Opinion Dynamics

TECH CLEAN CALIFORNIA PILOTS AND QUICK START GRANT EVALUATION

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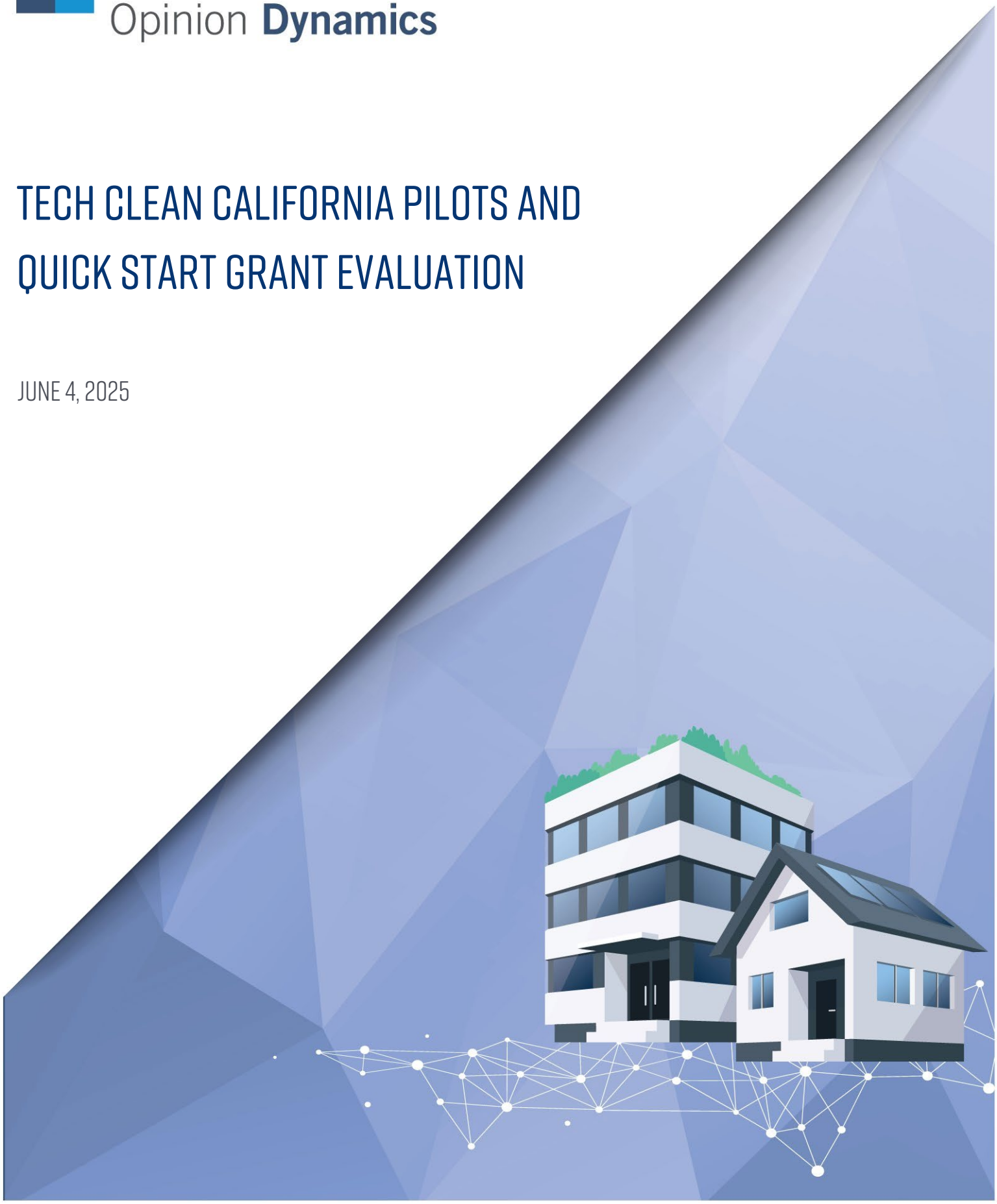

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I. EXECUTIVE SUMMARY

The Technology and Equipment for Clean Heating (TECH) Clean California Initiative was developed in response to Senate Bill 1477, passed in 2018. TECH Clean California is designed to advance the state's market for low-emission space and water-heating equipment for existing residential buildings. As stated in D. 20-03-027, the decision "Establishing Building Decarbonization Pilot Programs," the initiative is a building decarbonization pilot program "intended to raise awareness of building decarbonization technologies and applications, test program and policy designs, and gain practical implementation experience and knowledge necessary to develop a larger scale approach in the future."[1]

An element of the TECH Clean California Initiative is its pilots. There are seven pilots, although the seventh pilot is composed of 19 smaller Quick Start Grant (QSG) projects. Energy Solutions, the overarching TECH Initiative implementer, intended the pilots to run in parallel with and leverage TECH incentives for heat pumps and the market momentum generated by incentive-driven heat pump purchases. Energy Solutions partnered with VEIC as the main pilot implementation partner. Pilots 1 through 6 are large-scale projects requiring multi-year efforts and sustained support from dedicated teams of subject matter experts and program implementers. Energy Solutions chose these six pilots because they address structural barriers to heat pump adoption, involve a local or utility partner, and have a long-term strategy for scaling up or transitioning to another funder. These pilots were included in Energy Solutions' bid for the TECH implementation contractor. The QSGs were selected through two different public bid competitions included to produce a portfolio of small, local, and grassroots projects. Regardless of their size, Energy Solutions and its implementation partners intend the pilots and QSGs to help overcome market transformation barriers for heat pumps in California.

Opinion Dynamics is the independent evaluator for TECH Clean California, researching program impacts, market effects, policy developments, and technology advances alongside TECH Initiative implementation. Opinion Dynamics sought to evaluate the pilots as a strategy within the TECH Initiative, rather than the individual pilot projects themselves. Our evaluation objectives were to determine the extent to which the pilots have contributed to meeting TECH's goals and the extent to which VEIC successfully implemented the pilots. Opinion Dynamics completed a mixed methods evaluation of the pilot strategy, pulling from primary and secondary data sources. Primary data collection included interviews with oversight staff at VEIC and Energy Solutions and the Pilot teams themselves. We also conducted a brief survey of QSG team members. Secondary data encompassed data gathered by VEIC and Energy Solutions, such as spending summaries, quarterly reports, final reports, and a few internal documents.

The evaluation questions guiding this study were:

1. How did the pilots contribute to the goals of the TECH Initiative?
    a. What lessons were learned?
    b. What happens next to the pilots? Do the strategies become implemented into TECH? What impact can they have if scalability is determined to be worthwhile? Or, are there still key barriers in the way of scaling up successful pilots?
    c. Are the pilots and QSG program a worthwhile implementation strategy?
2. Did VEIC successfully implement the pilots and QSG program?

[1] https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M331/K772/331772660.PDF

d. How effective was the QSG solicitation process?

e. Were pilots implemented as intended? If not, were the adjustments appropriate and worthwhile?

f. Were the conclusions and lessons learned from the pilots collected and articulated? How were the conclusions and lessons learned disseminated?

KEY FINDINGS

- Pilot and to a limited extent QSG implementation occurred at a slower pace than planned, with many external factors like regulatory delays (lengthy timelines for CPUC decisions to be issued during regulatory proceedings), changing policies (a new CPUC program), and inconsistent incentive availability slowing pilot activities. Pilots adjusted their activities and scopes in response to such challenges. Although the TECH Initiative intended for all pilots to conclude by December 2023, four pilots were still ongoing (whether implementing activities or writing final reports) as of February 2025. In addition, two QSGs had not yet completed reporting by February 2025.
- Pilot efforts aligned well with TECH Initiative goals: each pilot and QSG carried out heat pump installations, barrier removal approaches, and/or research that could assist the TECH Initiative's market transformation efforts.
- Pilots and QSGs made three main contributions to California market transformation for heat pumps (Figure 1):

Figure 1. TECH Pilot Contributions

These contributions generated complementary but unique findings about market barriers, solutions (approaches to removing market barriers), and heat pump operation, performance, or installation. As such, the pilot strategy avoided redundant work across its 25 projects.

- Two QSGs failed to complete their implementation, with virtually no information about one of the failed projects available to the public.
- Pilot and QSG teams were positive about management practices and support levels provided by VEIC, the pilot strategy implementer.

CONCLUSIONS AND RECOMMENDATIONS

- Conclusion: As a strategy, the pilots have provided many lessons learned, potentially valuable information, and useful data to support TECH Initiative goals. However, the lack of detailed information about implementation challenges and inconsistent inclusion of evidence to back up accomplishments claimed in pilot and QSG reports and other documentation are missed opportunities to provide insights for course corrections, program improvements, and scaling plans.

- **Recommendation:** Continue producing briefs, case studies, and other media that distill and share key learnings and findings from pilots and QSGs, but also support VEIC in documenting comprehensive and cross-cutting information about the pilots and QSGs through more detailed final summary reports and other feasible means. These summary reports should be specific enough that TECH Initiative and other program staff can take concrete actions for both new and existing programs. Identify any information gaps regarding what the QSGs learned, including from the two failed QSGs, as the lack of information from these important experiences limit the lessons learned and implementation of beneficial adjustments in other projects. If needed, conduct additional interviews or outreach with the QSG teams to gather more detailed information so VEIC and Energy Solutions staff have a complete picture of what to continue and what to modify going forward. Consider compensating QSG team members for their time spent addressing these information gaps.
- **Recommendation:** Our current understanding is there will be additional QSG funds for 3-5 existing QSGs to scale up (the third cohort). For these scale-up fund recipients, increase the amount of data and evidence QSGs must include in their reports to back up their claims. Require that QSG reports clearly distinguish between information the QSG teams had in advance of the grant and information gained by grant implementation. Ensure that QSG reports are detailed enough to provide actionable insights to other stakeholders.
- **Recommendation**: Given their long timeframes, augment the distribution of information, findings, and lessons learned from the six large-scale pilots as they are ongoing, rather than using their final reports as the primary means of public dissemination. Periodic dissemination beyond the TECH Initiative team and CPUC stakeholders aligns with the spirit of TECH Initiative Goal 3 and may accelerate market transformation by making vital information accessible to more people and organizations who support decarbonization. Mechanisms for dissemination to the broader public could include webinars, videos, articles, or other media that make clear what pilots are accomplishing and learning as they go. Key considerations for dissemination are depth of detail so that another similar team could learn from or replicate something the pilot is doing, and availability. Information stored behind gatekeepers, like conference presentations, should also be posted to easily located public places, like the pilot webpages on the TECH Clean California website.

- Conclusion: Some of the tested approaches have begun to scale, but the degree of scaling isn't yet clear, and success isn't guaranteed given changes in the national policy and funding landscapes.
  - **Recommendation**: Create a framework or plan for scaling promising approaches uncovered by the pilots. Dedicate resources to their expansion, including by vehicles outside of the TECH Initiative such as CalNEXT, CalMTA, and the nascent California Heat Pump Partnership. Look for and, if needed, eliminate redundancies across programs. For scale-up grant recipients, clearly define which approaches are expanding and the reasons behind their expansion. Study the scaling results and improve the approaches iteratively. Direct resources to areas with lower heat pump adoption, such as Southern California. Ensure that scale up activities support the removal of market barriers to further market transformation.
- Conclusion: The market barriers facing households in Disadvantaged Communities (DACs), including limited access to capital and the substantial remediation needs of housing stock for electrification, are deeply entrenched and difficult to overcome. Although pilot projects and QSGs have demonstrated some small-scale solutions to address these challenges, they have yet to provide a clear pathway for scaling these efforts to larger markets. Activities such as funding building remediation projects, which are critical to addressing these issues, currently lack the necessary long-term and robust funding streams required for widespread implementation. This underscores the need for sustainable financial mechanisms and policy frameworks to overcome these persistent barriers and support the broader electrification of households in DACs.

- **Recommendation**: To the extent feasible with available resources, TECH Clean California should prioritize forming long-term partnerships with additional funders who can continue to address market barriers in DACs. At the same time, TECH Clean California should focus on continuing to evolve their equity-driven market strategy to include more tactics than rebates and funding building remediations residence by residence, as such activities may be unsustainably expensive and limited to benefiting direct recipients rather than removing market barriers at the scale needed to meet California's decarbonization goals.

- Conclusion: The evaluation team lacks sufficient evidence to determine if the large-scale pilot strategy is worthwhile because four of the large-scale pilots have not yet produced their final reports and information about their learnings and successes is thus not yet widely distributed. However, the completed pilots generated useful data and information for furthering market transformation and the ongoing pilots show potential to do the same.
  - **Recommendation**: Assess the value of the pilot strategy when all pilots have concluded. Consider the value of the knowledge, data gained, and scaling potential compared to the cost and time needed to carry out the pilots. Also, the CPUC may opt to define reasonable expenses for pilots and QSGs and require VEIC and Energy Solutions to adhere to the definition in future efforts.
- Conclusion: The QSGs in particular may provide more strategic value in the near-term given their fast pace, quick results, and low cost.
  - **Recommendation**: If the TECH Initiative receives additional funding to support a new cohort of QSGs, dedicate resources to identifying additional organizations that could carry out QSGs in areas that have lacked QSG applicants to date. Consider if successful QSG organizations could partner with new organizations to cross-pollinate ideas and support implementation of QSGs in new geographic areas.
- Conclusion: VEIC effectively implemented the pilot strategy, with the majority of interviewed and surveyed respondents pleased with their management and support.
  - **Recommendation**: Document lessons learned about overall pilot strategy management and implementation. Include feedback from this report in continuous improvement processes and work with Energy Solutions to adjust oversight processes as needed.

