heating. April 2025 https://www.aceee.org/sites/default/files/pdfs/b2502.pdf

[139] NRDC. Powering Change: Understanding California's Electric Rate Challenge and Affordability Solutions. March 2025. https://www.nrdc.org/sites/default/files/2025-03/PGE_Rates_Report_R_25-03-A_03.pdf

In the near-term, there is a large fraction of California households where the project operating cost economics are already compelling: 1) customers with existing cooling loads where AC-to-heat pump HVAC conversion provides significant bill savings, particularly in the hotter, inland areas of the state; 2) customers in publicly owned utilities with relatively low electricity rates; 3) customers with existing solar; 4) customers with comparatively high gas rates; and 5) customers with electric or propane heating.

The combination of heat pump technologies with rooftop solar and battery energy storage appears to be a particularly attractive package from the customer's perspective, judging from the high percentage of TECH Clean California participants who either have already adopted solar or are actively considering it. To increase heat pump adoption (and further mitigate peak grid impacts and lower GHGs), future building decarbonization efforts could explore opportunities to capture more of the existing solar market.

5.2 Streamline Sales and Installation Processes

A. Eliminating Starts and Stops can Simplify Program Participation

Funding for TECH Clean California has been allocated via several different funding mechanisms over time, each of which can have separate incentive amounts, eligibility requirements, or geographic funding allocations. Eliminating fluctuations in program funding and funding consistent incentives for the long term would have a cascading simplification effect and encourage broader participation by reducing the administrative costs and participant business risk inherent with short program funding windows. For example, TECH Clean California significantly increased heat pump HVAC program participation during the 18-month period from 2023-2025 when there no start/stops, despite incentives being lower than previous offerings, and received consistent feedback that this stability was a top priority for contractors. In terms of reducing administrative costs, consistent program funding would minimize the need to communicate incentive availability in near real time and reduce or eliminate the need for a preapproval process in advance of project initiation.

> *"Since its inception in the year 2021, the program has supported the increased sales of HPWHs by an estimated 500 percent between 2021 and 2025. Given the stops and starts of the program, significant dips occur when the program is running out of funds requiring a lot of additional work to re-start the work for contractors and distributors."* ***- Heat Pump Water Heater Manufacturer***

For more information, please reference *Section 3.2 C. Avoid Incentive Funding "Starts and Stops", which is Critical to Market Actor Engagement.*

B. Simplify the Application Process Where Possible

A complex or administratively burdensome incentive application process can significantly depress program participation and/or participant satisfaction, negatively impacting the ability of

programs to achieve their goals. Implementers should critically review application processes to streamline requirements where feasible, retaining only those requirements with a clear and compelling justification for inclusion. Where possible, regulators and policymakers should provide sufficient flexibility to implementers to modify programs to adapt to changing conditions and market feedback.

Beyond the program itself, policymakers could encourage or require Authorities Having Jurisdiction to standardize building permits requirements across the state, which would relieve an important pain point for contractors and may facilitate more uniform code enforcement.

Finally, policymakers should consider the pros and cons of requiring the program to enforce requirements that are either not applicable to the broader marketplace, not uniformly enforced, or may be better suited to be handled at a statewide level. Such requirements penalize program participants who must compete against nonparticipants who are not subject to the same requirements; where these requirements are necessary, they should be offset by enhanced incentives to maintain market interest.

For more discussion on this topic, please reference *Section 3.2 D. Simplify Program Requirements* Where Feasible.

5.3 Accelerate Market Adoption

The implementation team recommends continuing to prioritize capacity-building investments. As discussed in *Section 4. Supporting Sectors and Strategies*, TECH Clean California has invested heavily in contractor engagement, workforce education and training, and consumer engagement. The implementation team has continued to hone and refine its tactics over time, and those efforts appear to be having a positive effect. Customer awareness and satisfaction with heat pumps is rising, contractors are gaining proficiency and comfort with selling and installing heat pumps, and the changes are translating into both improved career opportunities for training participants and increased market share for both heat pump HVAC and heat pump water heaters.

5.4 Setting Market Transformation Metrics and "Stage Gates"

Long-term and impactful market transformation requires clearly defining a specific desired end state or set of objectives and optimizing to get there. Market transformation can facilitate multiple outcomes, such as technology or project cost decline, increased sales volumes, improved workforce readiness, and distributional outcomes across building sectors or demographics. Moreover, programs can be optimized to advance multiple policy priorities, including GHG emissions reduction, affordability and equity, peak load reductions, and maximized grid benefits. Each intended outcome and policy priority merits specific metrics to track progress and inform program refinements over time.

With clear program priorities in place, policymakers and program administrators can develop key metrics and set "stage gates" to pivot program strategy based on accomplishment of predetermined

market, policy, and regulatory milestones. As the heat pump installation market matures, market gains can be locked in via codes and standards, and program resources can shift to focus more narrowly on opportunities such as full phase outs of air conditioners in favor of heat pumps, zonal electrification, and support for those customers in danger of being left behind in the clean energy transition.

5.5 Proposed Long Term Approach

A. The Role of Building Decarbonization in Advancing Energy Affordability

The focus of the Heat Pump Partnership's Blueprint on customer economics aligns well with the broader policy focus on improving energy affordability across the board.

- **Focus market-rate program investments on high-value opportunities that deliver Total System Benefits exceeding investment requirements.** Building decarbonization efforts can act as an investment engine to accelerate affordability gains by achieving disproportionate customer and societal benefits in relation to program costs. The TECH Clean California team has found that grid benefits tend to co-occur with customer bill savings (reference *Section 3.1 D. Program and Portfolio Design Optimization and Strategies*); focusing on high value opportunities could deliver results at a modest cost per capita. A key precondition will be that policy and implementation will both need to maintain a disciplined focus on simplicity, stability, and scale.
- **Emphasize scale.** Achieving the state's heat pump and building decarbonization goals require approaches that align with the scale of that ambition, focusing on opportunities that are widespread and program designs that can serve high volumes of contractors and customers throughout the state. An explicit emphasis on scale drives market maturation. As decarbonization practices become "business as usual," public resources can increasingly focus on harder-to-reach segments.
- **Leverage market momentum.** Equity households will need more financial support than market-rate customers. However, TECH Clean California has found that many, if not most, equity households can address their decarbonization needs without requiring 100 percent of the project costs to be covered.

B. A Three-Pronged Approach to Building Decarbonization

Initially, TECH Clean California focused solely on a contractor-driven model, because 1) contractors are often a critical influence in customer's equipment replacement process, and 2) a midstream model allowed the program to collect highly granular data that can inform the state's long-term strategy.

A long-term approach must balance scale, simplicity, equity, and market development needs. Looking forward to how a future building decarbonization program might be designed to reflect the four years of lessons learned thus far, the TECH Clean California implementation team believes there would be value in a building decarbonization program portfolio with three major program

"prongs," since approaches to incentive design and market capacity building may not always perfectly align within a single program (reference *Section A. Program Design Decisions and Incentive Delivery Channels*):

4. **Statewide or regional distributor and retail point of sale incentives**, complemented by market development and consumer outreach and focused narrowly on cost-effective achievement of the state's climate and grid resiliency goals, with attention to customer economics and expanding participation.

1. **Statewide or regional contractor-based program, comprised of**
    - **Single family income-qualified incentives** to deliver program benefits broadly to equity households.
    - **Multifamily incentives and market support** to deliver benefits to equity households and renters.