2. INTRODUCTION

The Technology and Equipment for Clean Heating (TECH) Initiative[2] was developed in response to Senate Bill 1477, passed in 2018. The TECH Initiative is designed to advance the state's market for low-emission space and water-heating equipment for existing residential buildings. As stated in D. 20-03-027, the decision "Establishing Building Decarbonization Pilot Programs," the TECH Initiative is a building decarbonization pilot program "intended to raise awareness of building decarbonization technologies and applications, test program and policy designs, and gain practical implementation experience and knowledge necessary to develop a larger scale approach in the future."[3]

The TECH Initiative's overall objective is full-scale market transformation of the heat pump market in California to ensure a thriving market for clean heating technologies. The Decision also goes on to state that "market development initiatives involve phases that require development and testing of strategies and approaches to arrive at impactful market intervention efforts." The Decision gives the TECH implementer flexibility to determine and test specific tactics while also addressing the statutory mandates in SB 1477. In March 2020, the CPUC directed its administrator, Southern California Edison (SCE), to conduct a request for proposals for the TECH implementer. In November 2020, SCE/CPUC selected Energy Solutions and its team of subcontractors as the TECH Initiative implementer.

The TECH Initiative has three goals aligned with its overall objective (Figure 2):

Figure 2. TECH Initiative's Three Main Goals

Source: https://techcleanca.com/

Market transformation programs like TECH Clean California are distinct from traditional energy programs in that they focus on removing market barriers to adoption rather than simply subsidizing the purchase of equipment. While rebates and incentives are often part of market transformation programs, they are typically short-term tactics to address the barrier of high purchase price, while other longer-term tactics ameliorate additional market barriers preventing

[2] https://techcleanca.com/

[3] https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M331/K772/331772660.PDF

widespread adoption, such as a lack of equipment availability, consumer lack of awareness, or shortage of trained installers. A key distinction between market transformation and traditional energy programs is that the impacts of market transformation are more diffuse. There is rarely a direct, one-to-one relationship between a specific program activity and the installation of a particular piece of equipment, like a heat pump. For example, a training program may directly teach a set number of installers the best practices for installation, but those trained installers can then pass on their knowledge to others—expanding the program's impact well beyond its initial reach. This process of indirect knowledge diffusion is a core goal of market transformation programs, which are designed to scale up and create broader, more sustainable changes across the entire market.

2.1 OVERVIEW OF THE TECH PILOTS

The regional pilots referenced in Goal 2 of Figure 2 (hereafter, "pilots") are the focus of this evaluation report. Energy Solutions intended the pilots to run in parallel to and leverage TECH incentives for heat pumps and the market momentum generated by incentive-driven heat pump purchases for HVAC heat pumps and heat pump water heaters (HPWHs). Energy Solutions devised seven pilots as part of its proposal to the California Public Utilities Commission (CPUC). As of February 2025, these pilots' goals were to:

1. Inclusive Utility Investment (IUI) Finance Pilot (ongoing): Develop and launch a tariff-on-bill financing mechanism, testing design, consumer adoption, measurement and verification methodologies, etc.
2. Low-Income Heat Pump Adoption Pilot (ongoing): Document building and panel upgrade needs and fund building remediations in concert with existing low-income programs.
3. Multifamily Pilot (ongoing): Fund multifamily building remediations, study central Heat Pump Water Heater (HPWH) system installations, and develop tools and processes to promote whole building electrification plans for individual buildings and building portfolios.
4. Market Readiness for HPWH Load Shifting Pilot (complete): Study and develop recommendations for engaging with contractors about grid interactivity like demand response, and propose a new definition of HPWH upsizing.
5. Streamlining Permitting and HPWH Installation Pilot (complete): Study HPWH permitting practices and develop training materials in support of safe and effective HPWH permitting.
6. Innovative Customer Targeting Pilot (ongoing): Develop a data dashboard to identify customers with high electric savings potential and test messaging to targeted customers.
7. Quick Start Grants (QSGs; ongoing): Develop a competitive solicitation process and deploy a portfolio of small-scale heat pump projects.

Pilots 1 through 6 are large-scale projects requiring multi-year effort and sustained support from dedicated teams of experts and implementers. Energy Solutions chose these six pilot topics because they address structural barriers to heat pump adoption, involve a local or utility partner, and have a long-term strategy for scaling up or transitioning to another funder. Energy Solutions' decision making about the pilot topics was informed by a review of extant research and approximately 45 interviews with market actors working in electrification completed before the firm was awarded the TECH Initiative contract. The collection of interviewed market actors included individuals from utilities, equipment manufacturers and distributors, contractors, trade-skill educators and trainers, and clean energy financiers. Pilot funding was complex, sometimes braiding multiple non-TECH funding streams. As of December 2024, actual Pilot spending of TECH funds ranged from approximately $400,000 for the Innovative Customer Targeting Pilot to $5.5 million for the Low-Income Heat Pump Adoption Pilot.

Pilot 7's Quick Start Grants (hereafter, "QSGs") were selected through two public, competitive solicitations and were smaller in scale, resulting in a portfolio of local, more grassroots projects. Cohort 1, selected in 2021, garnered 11 projects from a pool of 35 applicants. Cohort 2, selected in 2022, resulted in 8 projects from 31 applicants. Cohort 1's solicitation was brief, occurring in September 2021. For Cohort 2, VEIC kept the solicitation window open for all of June and July in 2022. Target areas for the QSGs were:

- Scalable project finance solutions.
- Initiatives serving low-income households, disadvantaged communities, hard-to-reach customers, environmental and social justice communities, households with high energy burdens, multifamily buildings, or renters.
- Approaches that support whole home electrification.
- Innovative outreach, marketing, service delivery strategies, or business models.
- Projects that demonstrate ways to reduce total installed project costs.
- Demonstration of emerging technologies with potential to scale.
- Projects that test strategies to improve the customer or installer experience.
- Programs that can influence purchasing or management decisions for large groups.

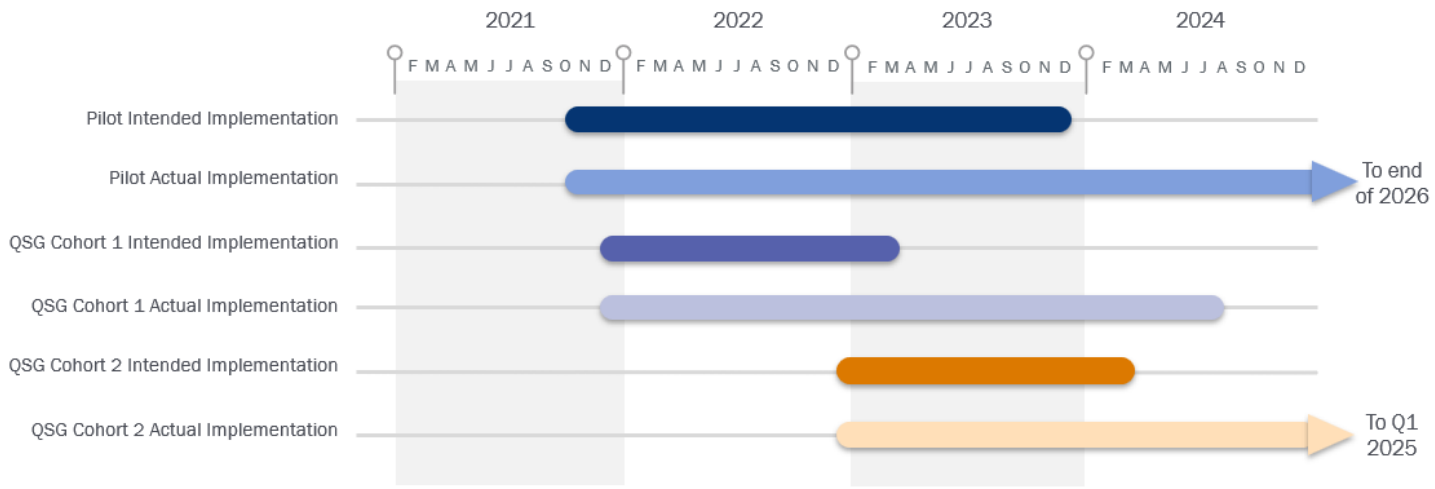
In late 2024, VEIC proposed a third cohort of QSGs dedicated to scaling up QSGs from the first two cohorts.[4] If funded, VEIC would select Cohort 3 QSGs via a closed solicitation limited to past grantees who either continue their existing QSG project or extend the lessons learned from that project. If enacted, the third QSG cohort will also include grants for secondary data analysis of TECH data and Clean Energy Access (CEA) Grant applicants who were unable to be funded by the state CEA Grant Account funding opportunity after its cancelation. VEIC proposed 3-5 grants totaling $1,000,000 to scale up prior QSG projects; $250,000 total for 3-5 secondary research projects; and $500,000 total for at least 3 CEA projects.

Although they were intended to be completed by 2023 (pilots) and 2024 (QSGs), pilot implementation unfolded more slowly and with more delays than anticipated. As of February 2025, four pilots were still implementing and two QSGs[5] had not yet published their final reports. We explain implementation delays in detail in the next chapter. Figure 3 shows the implementation timeline for the pilot strategy from 2021 to the end of 2024.

[4] Seel and Kirwan, *QSG Pilot Implementation Plan*.

[5] The QSGs that had not published their reports by February 2025 are Scaling Heat Pump Retrofits in Housing with Cost Barriers implemented by Climate Resolve and the US Green Building Council-LA, and Installation and Testing of Heat Pump Water Heating in Manufactured Housing implemented by AESC.

Figure 3. TECH Pilots and QSGs Timeline through 2024



Despite these relatively short implementation timelines, Energy Solutions intended the pilots to test market transformation activities that could be scaled up within TECH or by other funders or initiatives. In contrast, full scale market transformation programs generally encompass many different activities and take multiple years, even decades, to move entire markets to new products or practices. As such, Energy Solutions, VEIC, and collaborators designed the pilots to offer proof-of-concept rather than to achieve market transformation results at scale by the end of 2024.

3. EVALUATION METHODS

Opinion Dynamics sought to evaluate the pilots as a strategy within the TECH Initiative, rather than the individual pilot projects themselves. Our evaluation objectives were to determine the extent to which the pilots have contributed to meeting TECH's goals and the extent to which VEIC successfully implemented the pilots. Opinion Dynamics completed a mixed methods evaluation of the pilot strategy in March of 2025, pulling from primary and secondary data sources collected through February 2025. Primary data collection included interviews with oversight staff at VEIC and Energy Solutions and the pilot teams themselves, as well as a brief survey of QSG team members. Secondary data encompassed data gathered by VEIC and Energy Solutions, such as spending summaries and quarterly reports, as well as final reports. In all, the evaluation team reviewed 91 documents. The evaluation questions and related data collection methods follow in Table 1:

Table 1. Evaluation Questions and Data Sources

Evaluation Question	VEIC & Energy Solutions Interviews	Pilot Team Group Interviews	QSG Survey	Secondary Data
1. How did the pilots contribute to the goals of the TECH Initiative?	X	X	X	1. Pilot Reports 2. Guides and Resources Produced by Pilots 3. VEIC Subcontract with Energy Solutions
a. What lessons were learned?	X	X	X	1. Pilot Reports 2. Internal Program Memos and Reports
b. What happens next to the pilots? Do the strategies become implemented into TECH? What impact can they have if scalability is determined to be worthwhile? Or, are there still key barriers in the way of scaling up successful pilots?	X	X	X	1. Pilot Reports 2. Internal Program Memos and Reports
c. Are the pilots and QSG program a worthwhile implementation strategy?	X	X		1. Pilot Reports 2. TECH Website Web Analytics Data 3. Spending Data
2. Did VEIC successfully implement the pilots and QSG program?	X	X	X	1. Pilot Reports 2. Grantee Reports 3. TECH Website Web Analytics
a. How effective was the QSG solicitation process?	X			Proposal Review Documents
b. Were pilots implemented as intended? If not, were the adjustments appropriate and worthwhile?	X	X	X	1. Pilot Reports 2. Pilot Implementation Plans 3.VEIC Subcontract with Energy Solutions

Evaluation Question	VEIC & Energy Solutions Interviews	Pilot Team Group Interviews	QSG Survey	Secondary Data
c. Were the conclusions and lessons learned from the pilots collected and articulated? How were the conclusions and lessons learned disseminated?	X	X	X	1. TECH Website 2. Pilot Reports 3. Pilot Webinars 4. Dissemination Documentation

There are some significant limitations to the secondary data analyzed for this report. The amount of data available varied significantly across pilot projects, as some were still ongoing and thus had not yet produced a final report by February 2025. Final reports were an especially valuable data source, as they were the only documents showing the full breadth of pilot activities, challenges, and accomplishments. The six large-scale pilots also produced quarterly reports. Since QSGs did not produce such interim reports, we had very little data or information about the two QSGs that were still ongoing as of February 2025. Also, two QSGs did not complete implementation and did not produce public final reports. VEIC drafted internal reports about these QSGs, one of which was available to the evaluation team in time for inclusion in this report. Additionally, QSG final reports were generally short and differed widely in their level of detail; some reports offered only high-level takeaways without providing supporting evidence or data to back up their claims. Occasionally, QSG reports seemed to blur learnings from TECH-funded activities and knowledge already possessed by QSG teams. Some reports did not clearly document the type or number of materials produced or the extent to which work was completed in conjunction with other programs or funding streams. Finally, market transformation activities typically require years before generating measurable outcomes; unsurprisingly, the pilots and QSGs report many valuable outputs but few true market transformation outcomes. Future evaluation efforts could include further analysis of dissemination, scaling, and outcomes to better understand the pilots' impacts over time. The current evaluation does not include data sources that would be ideal for that, such as interviews or surveys with policymakers or program staff outside of TECH Clean California who could attest to the pilots' influence on their efforts to promote heat pumps.

For primary data, the evaluation team completed interviews with members of each of the six large-scale pilot teams, six key VEIC oversight staff, and two key Energy Solutions staff members accountable for the pilot effort. We completed two rounds of interviews: one in October 2024 and one in January 2025. We also invited all members of the QSG teams to complete the QSG survey during January and February 2025; 14 people representing 12 QSG projects responded to the survey. As is standard practice, the evaluation team assured confidentiality for all surveyed and interviewed respondents. Table 2 shows the sample frame and achieved response rates for the interviews and survey.