2. **Statewide or regional direct install program**, serving the most financially distressed households that need full subsidies and concierge program services to move forward.
    - Transition the Repair and Replacement program under Energy Savings Assistance to deliver electrification services as standard practice for replacing gas appliances.
    - Offer whole-house electrification upgrades to the most financially distressed households, particularly those that require some form of remediation assistance as a precondition for electrification.

These three core building electrification programs can be complemented as needed with local or regional programs to capture locally concentrated opportunities or stack additional grid benefits that are not fully realized within the core portfolio. A few possible examples include:

1. **Targeted zonal electrification initiatives**, focused on local opportunities to reduce or avoid gas infrastructure investments via whole-building electrification.

2. **Dedicated demand flexibility program** to maximize demand flexibility beyond the permanent load shifting and peak reduction benefits that would accrue from building electrification and time-of-use rates. This approach could stack on the core decarbonization portfolio via "bring your own thermostat" or "bring your own heat pump water heater" program models.

C. Statewide Distributor and Retail Incentives

As the heat pump markets mature, the implementation team believes there will be efficiencies to be gained by eventually shifting the incentive focus from contractors to distributors and retailers. The advantages would be:

- The program could reach virtually the entire market simply by enlisting the participation of a relatively small number of distributors and retailers.
- Engagement at the distributor and retailer level would facilitate collection of heat pump sales data, which enables regional/state level market tracking.

- By including both retailers and distributors, the program could serve both contractor installations and DIY projects (which are currently excluded as a viable program use case.
- The delivery of point-of-sale rebates removes program barriers to serving emergency replacements, which is currently a marginally viable program use case.
- The incentive model could readily be extended to cover the full range of climate-friendly appliances, not just space conditioning and water heating.
- By targeting incentives at the wholesale level, the point-of-sale price discount would be multiplied by the retail markup rate.
- Administrative burdens to contractors would be virtually eliminated, along with other participation barriers. Based on experience to date, expanded contractor participation should exert downward pressure on installation prices.
- Limited project-specific requirements translate to low transaction friction and low administrative cost.
- As previously noted, targeting air conditioner replacements in hot climates offers the biggest opportunity to maximize impacts per program dollar invested and optimize outcomes across multiple policy objectives. This design criterion could be met by benchmarking incentives to incremental costs relative to like-for-like air conditioner replacement and geographically targeting them to hot interior climate zones.

This approach does not lend itself to high-touch, project-specific oversight such as permit verification, tenant protections, high-road jobs requirements, etc. The approach would limit (but not eliminate) the ability to track meter-based project outcomes, and it would have limited ability to prioritize equity and target individual customers. For these reasons, the team believes that a certain level of market maturity is necessary to enable this approach. There needs to be a robust base of experienced contractors who can perform quality installations with little oversight beyond the standard building permit process. Meter-based project impacts need to be well understood to the point that additional data delivers diminishing returns. Most importantly, this approach should make up just one prong of a three-pronged strategy, with the remaining two prongs addressing equity gaps.

D. Statewide or Regional Contractor-based Program

The success of the TECH Clean California's equity-based bonus incentives for single-family customers highlights the existence of a substantial customer segment that needs more financial assistance than the standard market-rate incentive yet is able and willing to move forward with electrification upgrades without the need for 100 percent subsidies. These customers could be well served by the same "contractor open market" structure that underpins the current program. This approach offers multiple benefits:

- Compared to distributor and retailer incentives, contractors could more narrowly deliver program resources to specific households based on equity criteria

- The contractor delivery model would enable the program to require best practices for workforce quality and training that exceed standard practices in the marketplace. The extra administrative burden to contractors would need to be addressed as part of incentive design.
- The open market design would allow a path for these best practices to cross-pollinate the broader market. In doing so, the program avoids imposing a monopoly on publicly supported building decarbonization.
- Most importantly, scarce public resources for equity investments could be more broadly applied to serve more customers faster.

On the multifamily front, a contractor-based delivery model would disproportionately benefit low-income households and renters even in the absence of income eligibility requirements. The multifamily subprogram should be tailored to this segment rather than grafting a single-family program design onto the multifamily market. Key attributes of the multifamily engagement strategy should include:

- Program delivery through a "contractor open market" model that enables property owners to choose their own contractors and work with their in-house property maintenance teams.
- Long and flexible incentive timelines that allow for extended planning horizons and diverse upgrade strategies, ranging from gut rehabilitation to incremental upgrades of housing units over time (i.e. unit turnover, maintenance schedules, funding opportunities).
- Simple incentive requirements that enable funds to be combined from multiple sources.
- Planning and technical assistance, resources, and decision tools to help project sponsors map out an electrification readiness strategy that accommodates upgrades over time and across large project portfolios.
- Strong technical assistance, including training, case studies, and design best practices to address technical challenges with multifamily central heat pump water heater retrofits and electrical infrastructure evaluation. Programs may need to provide project-specific design consulting in some instances.
- Emphasis on capacity building, including knowledge transfer to contractors, engineers, maintenance personnel, property managers and owners and other decision-makers.

E. Statewide or Regional Direct Install Program

The implementation team recognizes the continuing need for direct install programs, such as the Energy Savings Assistance and Equitable Building Decarbonization programs, to offer full or nearly full subsidies and concierge services to the most financially distressed households. Within this segment, TECH Clean California has found a still narrower subset with costly remediation and minor home repair needs that must be addressed before decarbonization upgrades can even be considered. By pairing the direct install approach with the contractor-based, income-qualified approach, direct install resources can be narrowly targeted to those customers most in need while still offering every household a path forward.

Looking back over TECH Clean California's accomplishments to date, the team is proud of its successes, grateful for lessons learned, and confident that future heat pump efforts build on the TECH Clean California experience and support the California legislature's original intent in Senate Bill 1477 to "make low-emission heating equipment readily available and affordable in California."

Appendix A: Measure-Specific Best Practices

This section covers select technical best practices associated with each technology type (heat pump HVAC and heat pump water heater). Customer and contractor engagement best practices associated with each technology are described in Section 3. Program Design Best Practices and Section 4. Supporting Sectors and Strategies, respectively.

A.1 Heat Pump HVAC

Encourage (or require) dual-speed and/or variable speed compressors. TECH Clean California found that replacing an air conditioner with a heat pump with multi- or variable-speed compressor delivers nine times greater utility bill savings and twice the peak demand reduction, compared to a heat pump with a single speed compressor. In response, TECH Clean California eliminated incentives for single speed compressors in favor of multi- or variable-speed compressors (discussed in 3.6 Role of Data and Analytics in Supporting Heat Pump Adoption)

There are limited incremental benefits beyond 17 SEER2 for heat pump HVAC efficiency. SEER and HSPF are important metrics describing the cooling and heating efficiency, respectively, of heat pump HVAC equipment. Analysis of utility bill impacts indicates that HVAC equipment with HSPF lower than 8.5 tended to have reduced utility bill savings compared to the average project, while those with HSPF of at least 11.7 tended to have greater utility bill savings. However, increasing HSPF beyond 11.7 did not yield significant further increases in utility bills.

SEER and HSPF are important metrics describing the cooling and heating efficiency, respectively, of heat pump HVAC equipment. Analysis of utility bill impacts indicates that HVAC equipment with HSPF lower than 8.5 tended to have reduced utility bill savings compared to the average project, while those with HSPF of at least 11.7 tended to have greater utility bill savings. However, increasing HSPF beyond 11.7 did not yield significant further increases in utility bills.