Table 2. Primary Data Collection

	Pilot/QSG Sample Frame	Pilot /QSG Respondents	Pilot/QSG Response Rate	Individual Sample Frame	Individual Respondents	Individual Response Rate
Large-scale pilot team group interviews	6	6	100%	47	23	49%
VEIC key oversight staff interviews	N/A	N/A	N/A	7	6	86%
Energy Solutions key pilot staff interviews	N/A	N/A	N/A	3	2	67%
QSG team member survey	19	12	63%	40	14	35%

Opinion Dynamics' analysis comprised of qualitative analysis of all interviews, open-ended survey items, and secondary data sources using NVivo qualitative analysis software. To promote consistency, a single evaluation team member completed all analyses for this evaluation. The analyst utilized a limited set of *a priori* codes informed by the evaluation questions (for example, a code to capture lessons learned) as well as emergent codes to capture themes and patterns arising within and across data sources. In addition, the analyst tabulated quantitative survey data using Excel. When possible, the findings and themes were drawn from multiple data sources (i.e., triangulation across interviews and surveys). Finally, because the evaluation was of the pilots *as an overall strategy* rather than an evaluation of the individual pilot projects, our analyses aggregate findings across the pilots and QSGs. Aggregating information across pilots also helped to ensure the confidentiality for the relatively small number of primary research respondents. By design, we do not compare the specific pilot or QSGs because we are not attempting to assess their individual merits, strengths, or weaknesses, but rather providing overarching strengths and weakness given the sum of their activities to date. We invite curious readers to explore the pilot and QSG final reports, which are public documents.[6]

[6] The large-scale pilot reports and other documents are posted at https://techcleanca.com/pilots/. The QSG reports and other documents are posted at https://techcleanca.com/quick-start-grants/.

4. FINDINGS

In this chapter, we consider the implementation of pilots and QSGs separately, examining the challenges they faced and how their plans evolved. Next, we document their lessons learned, followed by contributions to the TECH Initiative, including results, dissemination, and scaling to date. We conclude the chapter with a summary of the effectiveness of the pilots as a strategy.

4.1 IMPLEMENTATION

The evaluation questions, "Were pilots implemented as intended?" and "If not, were the adjustments appropriate and worthwhile?" guide our examination of pilot and QSG implementation below. We consider the large-scale pilots first.

4.1.1 LARGE-SCALE PILOTS

In this section, we describe how the six large-scale pilots unfolded and the factors that influenced their implementation. As mentioned above, the six large-scale pilots were devised by Energy Solutions as part of their implementation of the TECH Initiative overall and did not include a separate application/selection process. Table 3 provides an overview of each of these six large-scale pilots. VEIC acted as Energy Solutions' program implementer for all six pilots. VEIC formed six unique pilot teams composed of a VEIC staff member plus staff from selected organizations with direct subject matter expertise, on-the-ground experience, and/or strong community relationships that were needed to address the pilot's priority market barriers. The VEIC staff member served as the pilot lead; VEIC selected these pilot leads for their subject matter expertise. Additionally, a small number of VEIC staff members served in an oversight role, working to ensure consistency across the pilots. They offered guidance and supported communication between the pilot team, Energy Solutions, and the CPUC.

Table 3. TECH Pilots Overview

Pilot	Team Member Organizations	Partners	Primary Barriers Targeted	Primary Goals	Primary Strategies
IUI Finance	▪ VEIC ▪ Energy Solutions ▪ Ardenna Energy ▪ Frontier Energy	Silicon Valley Clean Energy (SVCE)	Lack of access to capital for decarbonization.	Expand customer access to capital for clean energy investments, including those typically disqualified due to high debt-to-income ratios, poor credit, low home equity, or renter status.	▪ Create a Tariff on Bill (TOB) financial mechanism that can be applied statewide. ▪ Test a modified financial mechanism in SVCE service territory. ▪ Research and analysis on ways to quantify risk; refine energy savings prediction models; measure, capture, and monetize grid benefits; support risk mitigation and consumer protection.
Low Income	▪ VEIC ▪ The Ortiz Group ▪ Energy Solutions	▪ Pacific Gas and Electric (PG&E) and	▪ High upfront costs for heat pumps.	Test strategies to overcome economic and structural barriers	▪ Create a Low-Income Ambassador Panel to

Pilot	Team Member Organizations	Partners	Primary Barriers Targeted	Primary Goals	Primary Strategies
		Southern California Edison (SCE) San Joaquin Valley Disadvantaged Community Pilot ▪ PG&E Energy Savings Assistance Program (ESA) ▪ Southern California Edison (SCE) ESA Program ▪ SCE ESA Building Electrification Program	▪ Increased electric bills from electrification. ▪ Expensive home remediation needs to enable electrification. ▪ Lack of decarbonization workforce in low-income areas. ▪ Diversity of California languages and cultures. ▪ Structural inequities.	to decarbonizing low-income households, disadvantaged communities, and hard-to-reach households.	inform program decision making. ▪ Partner with existing low-income programs to augment the households they can serve. ▪ Fund building repairs and infrastructure that enable electrification but aren't covered by the other programs. ▪ Document needed panel upgrades and building remediations. ▪ Train contractors and contractor trainers.
Multifamily	▪ VEIC ▪ AEA ▪ Energy Solutions	N/A	▪ Lack of familiarity with decarbonization technologies. ▪ Limited access to capital. ▪ Higher incremental costs for decarbonization technologies. ▪ Larger scope for electrification projects due to infrastructure needs.	▪ Increase market familiarity with decarbonization technologies. ▪ Increase building owner and design team capacities to plan for and carry out electrification projects.	▪ Provide technical support for central HPWH installations. ▪ Monitor central HPWH installations pre/post. ▪ Create property-level, phased plans for full electrification. ▪ Provide portfolio owners with "roadmaps" for electrifying their portfolios. ▪ Create education and training materials. ▪ Fund building repairs and infrastructure that enable electrification but are not covered by the other programs.
HPWH Load Shifting	▪ VEIC ▪ Energy Solutions ▪ Recurve ▪ AEA ▪ Frontier Energy	▪ PG&E WatterSaver program ▪ BayREN HPWH Incentive Program ▪ Self-Generation Incentive Program (SGIP) HPWH Program	▪ Contractor lack of awareness about the benefits and value proposition of load shifting. ▪ Consumer privacy, security, and performance concerns with grid-connected HPWHs.	▪ Increase contractor familiarity and comfort with load shifting and Demand Response (DR). ▪ Increase DR program enrollment during the HPWH sales process.	▪ Incentivize thermostatic mixing value (TMV) installations and DR program enrollment. ▪ Train contractors about DR, HPWH load shifting, and new SGIP HPWH Program requirements. ▪ Conduct research on TMVs, HPWH upsizing, energy impacts, and barriers to DR participation.

Pilot	Team Member Organizations	Partners	Primary Barriers Targeted	Primary Goals	Primary Strategies
HPWH Permitting	▪ VEIC ▪ Frontier Energy ▪ Energy Solutions ▪ Recurve	▪ City of Pleasant Hill ▪ BayREN	Slower permitting for HPWHs than natural gas water heaters.	▪ Facilitate adoption of a single day permitting process for HPWHs. ▪ Increase building department staff understanding of heat pump water heater installation best practices.	▪ Study permitting processes and analyze permitting data. ▪ Produce permitting resources and educational and reference materials for building department staff and contractors.
Customer Targeting	▪ VEIC ▪ Energy Solutions ▪ Recurve ▪ Building Decarbonization Coalition	SCE	▪ Customers who electrify may increase their energy bills. ▪ Contractors and utilities do not have methods to identify customers who could save on their energy bills or reduce their greenhouse gas (GHG) emissions the most by switching to decarbonized technologies.	Test whether meter data analytics can identify households with the greatest likelihood of saving money and energy when installing a heat pump or otherwise electrifying.	▪ Create an interactive data dashboard to identify customers with the highest propensity to adopt decarbonization technologies and/or will realize the most savings from electrification. ▪ Develop tailored marketing promoting heat pumps to targeted customer groups. ▪ Test customer outreach strategies and analyze customer engagement rates.

Source: Pilot Implement Plans (PIPs) provided by VEIC and Energy Solutions as well as interviews with pilot team members.

Pilot teams had to meet several reporting requirements. Each pilot team created a Pilot Implementation Plan, which they then submitted to the CPUC for review before project initiation. During implementation, each pilot team provided formal quarterly updates on their progress. VEIC and pilot teams periodically presented at CPUC Quarterly Stakeholder Meetings. Also, pilot teams wrote quarterly reports documenting implementation successes, challenges, lessons learned, and adjustments to their original implementation plans in response to experiences in the field. By request from the CPUC, in mid-2024 pilot teams changed to providing higher-level presentation slides about project activities. In addition, pilot teams sometimes presented to CPUC Energy Division staff or contributed to CPUC proceedings. VEIC met with pilot teams on an ongoing basis, but the frequency of meetings shifted from monthly (when little implementation was occurring) to biweekly or weekly (when implementation or dissemination activity was especially busy).

IMPLEMENTATION CHALLENGES

Originally, VEIC staff planned for the pilots to be completed, including the publication of a public report, by December 2023. However, widespread challenges and adjustments resulted in implementation and reporting delays. In fact, only one of the six pilots completed its work in advance of the initial December 2023 deadline and another pilot concluded in November 2024. VEIC expects three more pilots to conclude implementation and reporting during 2025 and the remaining pilot to finish during 2026.

In some cases, pilots' drawn-out implementation was driven by unanticipated obstacles hindering project activities. For example, four pilot teams struggled to identify and recruit participants as quickly as they had planned. One was delayed by the months-long duration of construction planning and construction execution at multifamily buildings, which was compounded by staff turnover at a few of the participating properties. Pilot teams also described many other external factors impeding their work:

- Lack of access to utility and/or CEC data needed for critical analyses (n=3)
- Lack of TECH incentives due to repeated incentive budget exhaustion (n=2)
- Supply chain disruptions from the COVID-19 pandemic (n=2)
- Changed pilot scope due to CPUC directives and/or TECH Initiative changes (n=2)
- Uncertainty about and lengthy timelines for CPUC regulatory decisions (n=1)
- Protracted contracting processes for pilot activities (n=1)
- Lengthy timelines for pilot budget change approvals (n=1)
- Lengthy and detailed review process for proposed project materials to be disseminated to utility customers (n=1)

Interviewees expressed frustration about these external factors. Getting data from utilities or the state was "incredibly cumbersome," according to one interviewee. Speaking about the disappearance of TECH incentives, one person opined that such lack of consistency was itself a barrier to market transformation; another interviewee singled out the lack of stable, long-term, statewide incentive funding as the "biggest challenge" that "continually hamstrung all the pilots." One team whose scope had been changed by CPUC decisions felt the changes forced the pilot into a "one-size-fits-all approach" that "limits innovation and learning." Discussing lengthy timelines for CPUC decisions, another interviewee said that even though the pilots were essentially agents carrying out the work of the CPUC, the process had been "go, go, go, then slow, slow, slow, and then there's no, no, no information" from the CPUC.

In one instance, project delays ended up benefiting a pilot-funded retrofit project when a newly created program made more incentives available, which enabled a more comprehensive retrofit for the participating building when the new incentives were then layered with TECH incentives.

IMPLEMENTATION ADJUSTMENTS

These implementation challenges drove many adjustments to pilot work. During interviews, pilot teams described not only how obstacles slowed them down, but also how they fueled new approaches. For instance, one team recreated a building renovation planning tool it had developed for use by property owners. The team was "pivoting and adjusting to be responsive to this one owner [using the tool]. Trying to get feedback and learn what would be valuable and effective took a lot longer. Once that was in place, then subsequent [tools] took relatively less time." One pilot team tested paying large incentives via progress payments instead of full payment only after installation because smaller contractors struggled to carry installation expenses for large projects.

Three pilots shifted partners over the course of implementation. One moved from engagement with a local partner to statewide engagement after the local partnership failed to provide sufficient heat pump-related activity for the pilot to use. As part of the shift to working statewide, the pilot team also changed the training materials they were developing to make them relevant to multiple jurisdictions. The second explored a partnership with a private energy company but was unable to align with the company on the geographic area in which they would collaborate. The third pilot maintained its

partnership with one utility to test implementation ideas while simultaneously working to support IOUs statewide on related concepts and began exploring a partnership with a public utility district for further idea testing.

One pilot reported significant struggles getting access to data through the state and opted to work with its utility partner to access data through them, instead. Although the pilot team experienced temporary issues transferring the data from the utility, they also reported the utility data came with additional metadata that would not have been available to them via data acquisition from the state.

Three pilots had to repeat work due to changes in the TECH Initiative, such as revising training videos to reflect new programs and changed policies, changing marketing materials once TECH incentives ran out, or pivoting away from working with HVAC once HVAC heat pump incentives were exhausted.

Specific challenges forced four pilots to abandon certain activities altogether:

- One pilot was unable to study the impacts of incentives on adoption rates because TECH incentives were exhausted too rapidly, and then a measure being studied by the pilot became part of a new statewide program;
- One pilot was unable to carry out joint activity with a private energy company when that company decided not to work within the pilot's targeted geographic area, and then later the pilot team halted development of a new contractor tool due to instability in incentive availability;
- One pilot team realized their planned recruitment mechanism was insufficient to continue serving one of their intended target markets; and
- One pilot team learned a program they intended to partner with had incompatible program screening requirements for participating households.

In all four of these cases, the pilots continued the implementation of other activities. For example, when one of their pilot measures went statewide through a new program offering, the team pivoted from studying incentives for the measure to supporting contractors so they would be better able to adjust to the new program guidelines. The evaluation team did not find any instances of inappropriate adjustments to pilot implementation.

Finally, one pilot reduced the number of participants served due to the long timeframe needed for participating construction projects.

4.1.2 QSGS

The intention the QSGs was to "fund localized, vanguard approaches to accelerate deployment of heat pump space and water heating technologies in single-family and multifamily homes."[7] The QSGs predominantly focused on approaches to overcoming heat pump adoption in low-income households and historically underserved populations; the grants afforded the public and small organizations an opportunity to test potentially novel approaches to market transformation for these populations. The QSG Pilot Implementation Plan also stated that an objective of the program was to fund projects that could not be funded through other sources.