Contractors should advise customers with ducted heat pumps about what to expect with the air temperature coming out of their vents. In evaluator surveys, TECH Clean California customers noticed that the air coming out of the vents was not as hot as it had been with a furnace and that their heat pumps ran longer to heat up the home. About two-thirds of customers who noticed the change in air temperature from the vents were bothered by it. Contractors should educate their customers about these differences in what customers should expect during the sales process. Setting the customers' expectations in advance should reduce the number of callbacks and hopefully lead to a more satisfied customer.[140]

[140] Opinion Dynamics. *TECH Clean California Heat Pump Equipment: Insights into Customer Experience and Satisfaction*. September 15, 2023. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Customer_Experience_and_Satisfaction_Final_Report_9.15.23.pdf

Provide support to help ductless heat pump customers with their new thermostat. The TECH Clean California evaluator found that ductless heat pump users, in particular, were troubled by their thermostats, with about one-third of customers finding their ductless thermostat harder to use than their prior thermostat. A minority (39 percent) felt comfortable using their thermostat right away. It is important to enhance end-user guides and manuals to empower customers to troubleshoot issues as effectively as possible.[141]

Furnace decommissioning achieves larger GHG reductions than leaving a backup in place. Internal analysis by the Implementer showed that projects in which the furnace was fully decommissioned had 63 percent greater median annual GHG reductions than projects where the furnace was left in as backup/auxiliary heat.[142]

Right-sizing. Average heat pump HVAC total project cost increases significantly as heating capacity increases. Meanwhile, there is no evidence that utility bill savings increase as heating capacity increases. Preliminary analysis of customer return on investment (ROI), which incorporates both incremental upfront cost and lifecycle utility bill savings, suggests that heating and cooling capacity are two highly influential factors that tend to *decrease* customer ROI. Based on these findings, it is evident that right-sizing heat pump HVAC equipment is an effective way to decrease costs and therefore improve customer ROI. It is especially effective if a customer can avoid passing the cost thresholds at ~2.4 and ~3.4 tons of heating capacity, as these correspond with massive cost increases (Figure 8).

[141] Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction Wave 2*. March 27, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

[142] Sarkisian, Dylan. Energy Solutions. "The Roadmap to Scale: Using Analysis of Heat Pump Installations to Inform the Next 20 Million Projects" Slide 11. 2024 ACEEE Hot Water & Hot Air Forums. March 13, 2024. https://drive.google.com/file/d/1YrcUEcHaTh3Cw3dTrMpa5WuqttSSK967/view.

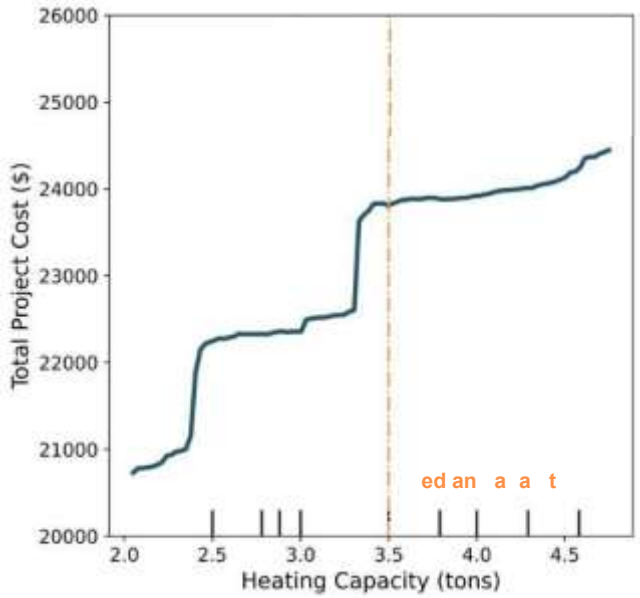

Figure 8: Average Total Project Cost versus Heating Capacity.[143]

A.2 Unitary Heat Pump Water Heaters

Tank upsizing reduces electricity consumption and GHGs, while improving hot water availability. Through a combination of contractor education and bonus incentives, TECH Clean California has encouraged contractors to upsize heat pump water heaters by *at least 20 percent above the existing water heater size* and include thermostatic mixing valves (TMV), both to improve GHG savings and help customers avoid running out of hot water. Since 2022, the fraction of TECH Clean California heat pump water heater installations with upsized tanks increased by 58 percentage points, from 34 to 92 percent (see *Section 3.6 C. Leveraging Program Data to Inform Incentive Design*). Internal analysis has shown that projects that up-sized the water heater tank by at least 20 percent produced 20 percent greater GHG savings, with minimal impact on peak demand.[144] The evaluator's 2024 customer satisfaction survey showed that 94 percent of TECH Clean California participants with a heat pump water heater had enough hot water to meet their needs "always" or "most of the time".[145]

120V heat pump water heaters play a meaningful role in the market. Partially attributed to a Quick Start Grant funded by TECH Clean California, New Buildings Institute (NBI) was able to

[143] Bay Area Air District (BAAD) Building Appliances Rule 9-4 Implementation Working Group (IWG) Phase 2 General Meeting #2, December 3, 2025. https://www.baaqmd.gov/en/community-health/building-appliances-rule-implement

[144] TECH Clean California. 15th Quarterly Stakeholder Presentation. October 30, 2025. https://techcleanca.com/documents/5673/TECH_15th_Quarterly_Stakeholder_Meeting_IPTFwGx.pdf

[145] Opinion Dynamics. *TECH Clean California: Insights into Customer Experience and Satisfaction, Wave 2*. March 27, 2025. https://opiniondynamics.com/wp-content/uploads/2025/09/TECH_Updated-Customer-Experience-and-Satisfaction-Report_3.31.2025_Clean_UPDATED.pdf

demonstrate that 120V heat pump water heaters can mitigate costly electrical infrastructure upgrades often required with traditional 240V heat pump model and can do so at a lower installed cost. From 2023-25, 120V units accounted for 21 percent of TECH Clean California unitary heat pump water heater projects, and they have dramatically reduced the need for electrical work when installing a heat pump water heater. Since TECH Clean California launched water heating incentives, 25 percent of 240V heat pump water heater installations involved electrical upgrades of some kind, such as new circuits or panel upsizing, while only 4 percent of 120V systems did – even though the average pre-installation panel capacity for 120V projects was 28 amps less than for 240V projects. On average, total project costs for 120V unit installations were 22 percent less than 240V installations.[146] This reflects a slightly higher equipment price for 120V units but a significantly lower installation cost, leading to an overall reduction in project cost.

Ensure contractors properly set the appropriate heat pump water heater mode at the time of installation: The TECH Clean California evaluator's analysis found that TECH Clean California contractors reported setting 4 percent of heat pump water heaters on electric resistance operating mode.[147] This setting sacrifices the benefits of the heat pump, resulting in fewer GHG savings and customer energy savings.

A.3 Central Heat Pump Water Heaters

Roughly half of TECH Clean California' s multi-family heat pump water heater projects have been served by central heat pump water heaters. Central heat pump water heaters are still in the early stages of market development, and thus require supplemental support, but significant potential to serve a broad segment of the state's multifamily households.

The complexity of central heat pump water heater projects requires heightened attention to technical assistance and market capacity building. Technical assistance should include:

- Pre-installation support such as system design and pre-retrofit monitoring, analysis, and fixes for issues such as distribution system imbalance—both to ensure sufficient upfront investment in proper sizing and to address distribution issues that would negatively impact the performance of a newly installed central heat pump water heater plant.
- Post-retrofit commissioning and monitoring is necessary to ensure systems are operating as intended, identify issues that arise over time, and support troubleshooting.
- Expanded training and technical support to build contractor knowledge and capacity to implement CHPWH projects.