VEIC publicized the QSG opportunity via outreach to 23 stakeholder organizations and consulted with these organizations to refine QSG priorities, application requirements, evaluation criteria, payment structures, etc. VEIC also publicized the QSG solicitation through the TECH Clean California listserv, Building Decarbonization Coalition listserv,

[7] Seel, Alison and Desmond Kirwan. *Quick Start Grants Cohort 3 Full Implementation Plan.* VEIC. August 2024.

and public webinars. Per the QSG Pilot Implementation Plan, Cohort 1 QSGs were intended to last 12-16 months and have a $50,000-$250,000 budget. VEIC increased the maximum budget per QSG to $350,000 for Cohort 2. As of February 2025, all 19 QSGs had completed field implementation, including two that were not fully implemented; two of the 19 had not yet published their final reports. Table 9 in the appendix provides an overview of each of the 19 QSGs awarded in Cohorts 1 and 2.

VEIC assigned one to two staff members to assist each QSG team and serve as a subject matter expert. Individual VEIC staff members supported as few as one QSG and as many as eight of them over time. Unlike the larger pilots, QSGs did not have a VEIC staff member as a part of the team. Nor did VEIC require QSGs to produce quarterly reports. VEIC asked "a large part" of Cohort 1 grantees to complete a monthly survey to provide updates, and asked Cohort 2 grantees to document progress and challenges in a collaborative spreadsheet. Almost all surveyed QSG teams reported monthly meetings with their VEIC liaison; two QSG teams said they met biweekly; and one met monthly and then quarterly during different phases of their QSG implementation. In addition, during Cohort 2 implementation, VEIC instituted cross-QSG meetings for different QSG teams to share ideas, think through shared challenges, and offer support to each other through a community of practitioners. As of February 2025, 15 of the QSGs had produced a final report.

IMPLEMENTATION CHALLENGES

Perhaps unsurprisingly, given their smaller scale, only two QSGs experienced lengthy delays in their implementation. One of these projects was delayed due to changing requirements from the U.S. Department of Housing and Urban Development (HUD). According to one interviewee, the project required HUD approval, "had received the green light," and was prepared to implement. Then HUD reneged its permission, sending the project "to a screeching halt" until the team devised a new approach. The project also struggled to recruit participants. The second delayed QSG also struggled to recruit participants and engage building owners, managers, and contractors.

Final reports from the 15 QSGs completed by February 2025 shed light on the many obstacles to their implementation:

- Lack of data from participants, such as downloads of utility bills (n=4)
- Lack of TECH incentives due to repeated incentive budget exhaustion (n=2)
- Restrictions from the COVID-19 pandemic (n=2)
- Cuts to home energy audit rebates (n=1)
- Lack of available home energy auditors (n=1)
- Lack of legal resources/capacity to support green leases (n=1)
- Difficulty recruiting qualified participants (n=1)
- Conflicting program eligibility criteria across "layered" programs (n=1)
- Difficulty communicating with participants or potential participants (n=1)
- High interest rates for building owners stymied ability to pay for retrofits (n=1)
- Inflation driving up the cost of equipment (n=1)
- Uncertainty driven by extreme weather events (n=1)
- Insufficient staff on QSG team (n=1)

- Lack of Wi-Fi access in participant residences (n=1)
- Lack of available electrical outlets for energy use monitors in participant residences (n=1)
- Difficultly getting feedback from stakeholders (n=1)
- Varying levels of expertise across stakeholders (n=1)
- Lengthy review/approval process for participating decisionmakers (n=1)
- Complexity of commercial heat pump installations, which requires coordination across contractors and the work of a design team (n=1)
- Costs incurred to upgrade aged building electrical systems (n=1)

Finally, two of the 19 QSGs failed to complete their grants. Neither of these failed grants published a public, final report and so the challenges they encountered were not as well documented as challenges faced by other projects. VEIC did produce internal reports that identified obstacles that thwarted these failed projects. The evaluation team received one of the internal reports and included it in analysis. This internal report identified a few issues that derailed the grant: a mismatch between the geographic area served by the grantee and its key partner and the area required to be served by the QSG funding stream; scope of work revisions due to the loss of the key partner given the geographic mismatch; staffing changes at the grantee organization; inability to recruit participants; and failure to reach early project milestones. Although the evaluation team was unable to review the internal report about the second failed project, other program documents note the project had "delays caused by staff turnover and difficulties recruiting suitable properties."

IMPLEMENTATION ADJUSTMENTS

As QSG teams implemented and grappled with the aforementioned challenges, they refined their tactics and activities. One project planned to support only HVAC HP installations but added HPWHs given demand for them from the participants and contractors they had recruited. Two projects described changes to their participant recruiting methods, with one project pivoting away from customer-focused outreach to contractor-focused outreach after observing that contractor outreach was more effective and another project shifting from direct marketing to consumers to recruiting through housing rehabilitation programs and housing associations. In the second case, this shift had the added benefit of providing data that could then be used to screen properties for project eligibility and allowed a trusted messenger to communicate with potential new participants.

Changes could be straightforward, like realizing a partner's marketing efforts were sufficient and so no additional marketing budget or activities were needed (n=1) or installing solar, batteries, and HPWHs at the same time to meet project deadlines (n=1). Lack of data resulted in less analytic work than planned (n=4). One team changed its stakeholder feedback process from group meetings to asynchronous review to drum up more participation. Another needed to extend project timelines to accommodate long decision-making timelines in multifamily buildings and manage extensive electrical upgrades needed before heat pumps could be installed. This grant also opted to include a multi-unit HVAC HP system instead of mini-splits in each housing unit to avoid electrical distribution upgrades, reduce outdoor space needed for condensers, and avoid penetrating exterior walls. Two QSGs were unable to implement all of their intended data collection. In both cases, the cost and resources needed to collect data such as water consumption outweighed the value gained by analyses of such data. None of the changes to project plans described in QSG reports or by interviewees were inappropriate.

4.2 LESSONS LEARNED

In this section, we address the evaluation question, "What lessons were learned?" We treat lessons learned as a distinct type of knowledge that reflects information acquired through direct project implementation experiences, as opposed to findings from research or formal study. As such, lessons learned tend to be procedural, administrative, or operational insights gained by the implementing team that could inform future implementation efforts, possibly making them more effective. For example, one QSG team had lessons learned about survey design, which is valuable but distinct from information gained by the actual survey data. We address pilot research findings later in the report.

4.2.1 LARGE-SCALE PILOTS

Pilot teams noted many lessons learned in their quarterly reporting, final reports, and interviews. Interestingly, each pilot generated unique lessons learned—there was no overlap across pilots. A possible implication is that the TECH Initiative successfully designed pilots that were different enough from each other to make unique contributions to knowledge building about market transformation programs for heat pumps. Table 4 summarizes the experiences and related lessons learned shared by pilot teams.

Table 4. Lessons Learned Reported by Pilot Teams

Experience	Lesson Learned
Different stakeholder groups generated unique and oftentimes contradictory feedback	Hold a joint feedback meeting with different stakeholder groups
Energy experts were ill-equipped to create marketing/outreach materials	Add marketing resources, such as a TECH Initiative marketing expert
Inability to download/transfer data to the pilot team	Data permission isn't sufficient to guarantee data access
Various project partners have different branding and engagement requirements	Build relationships with partner marketing staff from the beginning to have all brand guidelines in place; ensure project timelines consider lengthy review timelines for engagement materials
Smaller contractors experienced cashflow problems when carrying out larger installations/upgrades that require long timeframes to complete	Make progress or milestone payments instead of paying only after final installation
Building owners could not obtain detailed data about their properties or energy consumption	Work with owners to determine which data are feasible to include in pilot tools
Market actors had varying levels of knowledge about clean heating technologies	Create materials with different content so market actors can start with educational materials that build from their starting knowledge level
Partners had different ID numbers for customers	Identify the precise ID numbers needed when planning data acquisition/transfer
Making decisions by committee/group vote took more time but improved quality	Balance committee decisions and speed
Regulatory processes took an extended amount of time	Develop plans that allow critical work to continue in parallel to regulatory decision making
Complex retrofits of multifamily buildings required expensive upfront design work	Incentives for large, complex systems should cover upfront design work

Experience	Lesson Learned
Recruiting building owners to participate in pilots was difficult and time consuming	Engage with building owners when upgrades are already taking place to reduce burdening building staff; provide a breath of services to support overburdened building staff; design incentives to compensate for staff time and design activities rather than just equipment; do not rely on referrals from existing programs when trying to recruit owners who aren't being served by such programs; timing of funding drives many electrification projects
External program and policy changes made pilot engagement materials inaccurate or obsolete	Design materials with flexibility/changing information in mind
Scheduling training sessions was difficult because of conflicts with other trainings or commitments on the part of intended participants	Build a list of existing training courses and prioritize them, instead of creating new courses
Getting access to information and decision makers at jurisdiction building departments was challenging	Utilize contacts at Regional Energy Networks to engage jurisdiction decision makers
The pilot team was not legally allowed to share customer gas usage data with a partner electric utility	Ensure data tools include only high-level flags related to gas use, rather than specific data about customer gas use
Many jurisdictions had very few HPWH installations	Analyze HPWH installation data before selecting jurisdictions to partner with for HPWH-related efforts
Pilot activities revealed the pilot's target market barrier wasn't as widespread as believed, nor was the hypothesized solution always supportive of safe and effective installations.	Carry out research to confirm the market barrier(s) first, then design pilot activities to remedy the barriers.

4.2.2 QSGS

The 15 completed QSGs shared the following lessons learned in their public reports (Table 5). In one instance, listed in the first row, two QSGs experienced the same difficulty but took away different lessons from it. The rest of the rows represent experiences noted by single QSGs.

Table 5. Lessons Learned by QSG Teams

Experience	Lesson Learned
Participants did not provide needed data, such as from utility bills (n=2)	Require participants to submit the data upfront as part of project intake documentation (n=1); develop data collection plans that do not rely on participants providing data (n=1)
Unforeseen electrical system upgrades delayed retrofits and increased installation costs	Include an evaluation of property electrical systems in project feasibility studies
Contractors and technicians needed extra time and support to configure phones and tools for remote support	Provide a live, virtual support session to help contractors/technicians get set up

Experience	Lesson Learned
Experts or stakeholders were busy and struggled to attend feedback meetings	Gather feedback by independent document review; consolidate feedback into a single shared spreadsheet for evaluation; use a transparent process that explains how decisions about the use of feedback are made
Experts or stakeholders disagreed about the level of detailed needed in project documents	Explain the target level of detail and purpose for the documents to build clarity about document content
Small, rural contractors had low profit margins and a smaller, dispersed customer base	Rebate programs must be reliable and easy for rural contractors to engage; small contractors engaged when provided flexibility and support navigating rebates
Stacking multiple funding sources made project management challenging—some funder requirements were intricate or even contradictory	Intentionally design the program to take this into account; dedicate staff to meet the different program requirements; provide case management services to project partners and participants to help them navigate the requirements; project partners need to collaborate in communication with participants to reduce misunderstandings or mixed messages
When multiple contractors needed to be involved in a retrofit, homeowners struggled to manage them and were confused about which contractors provided which services	Rely on contractors with multiple trade licenses to minimize the number of firms involved
Competing priorities for decisionmakers at multifamily buildings limited the feasibility of performing multiple concurrent projects	Determine which retrofit projects to pursue at a given property by considering technical feasibility, interest in program offerings, and availability of property stakeholders to develop more than one project at a time
The project team did not have enough time to collect and analyze post-installation utility data from participating units or request utility data from comparison units	Plan additional lead time to collect post-installation data.
The project team served as a designated applicant to submit incentive reservations, which made responsibilities for meeting incentive requirements unclear	Clearly define roles and responsibilities to ensure contractors and project staff understand which party is responsible for meeting program requirements during planning and construction
Participants did not use their equipment effectively	Provide language-appropriate customer education and ongoing support from installation, through maintenance, operation, and repairs
Participating homeowners struggled to keep appointments with contractors and inspectors, and sometimes assumed a project was done before final inspection	Do not assume homeowners will adapt to project requirements simply because upgrades are free; set clear expectations with customers upfront; stagger contractor work to keep homes livable during retrofits; send regular reminders with clear messaging about permit and inspection deadlines
Confusion about and delayed reporting to the project's three funders	Engage project team members responsible for invoicing and reporting early in project design to ensure necessary information and formats are known in advance

Experience	Lesson Learned
Retrofit projects with multiple partners required separate work hours due to liability concerns, which extended timelines and made coordination challenging	Map out the participant journey during program design to plan delivery, streamline documentation and data collection, and identify opportunities for each partner to provide services
QSG grantee staffing constraints forced survey development to occur at the same time as outreach, resulting in late survey administration and missing data	Design participant feedback mechanisms early in the planning process to ensure appropriate timing, inclusion in project workflows, and alignment with project milestones
A participant provided critical feedback about a late equipment installation in a project survey, but the issue raised was beyond the influence of the QSG team	Projects collecting input or feedback from participants should prepare for critical feedback and to connect participants to supportive resources and information, where possible
A participant noted the language barrier between their household and the QSG team made progressing through the project difficult	Provide ongoing multilingual engagement, including flyers, resources, and in-person translation during events and remote support phone calls or emails
Offering customers one service/retrofit/upgrade at a time caused frequent team member or contractor visits to the same household	Provide eligible households with all potential electrification upgrades at once or at least from a single touchpoint with project staff; use a direct-install model with a single contractor handling installation, rebates, permits, inspections, and approvals
Long turnaround times between QSG funding and retrofits increased costs	Include inflation estimates in project budgets
No single community-based organization could gain the trust of diverse communities	Collaboration between community-based organizations allows for creative solutions using the strengths and addressing the weaknesses of individual organizations
Having an interdisciplinary QSG team opened access to additional funding for a multifamily retrofit project	Include members with expertise in engineering, project management, financial management, utility programs, grant writing, and construction/general contracting with experience in central HPWHs; expertise in utility programs, grant writing, and navigating complex incentive structures
Multifamily retrofit stakeholders and decisionmakers had many concerns and questions, and wanted to provide input on a large retrofit project	Provide clear communication with homeowners; incorporate their feedback to increase trust, knowledge and satisfaction; adjust project plans and messaging in line with feedback; provide tours of completed projects; collect pre- and post-surveys; provide information in group and individual settings; be transparent about timeline, potential challenges, and steps that would be taken to deal with project issues

4.3 CONTRIBUTIONS TO TECH GOALS

Implementing projects, even when learning and improving along the way, is necessary but not sufficient for a successful TECH Pilot program. The pilots must also be in the service of meeting the TECH Initiative's goals (Figure 4):

Figure 4. TECH Initiative Goals

Source: https://techcleanca.com/

Below, we assess pilot projects' alignment with TECH Initiative goals and additional pilot results as a strategy.

4.3.1 LARGE-SCALE PILOT AND QSG RESULTS

Here, we explore the evaluation question, "How did the pilots contribute to the goals of the TECH Initiative?" Unlike the preceding sections, we present findings for the pilots and QSGs together because many of their results are similar or complementary; listing them together as a single body of knowledge avoids repetition and illustrates the breadth of topics covered by the pilot strategy as a whole.

All pilots and QSGs aligned with at least one of the TECH Initiative goals. At first glance, the pilots and QSGs would seemingly align with TECH Initiative Goal 2: Demonstrate scalable solutions to key market barriers via regional pilot projects. The majority of the projects—20 of the 25—did, in fact, test or are currently testing at least one approach to removing market barriers. Table 6 summarizes approach testing outputs by market transformation barrier; for simplicity, we grouped similar barriers together. As mentioned above, two QSGs failed to complete their grants; neither was able to test their approaches. Also, 4 pilots and 12 QSGs funded, co-funded, and/or facilitated HP installations, or provided training or training materials about HP installations, thus aligning these projects with Goal 1: Make installing heat pumps easy and accessible for contractors and customers. These projects are **bolded** in Table 6.

Table 6. Pilot and QSG Market Transformation Approach Testing Results

Barriers	Number of Pilots and QSGs	Approaches Tested	Key Outputs
Customer lack of access to capital	▪ 1 pilot ▪ 1 QSG	▪ Statewide TOB financial mechanism ▪ Equipment loans ▪ Green Healthy Home Initiative (GHHI) financing model ▪ Green leases	▪ Published model TOB Design Framework (1 pilot) ▪ Proposed TOB approach which is pending CPUC approval (1 pilot) ▪ Field test of equipment loan began in late 2024 and is ongoing (1 pilot) ▪ GHHI financing model not ready for testing (1 QSG) ▪ Unable to test green leases (1 QSG) ▪ Drafted and revised green lease documents (1 QSG)
Economic and structural barriers for low-income households, DACs, and hard-to-reach households	▪ 2 pilots ▪ 8 QSGs	▪ Partner with low-income programs to augment households they can serve ▪ Fund building repairs and infrastructure to enable electrification ▪ Carry out engagement campaign centered on home assessments in collaboration with partner program ▪ Install HPs in diverse communities ▪ Distribute portable heat pumps and air purifiers to renters	▪ Co-funded repairs, infrastructure, and electrification at about 400 homes (1 pilot) ▪ Recruited ten multifamily properties for heat pump installations and electrification readiness planning, all ongoing (1 pilot) ▪ Completed 47 home upgrades (1 QSG) ▪ Installed HPs in low-income multifamily housing (1 QSG) ▪ Supported ~60 heat pump installations (4 QSGs) ▪ Completed 50 home assessments (1 QSG) ▪ Remediated and electrified 72 homes (2 QSGs) ▪ Distributed 26 portable heat pumps and air purifiers to renters (1 QSG)
Complexity and high cost of central HPWH installations	▪ 1 pilot ▪ 1 QSG	▪ Provide technical support for central HPWH installations ▪ Co-fund central HPWH installations ▪ Develop and text modular, pre-packaged central HPWH ▪ Create training materials	▪ Supported installations, pre- and/or post-install monitoring in ~30 multifamily properties, with work ongoing (1 pilot) ▪ Co-funded and supported a central HPWH install (1 QSG) ▪ Created training tools, including training curriculum, and a central HPWH case study (1 pilot)

Barriers	Number of Pilots and QSGs	Approaches Tested	Key Outputs
Lack of trained heat pump installers/contractors, including in DACs	▪ 3 pilots ▪ 3 QSGs	▪ Train contractors ▪ Train contractor educators/trainers ▪ Create training or educational materials ▪ Create training/QA tools	▪ **Trained 326 heat pump contractors about installations (2 pilots; 1 QSG)** ▪ **Trained over 300 contractors about demand response, load shifting, grid interactivity, etc. (1 pilot)** ▪ **Developed and tested remote training/QA software for smartphones with 37 contractors (1 QSG)** ▪ **Created HPWH best practices manual and job aids (1 QSG)** ▪ **Created recommendations for HPWH sizing (1 pilot)** ▪ **Created thermostatic mixing value training materials (1 pilot)** ▪ **Influenced training content for 3 curricula (1 pilot)**
Large, expensive scope for electrification projects in multifamily buildings	▪ 1 pilot ▪ 2 QSGs	▪ Support electrification of multifamily buildings ▪ Advise building portfolio owners on portfolio-wide electrification strategies with electrification plans (“roadmaps”) ▪ Create education materials	▪ **Recruited 5 building owners to undertake full electrification at a multifamily property, with one 1 install completed (1 pilot)** ▪ Recruited 6 portfolio owners, with work ongoing in 4 (1 pilot) ▪ **Completed electrification project scopes for 16 buildings (1 QSG)** ▪ **Completed technical and economic feasibility analyses for electrification for multi-owner equity community (1 QSG)** ▪ Developed electrification readiness webinar (1 pilot) ▪ Developed educational campaign about heat pump benefits (1 QSG) ▪ **Completed 101 heat pump installations (1 QSG)**
Lack of effective messaging and outreach strategies for DACs	▪ 1 pilot ▪ 2 QSGs	▪ Create, test, and iterate communication strategies and materials	▪ Recruited and trained contractors in DACs to promote retrofits (1 pilot) ▪ Partnered with income-qualified programs to augment their services to DACS (1 pilot) ▪ Developed website, videos, social media posts, as well as in-person visual displays, interactive games, and giveaways to engage and educate diverse community members about heat pumps (1 QSG) ▪ Tested using hazard mitigation/health support as an engagement method (1 QSG)

Barriers	Number of Pilots and QSGs	Approaches Tested	Key Outputs
HPWH permitting and installation is slower than for natural gas WHs	▪ 1 pilot ▪ 1 QSG	▪ Facilitate single-day permitting process for HPWHs ▪ Increase building department staff understanding of HPWH installation best practices ▪ Provide loaner WHs for customers to use while they await HPWH installations	▪ **Developed resources for permitting and energy code requirements: HPWH Permit Supplement Template, Electrical Load Estimator, and 2022 Building Code Assistance Sheet (1 pilot)** ▪ **Deployed 127 loaner HPWHs as part of 149 HPWH installations (1 QSG)**
Customers who electrify may increase their energy bills	▪ 1 pilot ▪ 2 QSGs	▪ Analyze customer meter data to identify customers who will realize the most savings from electrification or are likely to decarbonize ▪ Test customer outreach strategies ▪ Pair HPWHs with solar to protect against customer bill impacts	▪ Created customer targeting data dashboard for one electric utility (1 pilot) ▪ Created a prototype tool for contactors to identify customers with high savings potential (1 pilot) ▪ Developed and deployed marketing collateral (1 pilot) ▪ Assessment of targeted versus non-targeted customers' program engagement and energy impacts ▪ **3 HPWHs installed with solar (2 QSGs)**
Inaccurate utility allowances discourage electrification in subsidized rental housing	▪ 1 QSG	▪ Develop and share resources on how utility allowances affect heat pump installations and how building owners can access accurate utility allowances	▪ Produced three memos: Utility Allowances to Unlock Electrification in Subsidized Housing; HUD Utility Schedule; Best Practices for Engaging Building Owners on Utility Allowances (1 QSG) ▪ Produced one case study (1 QSG) ▪ Conducted three informational webinars (1 QSG)

Note: Bolded items also align with TECH Initiative Goal 1.
Sources: Final and interim pilot reports; QSG final reports

The three remaining QSGs not included in Table 6 above focused primarily on collecting data that could be used to better understand heat pump performance, energy use, cost savings, GHG emissions reductions, benefits of use, and user experiences with the equipment in various housing types. As such, these three projects aligned with TECH Initiative Goal 3: Inform California's decarbonization decision-making with public data, analyses, and case studies. Other projects, in particular the six large-scale pilots, also collected data, carried out analysis, and/or conducted research to inform or iterate upon their approaches. Aside from data related to incentive-supported installations in the TECH Heat Pump Data Repository[8] and findings included in public reports, it is unclear how much data from pilot projects is publicly available. Nonetheless, **4 pilots and 3 QSGs reported sharing findings or information with California policymakers, including state-level bodies such as the CPUC, CEC, and California Air Resources Board (CARB) and county- or city-level policymakers**. Also, as of February 2025, **one pilot and one QSG had published case studies**.

In addition to the outputs and lessons learned garnered by the pilots and QSGs, testing approaches and analyzing data yielded valuable information for future market transformation efforts to drive heat pump adoption. **The evaluation team**

[8] TECH Public Reporting Heat Pump Data

found that pilot and QSG projects contributed to a better understanding of barriers to heat pump adoption, a better understanding of solutions that reduce or remove such barriers, and a better understanding of heat pump systems as a technology. We delve into each of these contributions below. Our findings are drawn from interviews, resources produced by pilot/QSG teams, pilot quarterly reports, and pilot/QSG final reports. As mentioned above, some QSG reports were written at a high level that sometimes obscured whether information was gained by the TECH-funded activities or was already known by the QSG team members. Also, we were unable to determine the extent to which information gained by the pilots and QSGs was entirely new to the TECH Initiative rather than new to the pilot and QSG teams. The evaluation team attempted to discern new information gained through the TECH Initiative as much as possible, as well as to list only learnings backed by at least some evidence. We include relevant outcome information when available.

BETTER MARKET BARRIER UNDERSTANDING

Five pilots and 13 QSGs collected information or provided insights into market barriers. Understanding market barriers is a necessary first step toward market transformation and has great value for the design and iteration of TECH Initiative activities. Better understanding of market barriers spans several topics, such as limitations to HP equipment, building or infrastructure factors that constrain HP retrofits, market actor knowledge and attitudes, and more. Below we list barrier information and insights reported by the projects in their quarterly reports, final reports, interviews, and case studies. Note that a single pilot or QSG could provide multiple pieces of information or insights. We group findings by general topics areas.

Home Repairs/Infrastructure

- Home repairs needed to enable HP installations encompassed:
  - Adding a plenum or internal plenum, subpanel or subpanel with two dedicated circuits, a single dedicated circuit, or a conductor wire; replacing a plenum; repairing plumbing (1 QSG)
  - Adding an outdoor enclosure for upsized HPWHs; relocating the HPWH; increasing main panel amperage; upgrading the main panel because of panel age or the existing panel was unpermitted; electrical work; adding a new expansion tank (1 QSG)
  - For mobile homes: Tree trimming to clear overhead space for electrical lines, relocating HPWHs, removing old heat pumps, trenching, sealing floor and ceiling; electrical panel disconnect (1 pilot)
- Existing weatherization and housing rehabilitation programs often did not fund electrification-related work and their program implementers were unable to offer initiatives or funding sources that could; furthermore, these programs required the same contractor to complete all project work, though many of the contractors were unfamiliar with heat pumps (1 QSG)
- Deferred maintenance and unpermitted or non-code-compliant gas water heaters introduced significant and unexpected variations in HPWH retrofit costs (1 QSG)
- Home electrification required electrical upgrades and repairs such as needing a dedicated circuit for a stove or EV charger and building code required panels to be oversized by 20%, both of which drove up project costs (1 QSG)
- Effectiveness of a HPWH loaner program was contingent upon addressing common retrofit barriers like electrical panel capacity, space requirements, ventilation, and hot water capacity (1 QSG)

- Preparing mobile homes for heat pumps was more expensive than preparing site-built homes; also, mobile homes often needed to be upgraded *en masse* because they were connected to the same underground wiring that was impacted by trenching at one of the homes (1 pilot)
- Low-income apartments often had one window and limited electrical outlets, so adding portable heat pumps made conditions worse by limiting ventilation and/or overloading outlets (1 QSG)

Permitting and Building Departments

- HP installations in mobile homes were delayed by registration issues that prevented contractors from obtaining permits (1 pilot)
- Permitting requirements were highly variable across jurisdictions (1 QSG and 1 pilot); permitting staff also showed uneven understanding of the differences between traditional water heaters and HPWHs, and the implications for permitting processes to ensure safe HPWH installations (1 pilot)
- Building department staff or inspectors often lacked understanding of central HPWHs (1 QSG) and residential HPWHs (1 pilot); these market actors needed additional education about how these systems operate

Residential Customers

- High upfront costs for heat pumps, regardless of deep discounts and long-term savings, were insurmountable barriers for some low-income customers (2 QSGs)
- Customers sometimes declined heat pump installations out of fear permit inspections would find violations or unpermitted work completed outside the heat pump project (1 QSG)
- Limited availability of incentives prevented some customers from moving forward with heat pump installations, but other customers were spurred to act immediately (1 QSG)
- Many rural areas needed infrastructure improvements to increase grid reliability and capacity; rural customers hesitated to electrify due to past experiences with prolonged or frequent power outages (1 QSG)
- Offering HPWHs for free was insufficient to drive broad adoption of HPWHs (1 QSG)
- Electric utility rate increases after HP installations influenced participant perceptions of bill impacts; about half of portable HP HVAC recipients worried about their energy costs and some stopped using their equipment because the operating cost was too high (1 QSG)
- Currently available portable heat pumps required professional skill to install because they were large, heavy, and had configuration limitations; over 40% of users were unsure if they could remove the units and re-install them if they had to move (1 QSG)
- Low-income participants hesitated to provide their utility bill data out of concern their utility was a somewhat threatening authority “not to be messed with” (1 QSG)
- Large majorities for survey low-income households reported cost was a barrier to home electrification upgrades and they had deferred maintenance in their homes (1 QSG)
- Members of traditionally underserved communities were unaware of electrification and HPs; many people associated “electrification” with turning off lights to save energy and that using more electricity sounded like something to avoid; some with solar thought they had “done electric” while still using gas appliances (1 QSG)