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[146] TECH Clean California. 14th Quarterly Stakeholder Meeting. July 23, 2025. https://techcleanca.com/documents/5623/TECH_14th_Quarterly_Stakeholder_Meeting_Xt3e3vj.pdf

[147] Opinion Dynamics. *Interim Process Evaluation: Technology and Equipment for Clean Heating (TECH)*. November 7, 2022. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Interim_Process_Evaluation_Final_Report.pdf

Based on these key learnings, the next set of multifamily offerings through the TECH Clean California will include expanded and required training for contractors, training on industry best practices, standards for evaluation of existing systems, and system sizing incorporated into enhanced support pathway incentives. The offers will also include incentives for pre-retrofit monitoring to identify distribution issues and post-retrofit monitoring for performance verification.

Appendix B: Low-Income Leveraging Pilot Findings and Recommendations

See Low-income Leveraging Pilot Final Report, pages 5–11, for a list of recommendations pertaining to low-income programs and strategies to address remediation needs.[148]

Summary of Findings

Table 1: Qualitative Findings

Findings	Summary
The additional remediation needs of the households treated through this pilot range include a large range, with an average of $5,893 per project. Funding to support remediation work, whether challenged through low-income energy efficiency programs such as Energy Savings Assistance or otherwise, will need to increase dramatically to serve the households treated through this pilot — particularly to support households in disadvantaged communities and mobile and manufactured homes.	With a range of between $225 up to over $30,000 per project, 87 percent of all projects required less than or equal to $10,000 in supplemental remediation needs. While the average remediation contribution was $5,983, that average decreased to $4,989 when the highest 5th percentile was removed—indicative of the opportunity to serve the majority of participants at a lower overall average, when removing the highest-cost outliers. For single-family homes, 91 percent of projects fell at or below $10,000, while for mobile homes, only 58 percent fell below the threshold**. The average supplemental remediation contribution for single family homes was $5,197 (median of $4,071), compared with the average for mobile homes at $11,203 (median of $9,074).** Increasing program remediation caps to allow up to $10,000 in total remediation and minor home repair work within the Energy Savings Assistance (ESA) Program would have enabled the participation of 468 additional homes across the three leveraged and partner programs. This could have been managed against a lower average across the portfolio.

[148] Rachel Etherington, Irina Krishpinovich, and David Ortiz, The Ortiz Group LLC; Meghan Harwood, Becky Schaaf, Ben Staub, and Asa Parker, VEIC. *Pilot Project Final Report: Low-Income Leveraging Pilot*. December 15, 2025. https://techcleanca.com/documents/5705/8.2_Low_Income_Leveraging_Pilot_v260105.pdf

Findings	Summary
Leveraging existing low-income programs is a meaningful way to deliver benefits to disadvantaged communities.	While TECH Clean California's dedicated equity funds deliver benefits and incentives to a broad range of equity communities inclusive of disadvantaged communities, only 14 percent of TECH Clean California incentive projects occur in disadvantaged communities. Within the Low- Income Leveraging Pilot scope of income-qualified customers, **47 percent of pilot projects occurred in disadvantaged communities.**
Main panel upgrades and panel upsizing were expensive line items that impacted total remediation costs, though not as dramatically as expected.	**The average supplemental remediation contribution for households that involved a panel upgrade or upsizing was $6,387 (median of $5,760), compared with the average for households without an electrical upgrade at $5,150 (median of $3,529).** Additional pilot data discusses the portion of projects that fall within remediation cost categories, between projects that did include a panel upgrade or upsizing relative to those that did not (see: Figure 4).
Disadvantaged community status had a strong relationship with remediation costs and needs.	A larger portion of projects within the Low-Income Leveraging Pilot served households in disadvantaged communities, compared with the TECH Clean California program as a whole (see: Figure 3). **The average supplemental remediation contribution for households in a disadvantaged community was $7,505 (median of $6,509), compared with the average for households not in a disadvantaged community at $4,483 (median of $3,362).**
Unsurprisingly, projects that involved both heat pump heating, ventilation, and air conditioning and heat pump water heater installation — versus just a heat pump water heater — were more expensive and required more remediation needs.	The pilot gathered data on remediation costs for projects that involved only a heat pump water heater installation, relative to projects that involved both a heat pump water heater and heat pump heating, ventilation, and air conditioning retrofit (see: Figure 6).
Mobile homes have much costlier remediation and minor home repair needs than single family homes.	The pilot reports on the average remediation contribution for mobile home projects relative to single-family households and projects, inclusive of both heat pump water heater and heat pump HVAC

Findings	Summary
	projects (see: Table 4). Additionally, the pilot demonstrates the remediation cost range for mobile home projects relative to single-family households (see: Figure 7). **The average supplemental remediation contribution for single-family homes was $5,197 (median of $4,071), compared with the average for mobile homes at $11,203 (median of $9,074).**
Home vintage was an indicator of remediation and minor home repair costs and needs, but not as strong as we would have guessed.	**The average supplemental remediation contribution for homes built before 1978 was $7,808 (median of $7,331), compared with the average for homes built after 1978 of $4,604 (median of $3,362).** This report compares the remediation cost range for projects pre-1978 vintage relative to post-1978 vintage (see: Figure 8).
While older homes almost always required a main panel upgrade or sub-panel upgrade or upsize — i.e., panel upsizing — about half of newer post-1978 construction homes required an upgrade as well.	The report demonstrates remediation cost ranges for project participants, by home type, home vintage, and panel upsizing requirement (see: Figure 2).
Cost drivers and factors influencing remediation and minor home repair needs are site-specific, though commonalities indicate opportunities for targeted training and home assessment strategies.	Challenges varied from heat pump water heater relocation, sealing and ducting for heating, ventilation, and air conditioning retrofits, to electric panel upgrades or upsizing and access challenges. However, there are common challenges and solutions that could inform future training or home assessment and prioritization work. Those include things such as: 1) water heater relocations, prompted by space constraints (previous unit in a small interior closet), ventilation and air flow requirements, noise and vibration considerations, and more; 2) heating, ventilation, and air conditioning retrofit needs, such as new and extensive duct sealing or replacement, structural modifications, roof or wall repair work, and more; or 3) electric panel upsizing or main panel replacement, whether simply adding circuits to an existing panel or requiring an entire main panel upgrade.

Table 2: Qualitative Findings

Finding	Summary
Non-energy benefits are substantial to the participating households—low-income households and households in disadvantaged communities.	Non-energy benefits can include restoring basic access and functionality of air conditioning or water heater systems that deliver health, comfort, and safety in the face of extreme heat and weather events.
Program leveraging and incentive stacking are complex, and minimizing administrative burdens for participating contractors or homeowners is crucial. Providing robust technical assistance to minimize additional administrative or cost burden on participating contractors, alongside proactive incentives to layer on new scope and funding, served as an effective model.	As contractors are often disincentivized from maximizing layered funding on behalf of customers because of administrative burden, TECH Clean California offered a $225 incentive to ESA contractors to participate in and layer with TECH Clean California. That contractor incentive was intended to cover the labor cost of additional administrative work. In addition, Ortiz Group contributed in-kind technical assistance to simplify the process. The Ortiz Group supported contractors by writing a set of Standard Operating Procedure (SOP) documents and checklists for contractors (e.g., step by step how to enroll as a TECH Clean California contractor, submitting incentive applications, and field checklists to ensure contractors capture all photos and project documentation required to report on the incentive application). Stacking incentives with different rules and administrative requirements is extremely difficult for both contractors and homeowners. Simplifying program rules is the lowest-cost pathway to supporting funding stacking and avoids having to pay out more substantial incentives to contractors to encourage participation in multiple programs.
Identifying complementary scope of works between programs maximizes funding and retrofit potential.	This can include aligning programs based on their individual funding metrics, such as complementing programs tied to cost-effectiveness with more flexible funding.
Managing low-income programs using a portfolio-wide average instead of a per-household cap enables a program to serve more households at the same average cost.	Programs typically include a maximum allowable cost associated with the funds spent toward remediation. A portfolio-wide average provides flexibility to programs because they can accommodate higher costs while remaining within budget. This strategy enables higher cost outliers to participate when balanced with lower-