- Members of traditionally underserved communities expressed distrust to large, out-of-area companies, utilities, retailers, appliance manufacturers, and sometimes contractors (1 QSG)
- Members of traditionally underserved communities were overwhelmed by the time and effort needed to solicit contractor quotes, find incentives, and fill out applications; the majority cited high project costs and their status as renters as barriers to electrification; those who were homeowners noted high project costs, and feeling projects were too complicated and time consuming (1 QSG)
- Members of traditionally underserved communities reported difficulty finding contractors willing and able to install HPs, willing to address perceived project feasibility issues, and/or spoke Spanish (1 QSG)
- Higher-than-average income homeowners expressed concern about HP installation costs, even with rebates and incentives; they also expressed skepticism about HP performance in extreme weather, noise, size, practicality given power outages, and savings (1 pilot)

Contractors

- Delayed payment for incentives placed significant financial burdens on smaller contractors and dampened their interest in participating in incentive programs (1 QSG and 1 pilot)
- Some existing electrification training was not accessible to contractors from traditionally underserved communities; this occurred when courses were available only through local distributors based on exclusive supplier agreements or previous project volume, which excluded traditionally underserved contractors (1 QSG)
- Contractors needed customer and program management support when doing projects with funding from multiple programs; without such support, contractors may prioritize less complicated projects and underserve low-income communities (1 QSG)
- "Upsizing" HPWHs wasn't done consistently by TECH enrolled contractors (1 pilot)

Multifamily

- Landlords typically handled repairs and upgrades when something breaks (2 pilots)
- At least one existing tool to size central HPWHs in multifamily buildings did not work for smaller buildings (1 QSG)
- Affordable multifamily housing buildings had unique challenges for HP retrofits, including asbestos and poor insulation; remediation of these issues often took precedence over energy efficient projects (1 QSG)
- Affordable multifamily housing building decisionmakers strove to minimize inconvenience for residents by scheduling construction during tenant turnover, which could slow the pace of decarbonization (1 QSG)
- Public housing agency staff, property owners and heat pump installers lacked knowledge about how utility allowances are set and how they impact heat pump installations; public housing agency staff often relied on consultants to set utility allowances and did not know about heat pumps, HUD guidance on utility allowances, adverse impacts of gas appliances, or resources available to help them with housing allowances (1 QSG)
- Public housing agency staff often saw annual utility allowance updates as an unfunded mandate, while owners were unaware of the range of methods for setting utility allowances (1 QSG)
- Subsidized housing owners lacked staff capacity to obtain incentive funding (1 QSG)

- Only 36% of public housing authorities had electrification-friendly utility allowances because they estimated "typical" utility costs based on unit size rather than actual energy consumption (1 QSG)
- Electric cooking posed the greatest challenge to electrification in a multifamily building because three units typically shared a 90-amp breaker (1 QSG)
- When considering HPs, multifamily homeowners were concerned about system reliability and potential HOA fee increases, and were confused about the differences between HPs and other systems like solar heating (1 QSG)
- Not all problems with old electrical infrastructure in multifamily buildings were apparent until retrofit projects were in process (1 QSG)
- Project solicitation materials prepared for a multifamily electrification project did not have enough information for installation contractors to place bids; the materials lacked existing building condition for distribution panels, wiring, and individual unit electrical panels; hot water consumption monitoring was also needed for one building getting a central HPWH (1 QSG)
- Planning for comprehensive building electrification was a paradigm shift for multifamily building owners, because they typically did not carry out renovation or retrofit-related work that would not immediately yield improvements to the building, such as electrical system upgrades what would enable new electrical equipment years in the future; instead they focused on fixing immediate needs (1 pilot)
- Landlords cited risk of poor return on investment, high costs, lack of access to capital, potential tenant inconvenience, and potential disruptions to rental income as barriers to HP installations (1 pilot)

BETTER SOLUTION UNDERSTANDING

Pilot and QSG HP installations, attempts to reduce or remove market barriers, and data analyses also yielded beneficial information about the types of activities needed to transform California's markets for heat pumps. Six pilots and 11 QSGs garnered such information; as with barriers above, pilots and QSGs could provide multiple pieces of information or insights about solutions.

Better solution understanding encompassed a wide range of topics, such as recognizing market actors' motivations, effective means of communication or messaging, contractor training needs, equipment performance, and more. Important caveats are that 1) half of the pilots and all of the QSGs worked within prescribed geographic areas and 2) successful market transformation usually requires years of effort and clear evidence of impact emerges slowly. Thus, the insights gained by the pilots and QSGs about how to design or iterate upon market transformation approaches, though promising at limited scale and in the short term, may not generalize to statewide or other large-scale market transformation efforts.

Home Repairs/Infrastructure

- Using a tiered cost system for home remediations/repairs and HP installations sped up installations; instead of individualized quotes for repairs, each of the three repair tiers (minor, moderate, major) had a set price, which reduced contractor bidding effort and program administrator approval time; this system also encouraged contractors to perform comprehensive retrofits because they knew they will be compensated at a pre-determined rate agreed to by both parties (1 QSG)
- Prioritizing measures that realized immediate energy savings protected customers from bill increases during the early stages of their comprehensive home electrification projects; measures that led to bill savings were adding

rooftop solar (sized to accommodate HPWH load), time-of-use arbitrage for HPWHs, programming the HPWH to avoid peak hours, shedding HPWH load with home batteries, and customer education on HPWH programming and operations (1 QSG)

Permitting and Building Departments

- Local jurisdiction HPWH permit processing timelines accelerated once they had completed 10-20 HPWH permits; however, faster processing times sometimes reflected building department understaffing and department staff skipping safety and efficiency checks (1 pilot)
- Local jurisdiction building department staff would benefit from tailored experiential learning opportunities that align with their existing knowledge level and local needs; a minority of staff members preferred local resources and expertise to those offered by the state, but many used resources from code bodies and the CEC (1 pilot)

Residential Customers

- Effective outreach methods for rural and hard-to-reach customers included "blanket" customer outreach, working directly with contractors to support their 1:1 outreach efforts and help their customers understand how to use incentives; many rural contractors were a trusted community resource; also, rural contractors and customers needed access to on-demand technical assistance (1 QSG)
- Consumer education and outreach to low- to moderate-income communities needed to focus on health (1 pilot), comfort, and energy burden; general messaging about electrification did not resonate as well as messaging that addressed common health hazards like moisture, mold, asbestos, drafty spaces, and other quality of life concerns (1 QSG)
- Leveraging trusted housing rehabilitation programs was an effective way to recruit low- to moderate-income community members for electrification projects; customers were receptive to renovation projects when the information about grants, rebates, and low-cost financing options came from these programs (2 QSGs)
- For disadvantaged, underserved, and hard-to-reach communities, introducing residents to HPWHs via home water heater assessments and tune-up services built trust and generated buy-in for proactive HPWH installations because it engaged customers in a low-risk and low-effort first service with the team; the project team also established physical presence in the local community to build trust and collaborated with community partners for outreach in multiple languages and media (1 QSG)
- Prioritizing customer preferences for appliance colors, models, locations, and other factors before finalizing project designs avoided customer objections due to aesthetics or personal preferences (1 QSG)
- To adopt heat pumps, low-income renters needed ongoing support from trusted, well-established community-based organizations; support was 1:1 and included clear, language-appropriate educational materials such as reminders about heating capabilities of the HPs (1 QSG)
- Low-income renters used their portable HPs more for air conditioning than for heating, suggesting to the QSG team a need for more education about HP capabilities (1 QSG)
- Utility meter data can be used to identify and successfully market to customers who are likely to install a HP or are likely to realize high bill savings from a HP installation; targeted email marketing garnered higher email open rates and click-through rates than a comparison group of non-targeted emails and similar campaigns; email open rates

for targeted customers were generally high for example, 61% and 62% for two different campaigns), as were click-through rates of 1.5-3%. (1 pilot)

- Higher-than-average income homeowners had varying levels of knowledge about electrification and agreed moving away from fossil fuels was crucial for public health and planetary sustainability; they associated HPs with energy and utility bill savings, and reduced reliance on fossil fuels and emissions (1 pilot)
- Higher-than-average income homeowners relied on recommendations from friends, family, Yelp, Google, and annual service providers when planning home upgrades; they didn't actively seek rebates but appreciated them when they were easily accessible (1 pilot)
- When presented with a loan concept for HP installations, higher-than-average income homeowners were most interested in financial aspects like rebates and zero-interest loans; most needed reassurance financial benefits would be clear and tangible; they appreciated the convenience of a "one-stop-shop" process with pre-vetted contractors and high-quality equipment; they were hesitant to commit to long-term loans for HPs without clear financial benefits, as well as concerned about taking on more debt (1 pilot)

Contractors

- Using natural gas loaner water heaters while HPWH installations were in process increased the natural gas to HPWH conversation rate from less than 1% to 17.1%; cost was still a factor as customers chose to participate only when the cost of the HPWH was at parity with a natural gas water heater; other factors were immediate hot water restoration, streamlined incentive paperwork, instant rebates, and building customer trust (1 QSG)
- Expanding the natural gas loaner option would entail purchasing more loaners and having places to store them, which might require a partner to serve as a loaner host, as well as more well-trained installers, such as by training them as skill-specific rather than skill-general technicians (1 QSG)
- Training HVAC technicians in-house as part of employee onboarding did not take away from technician revenue generation (1 QSG) and in-house trainings alleviated contractor concerns their staff would interact with competitors (1 QSG)
- Using a single, experienced contractor to carry out home remediations/repairs and HP installations kept costs down, improved administrative efficiency, promoted quality installations (based on their experience and track record of installations for another program), and provided better customer service; also, using a closed contractor model in which only a small number of pre-vetted contractors participated in the program allowed those contractors to offer competitive pricing because they had a guaranteed portfolio of work (1 QSG)
- New technicians using remote HVAC HP support/QA software on their smartphones reported higher confidence levels when servicing and installing HVAC systems with the support; the live video support allowed service managers to oversee work without being onsite and allowed older staff a less physically taxing role in the industry, which could promote career longevity; new technicians especially valued the software/remote video support (1 QSG)
- Testimonials from contractor peers were persuasive ways to explain electrification's benefit to contractor businesses (1 QSG)
- With training, surveyed contractors self-reported they could confidently convey information about demand response program enrollment and load shifting, and during one-on-one conversations with contractors, they were

not unsettled by the addition of a new demand response program documentation requirement for incented HPWHs (1 pilot)

- Contractors in disadvantaged communities needed reliable and fast incentive payments to remain interested in TECH Initiative participation (1 pilot)

Multifamily

- Lowering utility costs and protecting occupant health were top priorities for multifamily building residents (1 QSG)
- Critical components of programs to support multifamily building owners, managers, and tenants in DACs were providing no-cost installations; providing no-cost technical support on how to project the impact of retrofits on utility costs, return on investment and on program requirements; minimizing disruption to tenants by scoping retrofits during tenant turnover; avoiding electrical upgrades in older buildings by encouraging like-for-like swap outs and modular construction; and prioritizing occupant comfort and satisfaction (1 QSG)
- Successful installations depended on a "champion" committed to HP adoption with authority to advance projects at multifamily properties; champions included an HOA president, an in-house electrical contractor, to a property manager (1 QSG)
- One stop, turnkey HP installation support with financing may encourage subsidized housing owners to choose to install heat pumps; without significant incentive funding, subsidized housing properties were unlikely to install heat pumps outside their tax credit recapitalization cycle, so outreach to owners should be 2-3 years before the end of their current tax credit authorization term to allow owners to plan for electrification alongside recapitalization (1 QSG)
- Providers of subsidized affordable housing needed clearer utility allowance calculation methodologies; such methodologies could be published on a centralized website to provide access and promote transparency (1 QSG)
- Landlords favored equipment replacement over repair because high repair costs often matched or exceeded replacement costs; they also preferred high-efficiency or high-quality equipment, including ENERGY STAR labeled and with extended warranties (1 pilot)
- When pitched a loan program concept for HP installations, landlords found the idea of a "one-stop-shop" installation process with pre-vetted contractors and pre-negotiated prices appealing; they had specific concerns about reliance on tenant involvement for on-bill financing, having to explain or transfer financing obligations to new tenants, and about using pre-vetted contractors; they also had questions about upfront costs and return on investment (1 pilot)
- Landlords were motivated by the positive impacts of HP installations on tenant satisfaction, reduced energy consumption, decreased reliance on fossil fuels, and offering an environmentally friendly alternative (1 pilot)
- To pay for building upgrades, landlords set aside funds regularly to cover large expenses when they arise, use rental income to cover costs, and generally avoid borrowing (1 pilot)

Financing

- Understanding of financing options improved with the development of a typography of customer use cases that probed the risks and possible remedies for non-payment for financed HP installations (1 pilot)

- Baseline weather-adjusted energy consumption data appeared to have little "noise" that it carried low risk for use in savings calculations for financing models (1 pilot)

BETTER UNDERSTANDING OF HEAT PUMPS

A final category of important contributions to California's market transformation for HPs efforts is better understanding of HPs, including their performance, design, installation, and impacts on crucial outcomes like energy use, customer bills, GHG emissions reductions, and more. Two pilots and 6 QSGs studied heat pump equipment installed in homes and multifamily buildings; two QSGs were ongoing as of February 2025 so their results are not included below. These efforts included analysis of data from meters, energy use monitors, and other physical sources of information rather than perceived changes derived from interviews, surveys, and focus groups (which we captured in the preceding sections).

- The most common issue after a multifamily central HPWH installation was water crossover, where cold water mixed with hot inside the plumbing system of individual residences due to faulty fixtures, valves, or other issues that were masked by setting the previous natural gas water heater to a high temperature; these issues had to be individually diagnosed and addressed by post-installation monitoring to ensure optimized performance (1 QSG and 1 pilot)
- Despite the availability of 120V HPWHs, there remained an immediate need for smaller footprint/form factor 120V HPWHs and products with better compressor capability for cold climates (1 QSG)
- Skidded central HPWH systems that included all HPs, tanks, and accessories on a platform or "skid" that can be moved into place as a unit did not fit into existing multifamily building mechanical rooms or spaces outside mechanical rooms (1 QSG)
- A small number of portable heat pumps needed repair due to manufacturing defects or improper care; users also struggled to maintain air filters or ensure adequate airflow (1 QSG)
- Installing thermostatic mixing values did not meaningfully increase total HPWH installation cost (1 pilot)
- 120V HPWHs were potentially a viable water heater technology for households with limited available ampacity (1 QSG); but households with high water usage also experienced hot water runouts and may benefit from "upsized" tanks (1 QSG)
- A modular, pre-packed central HPWH was adaptable to multiple buildings rather than requiring building modifications (1 QSG)

4.3.2 LARGE-SCALE PILOT AND QSG DISSEMINATION

In this section, we report on our evaluation questions, "Were the conclusions and lessons learned from the pilots collected and articulated?" and "How were the conclusions and lessons learned disseminated?" Of all aspects of the evaluation, understanding the spread of ideas from the pilots and scaling was the most constrained by the timing and limitations of the data available for the evaluation. With four of the six pilots and two of the 19 QSGs without final reports by February 2025, we had little to no information about the conclusions or the full complement of lessons learned from these projects. Also, dissemination often lags behind implementation, and it's unclear if a full accounting of dissemination of completed projects is possible at this time. Nonetheless, we learned during interviews that VEIC will produce final reports summing up results from the pilots and QSGs, respectively; as of February 2025, these reports

were under development and presumably will be a key mechanism for collecting, articulating, and sharing conclusions and lessons learned from the pilots. Finally, scaling is most likely to occur after pilots have concluded and is unlikely to be documented in final reports. Despite these limitations, we analyzed relevant data from reports, interviews, the QSG survey, web analytics data from the TECH Initiative website compiled by Energy Solutions, and a summary of dissemination and scaling activities compiled for the evaluation team by VEIC.

Publicly available information about the pilots and QSGs is available on the TECH Clean California website.[9] The website includes high-level description pages for each pilot and QSG, as well as final reports for the two completed pilots and 15 completed QSGs; slide decks from stakeholder workshops for two pilots; one pilot case study; and tools/resources developed by four of the pilots and 1 QSG. At least two of the pilots and one QSG contributed to resources on the TECH Clean California Contractor Knowledge Base webpage[10], but their exact contributions to this webpage were not labeled or identifiable. Cumulative web analytics showed pilots and QSGs varied in the number of webpage active users and resource downloads from their web pages (Table 7).

Table 7. Web Analytics Ranges and Totals for Pilots and QSGs

	Pilot Low	Pilot High	QSG Low	QSG High	Total
Webpage active users	479	1071	117	954	11,840
Downloads	1[a]	370	40	413	1,801

[a] At the time of analysis, the pilot with a single download did not have any resources available for download.

Source: Web analytics data provided by Energy Solutions.

For context, the pilots and VEIC identified their target audiences for dissemination as the following:

- Utilities and community choice aggregators
- Utility regulators
- Consumer and low-income advocates
- Energy Savings Assistance Program Implementors from IOUs
- State and local jurisdictions, permitting authorities, and program administrators
- Multifamily portfolio owners, HVAC contractors, hot water contractors, and mechanical, electrical, and plumbing (MEP) contractors
- Single-family HPWH contractors

However, the exact size of these target audiences and their alignment with the active users and downloaders on the pilot and QSG web pages are unknown.

For the QSG target audiences, individual QSG grantees identified their key audiences and listed those organizations and individuals for VEIC to include in outreach promoting QSG findings. Beginning with Cohort 2, the two primary modes of dissemination for QSGs were webinars and blog posts; 12 QSGs completed each of these dissemination activities. In advance of their webinars, VEIC emailed each QSG's target audience organizations and individuals, supplemented by additional relevant organizations and individuals provided by VEIC and Energy Solutions. Web analytics of QSG webinar

[9] https://techcleanca.com/

[10] https://frontierenergy-tech.my.site.com/contractorsupport/s/

email opens spanned from 595 to 1035 individuals; a total of 548 people attended the QSG webinars thus far. Attendees at QSG webinars included individuals from:

- State agencies like the CEC and CPUC
- IOUs
- Local government entities like the Bay Area Air Quality Management District (BAAQMD) and BayREN
- Community Choice Aggregators
- Organizations such as Lawrence Berkeley National Laboratory, Rewiring America, and GRID Alternatives
- Industry participants like HVAC and contractor businesses
- HP equipment manufacturers

QSG webinars, then, attracted audiences who could influence market transformation for heat pumps in California.

One interviewee revealed satisfaction with dissemination to fewer but more influential individuals, especially policymakers, stating, "It's great to have dissemination and that's useful, but if we get that one key stakeholder, that's success." As noted above, four pilots and 3 QSGs reported sharing findings or information with California policymakers, including state-level bodies such as the CPUC, California Energy Commission (CEC), and the California Air Resources Board (CARB), and county- or city-level policymakers, and thus disseminated directly to key audiences who could further influence market transformation in the state.

Dissemination activities carried out by VEIC in support of the pilots included:

- Webinars, including those through the TECH Initiative: 2 pilots and 12 QSGs
- Conference or trade group presentations, workshops, or posters: 5 by VEIC staff, 3 pilots, and 6 QSGs
- Blog posts or online articles: 5 pilots and 12 QSGs
- Case studies or additional reports: 1 pilot and 2 QSGs
- Press interviews or podcasts: 3 VEIC staff and 2 QSGs
- Organization/project website: 1 QSG

Pilots worked to keep the CPUC informed of their activities, lessons learned, and findings as they came available. As noted above, each pilot team provided quarterly updates on their progress to the CPUC. First, VEIC and pilot teams presented at CPUC Quarterly Stakeholder Meetings. Presentations included "progress on all pilots" as well as "rotating deep dives on pilot activities and results, and opportunities to provide feedback or participate in pilot activities." Second, beginning in early 2022, pilot teams provided quarterly written reports documenting implementation successes, challenges, lessons learned, and adjustments to their original implementation plans. In mid-2024, the CPUC requested pilot teams instead provide "live briefings" with slide decks in lieu of the written reports. Pilot teams also periodically presented *ad hoc* to CPUC Energy Division staff or contributed to four CPUC proceedings. VEIC prepared and submitted an initial Pilot Summary and Recommendations Report for the CPUC in December 2023; a final, public report is forthcoming in late 2025.

Also, pilots engaged in many stakeholder engagement activities primarily to support their design process by gathering stakeholder input and feedback. For example, early on one pilot team held a series of seven stakeholder workshops to gather input and feedback on their initial design ideas. This valuable work helped the pilot create and refine its activities, rather than to publicize conclusions or findings from its implementation.

As part of this evaluation report, the CPUC asked the evaluation team to gather feedback from the pilot teams about their communication with the Commission. We included questions about communication with the Commission in our interview guides. Interviewees noted efforts like presentations to share information with the CPUC, but generally described communication as one-sided, with information flowing to the CPUC but not back to pilot teams. One interviewee described the presentations as a "fire hose of information" that seemed to overwhelm the CPUC audience. Another said of the CPUC, "They never talk to us…I don't even know who to talk to" at the CPUC. In contrast, one pilot team described collaborative decision making with the CPUC about their scaling plans. Although most interviewees felt communication with the CPUC could be improved, aside from having longer meetings, they did not have additional ideas for improving the flow of information back and forth between pilots and the Commission.

4.3.3 LARGE-SCALE PILOT AND QSG SCALING

Here, we report findings from a set of scaling-related evaluation questions:

- What happens next to the pilots?
- Do the strategies become implemented into the TECH Initiative?
- What impact can they have if scalability is determined to be worthwhile? Or, are there still key barriers in the way of scaling up successful pilots?

We define scaling as increasing the amount of what is implemented such as serving more people (including customers, contractors, members of the supply chain, etc.), buildings, and/or places than planned or originally funded by the TECH Initiative. Interestingly, three of the pilots scaled considerably beyond the limited geographic scope planned in their Pilot Implementation Plans as part of their implementation. In one case, a pilot pivoted from partnering with a single community choice aggregator to supporting all four of the state's IOUs after the CPUC ordered the IOUs to work together and recommended they use the pilot team's work as a model. In another case, a pilot team expanded from implementing in one region of the state to supporting a new statewide CPUC-created incentive program; the pilot team shifted its scope to informing the new program and aiding contractors statewide. The third pilot also expanded from a planned implementation within a single jurisdiction to statewide research and training material development.

Typically, though, scaling occurred after initial implementation. Based on the available data, the following scaling has begun:

- Team members carried out similar work for the TECH Clean California Strategic Early Retirement Program: 1 pilot
- Team members carried out similar work for additional non-TECH Clean California efforts, such as IOU programs, private business, CEC programs, other grants, etc.: 2 pilots and 9 QSGs
- Approaches or recommendations informed non-TECH Initiative programs: Energy Solutions oversight staff, 1 pilot, and 1 QSG
- Team members informed CPUC proceedings or programs/incentives: 3 pilots

Furthermore, complete pilots and QSGs described scaling plans or recommendations in their final reports, but aside from the aforementioned scaling activities, we do not have evidence that these plans have been executed. Similarly, while the TECH Clean California Initiative logic model includes an intended outcome of "scaling effective pilot strategies to statewide implementation," the evaluation did not reveal a framework or plan for carrying out such scaling as the

Initiative continues. However, there may also be additional TECH Initiative-funded scaling via the QSG Cohort 3 effort in the future.

A few pilot approaches have also begun scaling outside of California. Tools developed by one are being used as a model for properties participating in national Greenhouse Gas Reduction Fund activities. Also, according to one interviewee, the New England Heat Pump Accelerator is itself modeled after the TECH Initiative, including the pilots and QSGs.

Finally, during interviews with pilot teams, we asked about remaining barriers to market transformation or scaling. Interviewees suggested the following barriers remain:

- High costs for heat pumps, including price increases for heat pumps by supply chain market actors and contractors that negate/take advantage of incentive price reductions for consumers (2 pilots)
- Difficulty attracting third-party capital to financing for heat pumps (1 pilot)
- Regulatory barriers to combining solar, storage, and heat pumps (1 pilot)
- Limited grid connectivity options for HPWHs; the need for manufacturers to evolve connectivity technology (1 pilot)
- Lack of contractors, especially in rural areas and DACs (1 pilot)
- Legislative requirement that incentives pass from contractors to customers, rather than straight to customers (1 pilot)
- Complexity of heat pump installations (1 pilot)
- Need for electrical upgrades for heat pump installations (1 pilot)

4.4 EFFECTIVENESS

Two of our evaluation questions related to the effectiveness of both the pilots and QSGS: Did VEIC successfully implement the pilots, and, Are the pilots a worthwhile implementation strategy? We address these questions in section 4.4.1 below.

4.4.1 LARGE-SCALE PILOTS AND QSGS

During interviews with pilot teams and as part of the QSG survey, we asked respondents about their experiences with the TECH Initiative implementation team. The majority of respondents were positive about the support they received from VEIC and, if applicable, Energy Solutions. Interviewees from all pilot teams reported feeling supported by VEIC, though one team also pinpointed some possible areas for improvement (see below). Overall, pilot team members cited VEIC staff members as being "very knowledgeable and they have individuals on the team that are just excellent experts in their field." One team remarked that VEIC staff were "good people." Another pilot team offered, "They've been a great partner, very supportive and great to bounce ideas off of and keep each other accountable" as well as "Very helpful on the administrative side" by being "helpful as project managers and making sure we met requirements like the quarterly reports, helping with those, and managing interactions with the CPUC." Another pilot team said VEIC staff had "actual technical expertise" and "know the market and contractors."

The sole pilot team that mentioned needing more support from VEIC felt there was "a lot of hemming and hawing, and 'let me talk to so-and-so'" instead of the "black and white type of direction" that was needed for the pilot to move

forward. This team reported experiencing lengthy deliberations and "never got a straight answer" about one issue. No other pilot teams reported a lack of responsiveness from VEIC, instead finding VEIC "very" to "fairly responsive."

Also, one pilot team struggled with the organizational structure of the pilot, saying, "The hierarchy just did not really work" because the pilot team felt their expertise sometimes exceeded VEIC's and the organizational structure didn't adequately "harness the strengths of both teams." Finally, the team expressed some frustration that in the industry, local experts "go give their expertise and connections over to other companies" brought in to implement programs, implying that smaller companies end up helping larger companies succeed but don't reap similar benefits from such partnerships.

QSG team members who completed the survey were uniformly positive about VEIC and the support they received. Twelve of the 14 respondents felt "very supported" by VEIC staff; the remaining two respondents felt "somewhat supported." The same proportions felt VEIC was "very helpful" in helping the QSG team overcome challenges (12 of 14) or "Somewhat helpful" (2 of 14). A survey respondent elaborated on their "somewhat supported" and "somewhat helpful" responses, writing their responses weren't higher because "some of the issues we had could not be supported further because of the nature of the research we were doing," though they did not clarify why this was the case. Eleven of the 14 respondents said VEIC was "very responsive" to requests for additional resources; 2 of 14 respondents said VEIC was "somewhat responsive;" 1 of 14 said they had not needed to request additional resources. Survey respondents provided mostly positive open-ended responses about their experiences on their QSGs, such as:

- "We are grateful for the QSG grant and the support provided by VEIC; the process was easy to manage and helpful"
- "[The] QSG has provided an opportunity to fund true creative solutions by frontline organizations with boots on the ground, in a way that other grant opportunities have not. We have seen multiple efforts to make space for creativity and collaboration but usually tied to restrictive funding guidelines and heavy reporting, sometimes because of an unnecessary layer of government red tape, and other times the reason is simply lack of trust. QSG has been different in that sense, and it provided space for pivoting, pushing limits, and finding root causes."
- "The way the QSG was managed has really made a difference in what small local organizations like ours now ask of other grantors. The VEIC was able to push, from the beginning, the unnecessary limits of the type of support and trust a grantor can provide grantees. We are thankful and hope to work together again in the near future."
- "VEIC was top-notch. They understood the complexity of the work and the 'we don't know what we don't know' aspect. I really really appreciate them."
- "This type of flexible funding is incredibly valuable for advancing heat pump deployment in low-income households, i.e., flexibility to direct funding to heat pump HVAC units versus water heaters, depending on the homeowner need, and address the circuitry or other building upgrade needs to support code-compliant heat pumps is very valuable. Simplicity in this QSG funding reporting is valuable since many grant and incentive programs cost more in administrative time and resources than what is dispersed in the funding itself."
- "The QSG was instrumental in building out our product line from concept to proven product that is now on the market and selling."