Finding	Summary
	cost projects, allowing a program administrator to manage an expected average portfolio cost. Programs typically include a maximum allowable cost associated with the funds spent toward remediation. A portfolio-wide average provides flexibility to programs because they can accommodate higher costs while remaining within budget.
Ensure strong coordination and alignment between various program administrators and implementers.	This includes creating opportunities for a project manager to review project needs on a flexible basis, with an eye toward avoiding duplicative efforts, streamlining processes, as well as seeking project cost-reduction measures.
Contractors remain unfamiliar with heat pumps, both as a new technology and the varied installation challenges in the field. Training should include heat pump-specific education and field training.	This should include hands-on troubleshooting and a focus on real-world challenges, such as electrical upgrades, panel sizing and airflow, and common remediation scopes across different building typologies. Program administrators might also consider on-going technical support for contractors, such as electrification specific on-site advisors, or the creation of peer learning and mentorship networks.

Summary of Recommendations and Future Areas for Research

FOR POLICYMAKERS AND PROGRAM DESIGN

Prioritize flexibility over funding caps and enable portfolio-level goal setting. This enables programs to serve higher-cost outliers and acknowledge regional differences in housing conditions within a program's service territory, for example, while planning toward a portfolio-wide average.

Align program rules and regulations to minimize administrative burden to support flexibility, funding streamlining, and layering. Where possible, enable funding stacking and project intake through existing programs — including ones with existing income qualification and customer outreach processes. Policymakers and regulators should coordinate funding initiatives by pairing more flexible sources with more stringent ones to maximize impact, whether enabling deeper retrofits per house, furthering reach in higher-need low-income households, or otherwise.

Focus on electrification-ready measures, including weatherization, efficiency, and optimized electrical upsizing or upgrades. Though expensive upfront, measures such as attic insulation and air sealing can be crucial for long-term affordability. Similarly, efficient and optimized electrical upsizing or upgrades can set up a household for longer-term decarbonization while saving costs upfront.

Value non-energy household benefits and climate benefits of electrification. Whenever possible, particularly for more flexible funding sources, programs should account for the individual household financial, health, comfort, and other benefits, as well as societal benefits.

Programs should manage toward and optimize for high-impact outcomes —whether cost-effectiveness, energy savings, greenhouse gas impact, or customer benefits — on a portfolio basis. At the same time, programs and policymakers must plan for long-term equity and market transformation by investing in technological, financial, and delivery solutions tailored to serve high-need, high-cost homes over time. This includes building separate, sustained funding pathways or specialized interventions for homes with extensive remediation needs, rather than expecting every core program to absorb all outlier costs. A cost-effective portfolio should be designed to enable some higher-cost projects, while optimizing for specific metrics and outcomes — whether maximizing energy savings, cost-effectiveness or Total System Benefit, minimizing bill impacts, or otherwise. Programs and policymakers need to simultaneously focus on transforming the market for low-income households, investing in solutions to common challenges such as heat pump technologies for households that are space constrained or have minimal electrical capacity, such as 120V solutions; installation solutions that minimize cost and complexity, such as power-efficient approaches and panel optimization; program solutions that enable scale, such as accessible financing; and other policy solutions to enhance affordability, such as equitable rate design. This is particularly important as the state advances appliance standards policies, when low-income households with high remediation needs will need the most support in electrifying.

Consider mechanisms for supporting low-income electrification as a long-term affordability strategy. Ensuring low-income households are not left with future stranded gas assets, volatile fuel prices, and the negative health benefits of gas appliances is crucial for long-term affordability. Existing data can be used to target and support households expected to have immediate bill savings from electrification with retrofit and program support before appliances fail. When managing emergency replacements, minimizing or neutralizing negative bill impacts will remain crucial — whether through specific rates, pairing a retrofit with robust efficiency and weatherization or solar measures, or otherwise. It will also be critical to avoid funding new gas appliances, which will become stranded assets over time.

FOR PROGRAM ADMINISTRATORS AND IMPLEMENTERS

Invest in contractor training for both electrification and electrification-ready measures. This should include proactive and hands-on training for contractors who traditionally support low-income direct-install programs and energy efficiency and weatherization — such as Energy Savings Assistance program contractors — related to heat pumps, on-site remediation trends and needs, bill impact assessment tools, and panel optimization opportunities.

Fund detailed site assessments and building stock characterization work to account for and understand the variation among properties. Detailed site and market assessments can source main drivers of variation across geographies, for example. Programs should create processes for protocol and best practice sharing among contractors and program administrators to avoid unexpected or unnecessary costs.

Develop culturally and locally relevant electrification educational materials, both for homeowners and contractors. Highlight the non-energy benefits of electrification, and develop materials in multiple formats and languages, which enables households to make decisions based on their own priorities.

FOR FUTURE RESEARCH

Invest in market characterization and transformation for low-income households specifically, as well as the higher-cost outliers that are continuously left behind. This can include developing better standards, best practices, and protocols for managing high-cost remediation needs that are commonplace in specific building stock or geographies. It should also include researching and investing in new technological or market solutions — such as 120V technologies, inclusive and accessible financing, panel upgrade alternatives, and more.

Create a value proposition for contractors that enables funding stacking/leveraging without driving up project costs. This includes further understanding the adequate incentives — whether financial or otherwise — to encourage contractors to participate and layer funding.

Develop new resources for contractors for low-income electrification, focused on remediation and minor home repair challenges, as well as cost-savings strategies like panel optimization and panel upgrade alternatives. This could also include materials on best practices or existing tools for bill impact assessments.

Appendix C: Residential Decarbonization Measure List

Below is a table listing the eligible residential decarbonization measures applicable for participants of the Equitable Building Decarbonization Program (EBD).[149]

Category	Measure	Details
Heating and Cooling	Heat pump for space heating and cooling	Eligible as a replacement for gas-fired or electric resistance heating equipment. Must meet the highest efficiency tier (not including any advanced tier) established by the Consortium for Energy Efficiency (CEE). Equipment installed on or after 7/1/24 must use refrigerant with global warming potential (GWP) less than 750.21 Installer must possess U.S. Environmental Protection Agency Section 608 Technician Certification. Home Energy Rating System (HERS) field verification and diagnostic testing is required consistent with the California Energy Code.
Heating and Cooling	Duct testing/sealing, and/or new ducts, returns, and registers	Duct testing/sealing is required in conjunction with installation of a ducted heat pump for space heating and cooling consistent with the California Energy Code.
Heating and Cooling	Occupant controlled smart thermostat	Required in buildings with central heating/cooling system, if not already present. Must be certified compliant with Joint Appendix 5 (JA5) of the California Energy Code
Heating and Cooling	Ceiling fan or whole-house fan	Ceiling fans must be ENERGY STAR®-certified
Building Envelope	Air sealing	

[149] California Energy Commission. *Equitable Building Decarbonization Direct Install Program Guidelines (Adopted)*. CEC-400-2023-003-CMF. October 23, 2023. https://efiling.energy.ca.gov/GetDocument.aspx?tn=252682&DocumentContentId=87762

Category	Measure	Details
Building Envelope	Insulation	
Building Envelope	Solar window film	Must be certified by the National Fenestration Rating Council
Water Heating	Heat pump water heater (unitary)	Eligible as a replacement for a gas-fired or electric resistance water heater. 240V heat pump water heaters must meet Northwest Energy Efficiency Alliance (NEEA) Advanced Water Heater Specification for Integrated or Split-System Heat Pump Water Heaters at Tier 3 or higher; 120V heat pump water heaters must meet NEEA Advanced Water Heater Specification for Plug-In Heat Pump Water Heaters at Tier 2 or higher. Must be certified compliant with Joint Appendix 13 (JA13) of the California Energy Code and installed in accordance with JA13 specifications. Must meet the highest efficiency tier (not including any advanced tier) established CEE.
Water Heating	Heat pump water heater (central)	Eligible as a replacement for a gas-fired or electric resistance water heating system. Must appear on CEC's Central Heat Pump Water Heater Performance Map Certification List.
Water Heating	Low-flow showerheads and faucets	Low-flow showerheads are required in conjunction with heat pump water heater installation, if not already present. Must be WaterSense certified and comply with California Tile 20 standard for water efficiency.
Cooking	Induction range or cooktop	Only eligible as a replacement for a gas range or cooktop. Provide gift card for purchase of compatible cookware.
Laundry	Electric clothes dryer (heat pump or electric resistance)	Only eligible as a replacement for a gas clothes dryer. Must be ENERGY STAR-certified.

Category	Measure	Details
Lighting	Light-emitting diode (LED) bulbs and fixtures	Replace interior and exterior incandescent, compact fluorescent, halogen, and T12 linear fluorescent bulbs with LED. New fixtures may be installed where existing bulbs cannot be upgraded. Must be certified compliant with Joint Appendix 8 (JA8) of the California Energy Code.
Indoor air quality	Air filtration	Replace existing air filter with a Minimum Efficiency Reporting Value (MERV) 13-rated filter, and associated modifications needed to comply with pressure drop requirements in the California Energy Code.
Electrical	Electrical wiring and panel upsizing	Upgrades and new wiring needed to enable full electrification of the building. Excludes upgrades on the utility side of the meter and distribution system upgrades, which are ineligible for program funding. Subject to cost caps (see Table 5). See Section 5, Electrical Upgrades.
Electrical	Automatic circuit sharing	See Section 5, Electrical Upgrades
Remediation and safety	May include construction needed to create physical space for decarbonization measures, repair of roof or envelope leaks/damage, remediation of galvanized pipe, lead paint, asbestos, and/or mold, installation of smoke and carbon monoxide alarms, ventilation, and other work needed to bring property up to code.	Subject to cost caps (see Table 5)

Appendix D: Program Theory Logic Model

The evaluator created a Program Theory Logic Model (PTLM) for the TECH Clean California program. The PTLM documents how the activities, outputs, and short- and long-term outcomes are interconnected. The PTLM activities are listed from left to right, and the outcome categories are listed in chronological order from top to bottom. The PTLM features arrows labelled with numbers, and these arrows represent linkages.

Opinion Dynamics started the PTLM development process by creating an initial PTLM that captured the core theory behind TECH Clean California including its key activities, outputs of activities, and intended outcomes. This initial PTLM was informed by review of TECH Clean California implementation plans. The evaluation team presented this initial PTLM to key staff from the Energy Solutions implementation team and solicited feedback about the accuracy of each element. We used feedback to refine the PTLM, which is presented below.

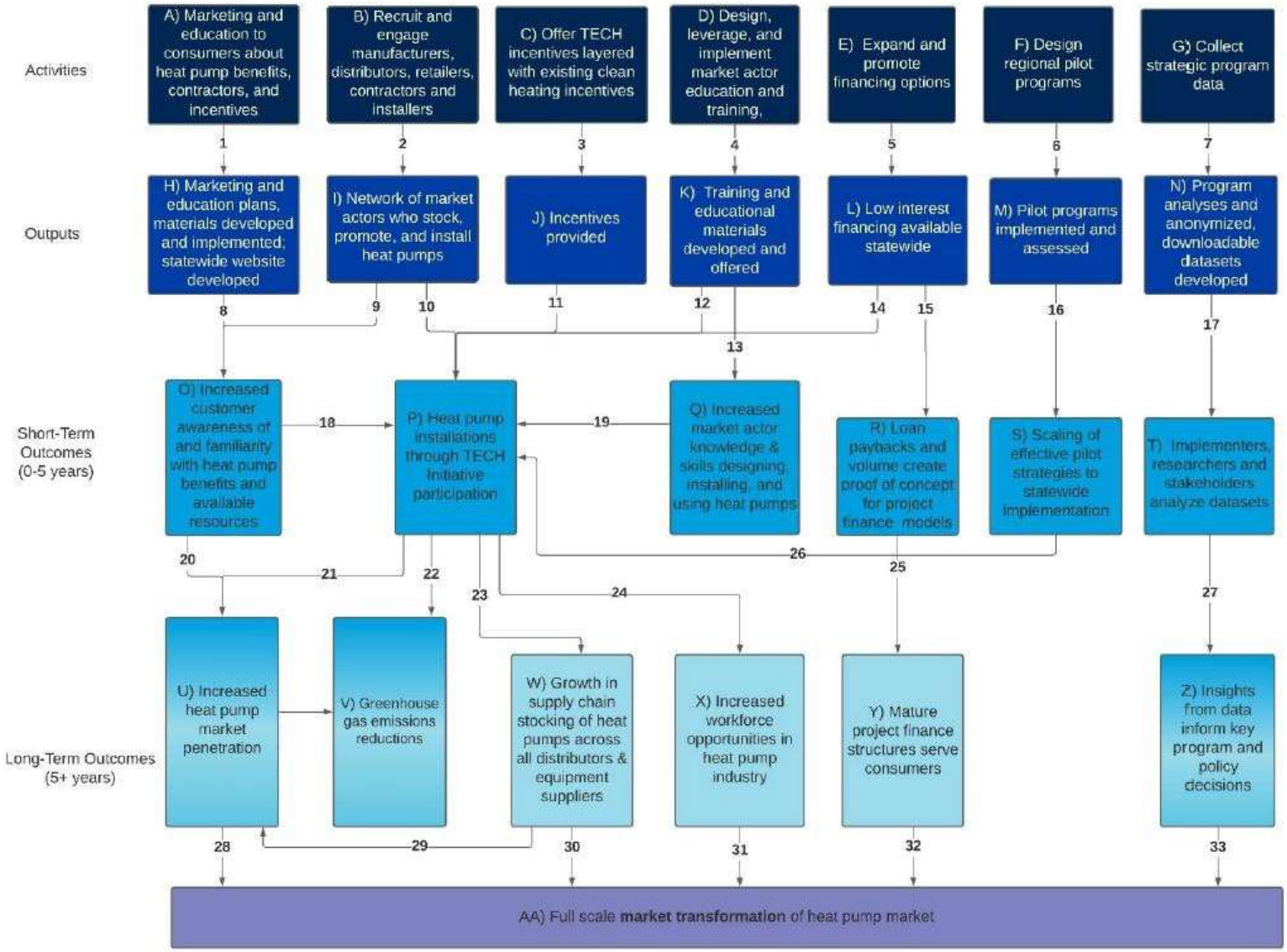

Figure 9. TECH Clean California Program Theory Logic Model

Appendix E: Frameworks for Optimizing Policy Objectives

E.1 Reconciling Competing Objectives for Program Optimization

The electrification initiatives are frequently asked to advance multiple policy objectives simultaneously: reducing greenhouse gas (GHG) emissions, improving customer affordability, delivering system benefits, and prioritizing low-income, hard-to-reach (HTR), and disadvantaged communities (DACs). These goals are not always aligned. For example, projects with the highest system value may not always be located in priority equity communities, and projects that maximize GHG reductions may not always yield the largest bill savings.

To manage these trade-offs in a transparent and repeatable way, analysis of key drivers of outcomes can be used to create a multivariate optimization framework and produce a single Electrification Potential Score for prospective projects. This score reflects how well that project may advance a weighted combination of program objectives and can be forecasted in advance for all prospective participants.

E.2 Objectives and Scoring Framework

The framework incorporates multiple objectives for an HVAC electrification portfolio:

Maximize GHG emissions reductions	Maximize system benefits	Maximize customer bill savings
Maximize peak period savings	Serve low-income customers	Serve hard-to-reach (HTR) customers and disadvantaged communities (DACs)

Program administrators assign weights to each objective based on its relative importance, with the weights summing to 100 percent. Equity metrics (low-income, HTR, DAC) can be scored so that each flag provides a meaningful advantage in the final score, relative to other core program objectives, such as peak savings, bill savings, and the combination of system benefits and GHG savings.

To put all objectives on a common footing once they have been weighted by importance, each objective is normalized to a 0-1 range. Continuous metrics (system benefits, GHG savings, bill savings, peak MWh savings) are normalized using a Min-Max-style transformation that preserves their relative distribution, and equity indicators are represented as binary values (1 for True, 0 for False).

Each project's Electrification Potential Score is then computed as the weighted sum of its scaled objective values. If a component is missing (for example, a bill impact where rate data are

unavailable), that component is set to zero, and the score is re-scaled based on the sum of the weights of the available components, preserving comparability across projects.

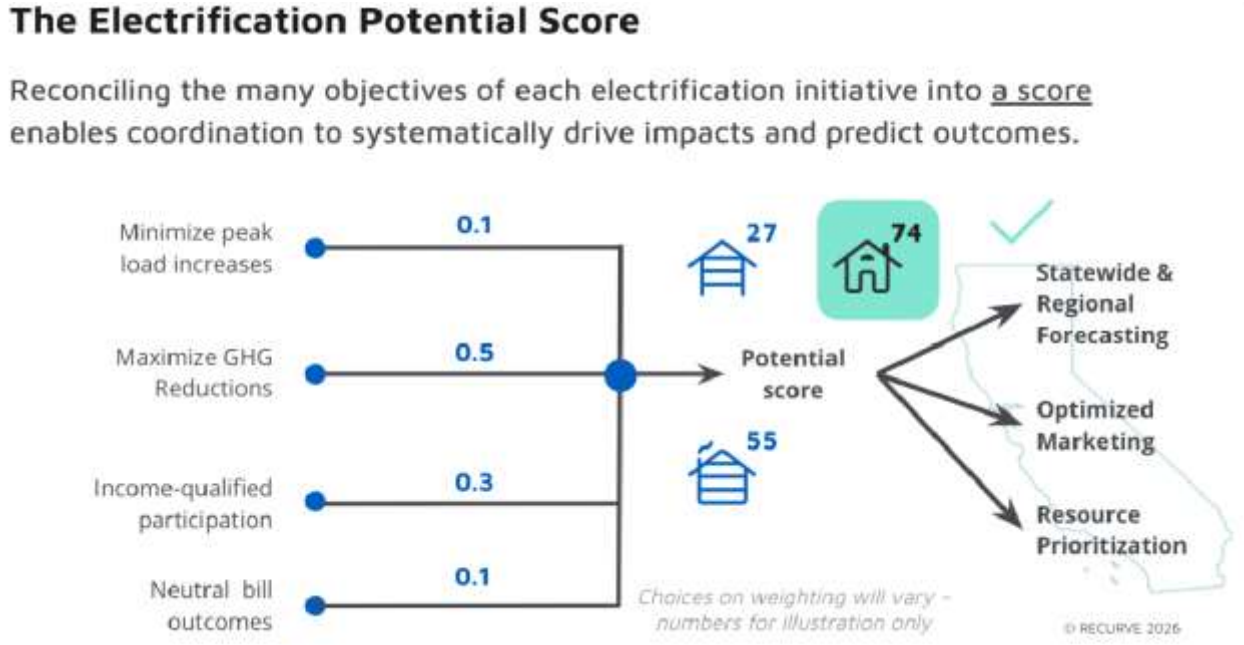

Figure 10: Steps for scoring an electrification initiative.

E.3 Forecasting Scores for Prospective Participants

Once measured in Recurve's FLEX platform, Electrification Potential Scores are established for existing projects. The machine-learning forecasting engine is calibrated to predict scores based on drivers using available data for all prospective TECH Clean California participants (e.g., pre-program load shapes, climate zone, equity flags, utility, and rate category).

The model can reliably separate projects into score quartiles, with predicted and measured scores closely aligned on average. This validates the framework as a practical targeting tool: scores can be assigned to all eligible customers in the population dataset prior to enrollment, and implementation teams can prioritize marketing messaging and geographic outreach to groups with the highest Electrification Potential Scores.

E.4 Optimization as an Electrification Best Practice

By intentionally considering the role of multiple, sometimes competing, program objectives within a standardized framework, program administrators, regulators, and stakeholders can gain a clearer understanding of the trade-offs and ensure that resources are focused where they have the potential to deliver the biggest impact.

Projects in the top-scoring quartile have the potential to deliver substantially greater impacts than those in the bottom quartile. By intentionally weighting equity factors, they will be represented in the top-quartile focus groups alongside other drivers that affect their outcomes.

This best practice makes policy trade-offs explicit and actionable through objective weighting. The drivers identified in TECH Clean California provide a foundation for forecasting outcomes and optimizing future initiatives. It provides a transparent, quantitative basis for prioritizing outreach and incentives and can be updated over time as more meter data becomes available or as policy priorities evolve.

In short, the multivariate optimization framework has turned the TECH Clean California meter data into an operational tool for designing and targeting electrification portfolios that simultaneously support decarbonization, affordability, system value, and equity.

Appendix F: Driver Analysis and the Importance of Site-Level Granularity

F.1 Identifying Baseline AC use is Essential to Electrification Program Optimization.

A central finding of the implementation team's analysis is that site-level drivers–in particular, whether a home had preexisting air conditioning (AC)–strongly influence both grid and customer outcomes from heat pump electrification. This appendix summarizes AC's role as a key driver and explains why site-level granularity is essential for optimizing the design of electrification programs.

F.2 Presence of AC as a Primary Outcome Driver

Recurve's FLEX Platform was used to identify the presence of AC in homes participating in the TECH Clean California.[150] This visibility into baseline technology identified that the preexistence of AC as one of the key drivers of customer and grid impacts in a detailed value stream analysis. In the analysis, heat pump HVAC projects were divided into two canonical portfolios based on pre-program AC status:

- HVAC, AC Detected – homes where a heat pump replaces both a gas furnace and an existing AC system.
- HVAC, No AC Detected – homes where a heat pump replaces a gas furnace in homes without detectable prior AC, effectively adding cooling service.

HVAC electrification operates differently in these two cases:

- In homes with AC, the heat pump serves as both a fuel switch (gas-to-electric for heating) and an efficiency upgrade for cooling. Analysis found that these projects reduce summer peak electric load because the new heat pump is more efficient than the existing AC, resulting in significant GHG savings from reduced electricity use during California's summer peak hours of 4 pm to 9 pm.
- In homes without AC, the heat pump is displacing gas heating, but it also introduces new cooling load where little or none existed before. Under hot conditions, these projects increase summer peak demand, and customers may experience higher electric bills if rate design and building shell conditions are not supportive.

At the same time, both portfolios deliver substantial gas savings—on the order of 200+ therms per year on average—which drive large GHG reductions.

[150] See FLEX Platform capabilities. https://recurve.com/platform/how-it-works/

The impact of just this one driver is important to consider in policy decisions and program design and tactics. The same electrification technology can either reduce or increase summer peak load and bills, depending largely on whether AC was present beforehand.

F.3 Regional and System Planning Implications

The distribution of AC status across regions further amplifies its importance as a driver. In the Inland/Desert region, most customers already have AC, so heat pump HVAC largely acts as an AC efficiency upgrade. Installing one million such projects with a 90/10 split between customers with and without preexisting AC would reduce summer evening peak demand by more than 300 MW.

In contrast, in cooler Coastal/Northern regions, a higher share of projects is in homes without prior AC, so electrification tends to add summer peak load, even as it reduces gas use and improves comfort.

These differences cannot be managed by limiting certain technology types; they emerge only when site characteristics like existing AC status are measured and analyzed.

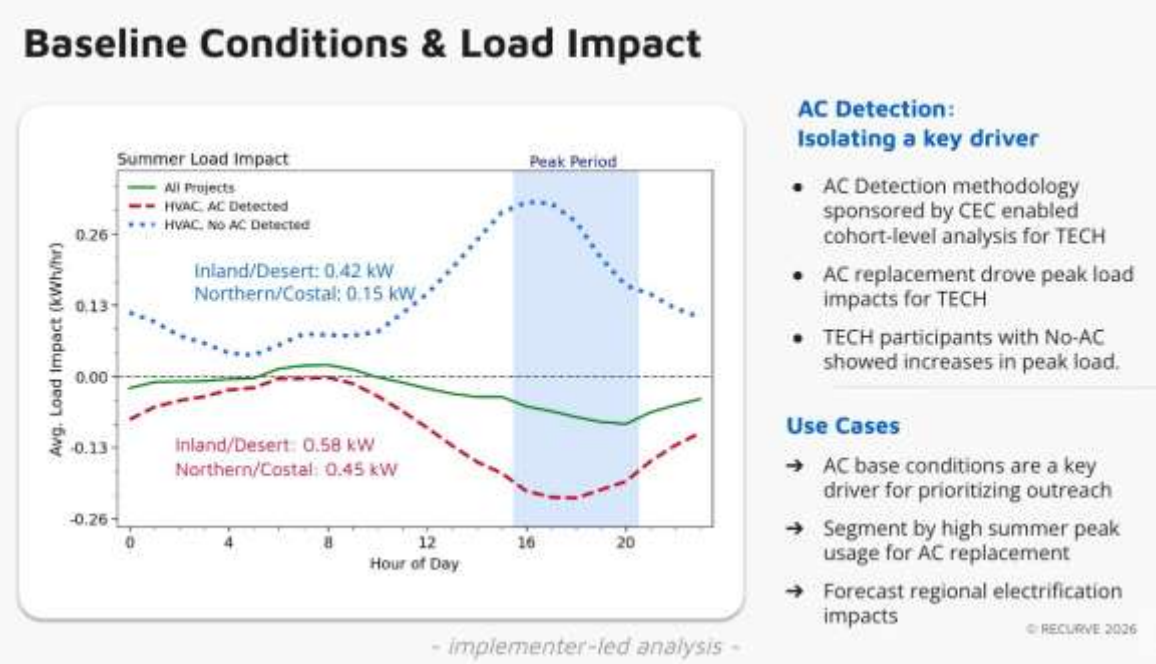

Figure 11: Baseline Conditions and Load Impact.[151]

[151] Recurve. Scheer, Adam. 2025 ACEEE Hot Water & Air Forum Presentation "Measured Impacts of TECH Heat Pump Installations". March 6, 2025. https://drive.google.com/file/d/1oju5s-S4zltvkv5rzDFuDu6k3ftKujPT/view

F.4 Why Site Granularity Is Essential for Program Optimization

As illustrated in this one example, the presence or absence of AC so strongly shapes outcomes that site granularity is not a "nice to have"; it is a prerequisite for designing responsible, scalable electrification portfolios.

Specifically, site data enable programs to:

- **Differentiate core use cases**. The same "heat pump HVAC" measure represents either a fuel switch plus efficiency upgrade (AC Detected) or a fuel switch plus comfort and service expansion (No AC Detected). Treating them as a single category obscures critical differences in peak impacts and bill risk.
- **Target high-value, low-risk segments**. With meter-based driver analysis, programs can prioritize replacement projects in regions where summer peak relief is most valuable and identify homes where added cooling can be delivered with manageable bill and capacity impacts.
- **Feed multivariate optimization and scoring** by understanding the underlying drivers and the relationships between drivers of program outcomes.

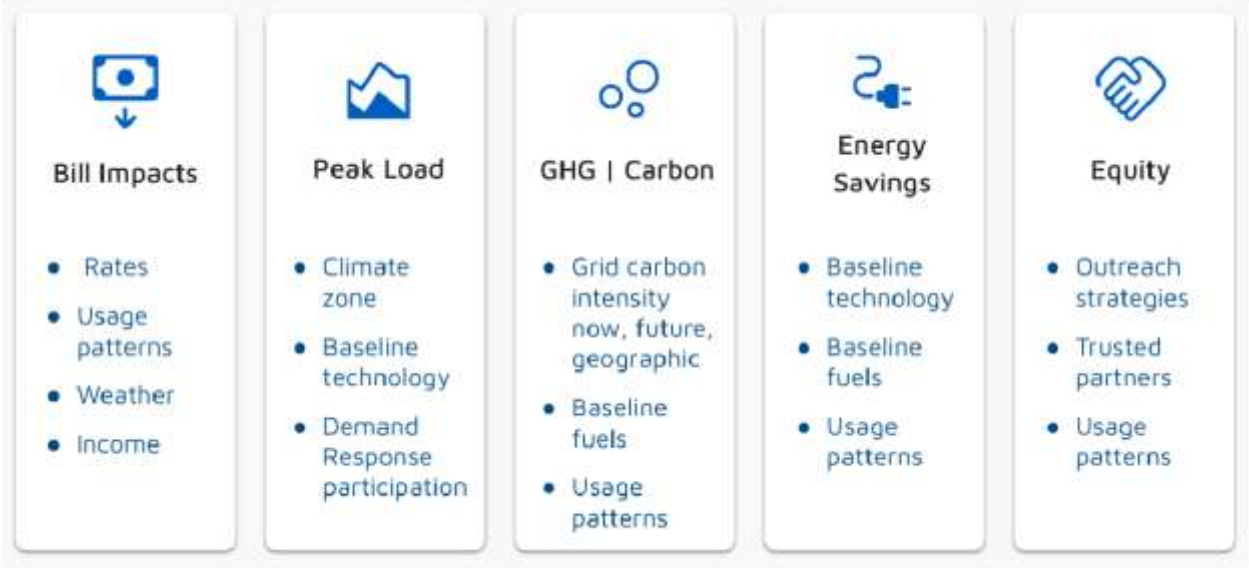

Figure 12: Factors to include in site descriptions.

Driver analysis provides critical insights into how to achieve program goals for grid support, GHG, and bill outcomes. Site-level granularity is indispensable for managing affordable electrification to maximize value and advance affordability and equity.