The sole negative open-ended comment from survey respondents was,

- "The payment process was not good at all. I don't think program implementers understand the cash flow impact at the project level. For example, the final $50k payment took 4 months."

We asked select interviewees about Energy Solutions' oversight role and have limited data about this topic. Two interviewees described Energy Solutions oversight staff as "collaborative." Two also mentioned Energy Solutions as a problem-solving resource, including one who said their oversight staff was "there to help us think through implementation challenges and issues." One interviewee noted that Energy Solutions was the entity that considered pilot teams' proposals to change their implementation contracts and, after review, approved contractual changes. During a single interview, a pilot team member said Energy Solutions oversight staff showed "pretty light engagement" except during difficult points like TECH Initiative incentives ending. This pilot team member was "dissatisfied with their support" because they believed Energy Solutions oversight staff "did not take much of an interest" in the pilot. This lack of interest meant Energy Solutions oversight staff "weren't very effective if the CPUC had questions" the pilot needed to respond to. The interviewee concluded, "I do think it was a little bit to the pilot's detriment that the lead organization for the whole initiative didn't really engage."

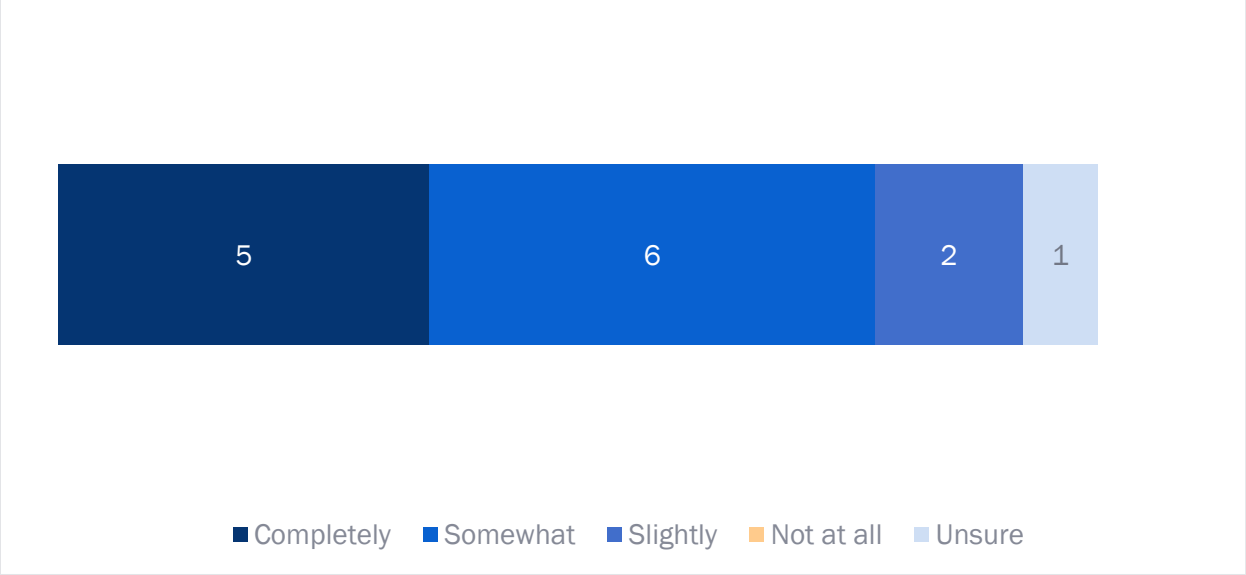
The final element we considered in evaluating implementation effectiveness was funding. All pilot teams felt budgets were sufficient for their work. In the words of one pilot team member,

> "I don't recall a time when [the pilot budget] was a boundary to our success."

Please note that pilots partnered with other programs, agencies, or companies, and those partners shouldered at least some pilot-related costs. Also, the majority of incentives were not paid by the pilots, but by the TECH Initiative and partner programs, when applicable. As mentioned above, the shortage of funding for TECH Initiative incentives was a challenge for some pilots.

The QSG survey included one item asking if the QSG budget was sufficient to fully implement the team's planned work. Eleven of the 14 respondents indicated their budget was completely or somewhat sufficient (Figure 5). Two (of 14) said their budget was slightly sufficient; one respondent was unsure about budget sufficiency.

Figure 5. QSG Budget Sufficiency to Fully Implement (n=14)



In summary, VEIC's implementation of the pilots was generally effective, with a few opportunities for improvement voiced by a minority of respondents. Similarly, Energy Solutions offered collaborative oversight but could deepen its engagement with pilot teams.

To answer our evaluation question, "Are the pilots a worthwhile implementation strategy?" we considered two additional factors: the uniqueness of the contributions made by pilots and QSGs, and their cost. By unique contributions, we mean work the pilots and QSGs engaged in that was unlike work other organizations in California have carried out. The evaluation team included questions about accomplishments and unique contributions in interview guides and the QSG survey. Pilot and QSG reports also mentioned ways grantees believed their work stood apart from other heat pump market transformation efforts within the state. One limitation to our analysis: the evaluation team has limited insight into the full breadth of programs and market engagement for heat pump adoption underway in California, and so we relied on respondents' assessments of uniqueness.

Pilots and QSGs reported the following as unique endeavors:

- Compiled best practices and procedures for heat pump installations into accessible formats (1 QSG)
- Studied the unique governance, financing, and installation context of multifamily complexes with homeowners' associations (1 QSG)
- Studied and tested measurement and verification methods for heat pump financing (1 pilot)
- Studied and tested methods to shield consumers from risks associated with heat pump financing (1 pilot)
- "Charted a path" to consumer financing for heat pump installations via a tariff-on-bill template and assistance to IOUs tasked to create TOB by the CPUC (1 pilot)
- Tested an average remediation cost cap instead of the traditional per home remediation cost caps used by utilities and found using the average increased the number of homes that could be served (1 pilot)
- Identified the most common home remediation needs for lower-income households and documented their costs (1 pilot and 1 QSG)
- Studied the benefits of monitoring central HPWH installations as a means of correctly sizing and installing them (1 pilot)
- Tested tools and tactics to prepare multifamily building owners for long-term electrical infrastructure improvements that would result in electrification ("infrastructure with no appliance at the end") (1 pilot)
- Tested heat pump contractors as the messengers for demand response and load shifting programs and learned of the additional supports and education needed (1 pilot)
- Tested meter-based customer targeting tools that identified customers with predicted greater than average bill savings from electrification (1 pilot)
- Studied the needs for manufactured home retrofit HPWH adoption as well as the potential impacts of their adoption (1 pilot and 1 QSG)
- Studied utility allowances, a previously unexamined barrier (1 QSG)
- Developed a lifecycle cost analysis tool intended to attract more private capital through sustainable finance (1 QSG)
- Studied the needs and challenges of non-regulated fuel (e.g., propane) customers in adopting heat pumps (1 QSG)

- Created and tested a "fairly groundbreaking tool," a "portfolio roadmap" for property portfolio owners to plan out and prioritize building electrification projects across their entire portfolio of buildings, as well as to track progress on electrification over time (1 pilot)

In addition, interviewees opined about ways the pilot strategy was unique in the market transformation of the electrification space. Two interviewees believed that only the TECH Initiative was able to fund the pilot projects, given constraints on other funding streams. As stated by one, "Without the co-funding, who would have figured these things out? I'm not sure anyone would have." Interestingly, one pilot interviewee spontaneously brought up the QSGs stating,

"The Quick Start Grants are a phenomenal little machine and it's an amazing incubator that everyone should be really proud of."

Our last consideration is the pilot strategy's cost. According to pilot and QSG expenditure data, between 2021 and 2024 the total pilot expenditure for labor and non-labor totaled $17,201,246 (Table 8). The average per pilot expenditure was $1,951,895; for QSGs, the average was $288,940. Figure 6 illustrates pilot expenditures increased year over year while QSG expenditures ramped down in 2024.

Table 8. Pilot and QSG Expenditures Through December 2024

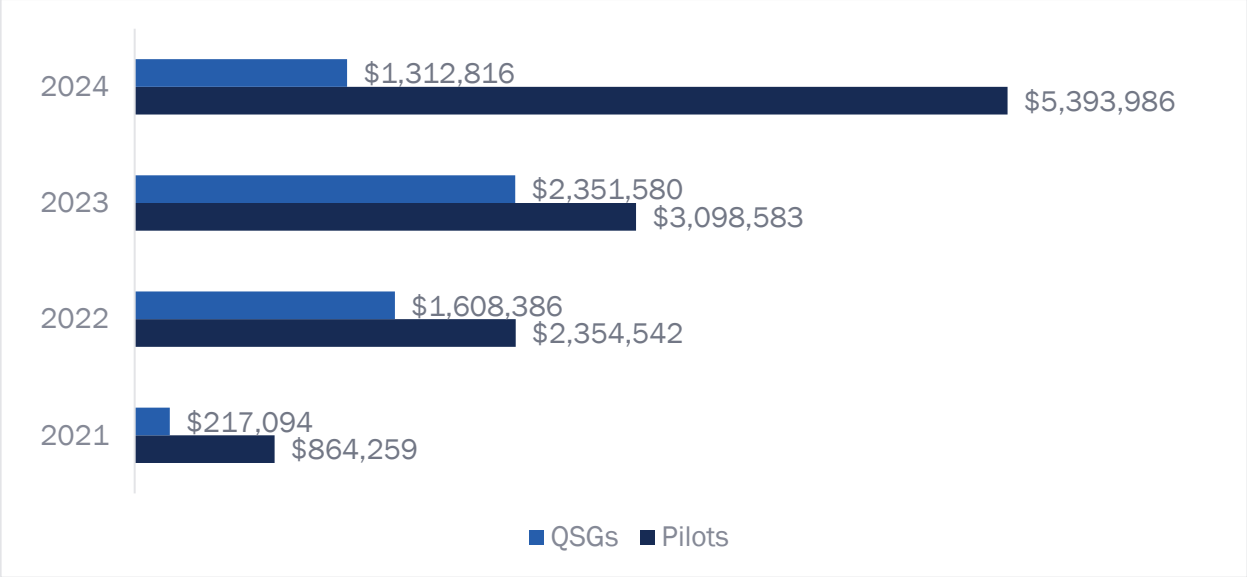
	IUI Finance	Low Income	Multifamily	HPWH Load Shifting	HPWH Permitting	Customer Targeting	QSGs	Total
Total Labor[a]	$1,655,695	$3,154,024	$2,242,112	$489,666	$455,757	$409,361	$1,641,163	$10,047,779
Total Non-Labor[b]	$228,529	$2,299,527	$719,899	$56,100	$0	$700	$3,848,712	$7,153,468
Total	**$1,884,225**	**$5,453,551**	**$2,962,011**	**$545,766**	**$455,757**	**$410,061**	**$5,489,875**	**$17,201,246**

[a]Labor expenses include all TECH Initiative staff.

[b]Non-labor expenses varied across pilots but included home remediation costs, equipment, and various payments to contractors. QSG non-labor expenses included grant-awarded incentives. Some grantees also applied for standard TECH Initiative equipment incentives.

Source: Expenditure data provided by Energy Solutions

Figure 6. Pilot and QSG Yearly Total Expenditures



4.4.2 QSG SOLICITATION PROCESS

Our final effectiveness evaluation question is related only to the QSGs: How effective was the QSG solicitation process? As described above, the QSGs were selected through two public, competitive solicitations. Presentation materials about the QSG solicitation process, the QSG Program Implementation Plan, and interviewees described VEIC's process to co-create the solicitation process through engagement with a diverse set of 23 stakeholder organizations in order to promote inclusivity and accessibility for a wide range of applicants. One goal mentioned in the QSG Pilot Implementation Plan was for the pilot to allocate 40% of funds to projects benefiting low-income households, DACs, or other hard-to-reach customers. The QSG team shared a draft version of the solicitation and evaluation materials with these organizations and then held 1:1 meetings with them to get feedback about grant requirements, funding amounts, evaluation criteria, and more. After VEIC finalized the solicitation materials, they asked the stakeholder organizations to circulate the solicitations to their networks.

The solicitation for Cohort 1, selected in 2021, garnered 11 projects from a pool of 36 applicants. The solicitation for Cohort 2, selected in 2022, resulted in 8 projects from 31 applicants. VEIC's QSG team reviewed each applicant's proposal using a QSG Evaluation Rubric.

Interviewees noted the QSG solicitation process evolved between the first and second rounds to make the competition more accessible for organizations that may have had good ideas but lacked grant writing expertise: the application window increased to two months to give applicants more time to respond, and applicants participated in interviews to give those with less experience writing formal proposals an additional avenue for describing their ideas. Also, the QSG team opted to allocate 100% of funds to projects serving low-income households, DACs, or other hard-to-reach customers during the second solicitation.

Of the 19 QSGs, 17 either completed their implementation or are in the process of completing it. All 17 of the completed or ongoing QSGs contributed to at least one of the TECH Initiative's goals. Interviewees described the quality of the QSG applicants as "pretty strong" and "very high," and proposals brought in "lots of interesting ideas" that addressed different barriers and didn't replicate work. Regarding the proposal scoring, "only a few didn't score high."

Interviewees were also satisfied with the quantity of applicants overall. Speaking of the two solicitation rounds, one interviewee said,

> "Both of those responses were definitely robust enough for us to feel like the projects we selected were going to be great projects. Both years, there were projects we were very disappointed we couldn't fund."

SB 1477 made available $120 million to the TECH Initiative, derived from the revenue generated from the greenhouse gas (GHG) emission allowances directly allocated to gas corporations and cosigned to auction as part of the California Air Resources Board (CARB) Cap-and-Trade program. As such TECH spending must be allocated proportionally directed to gas corporation services territories where the funds are derived. This meant the amount of available QSG funding was capped for each natural gas IOU's territory. An interviewee emphasized there were "quality ideas" left unfunded that could still support market transformation. Since QSG proposals were not equally distributed across the natural gas IOU's territories, more ideas than could be funded came from one territory, while another territory generated only a single, relatively weak proposal. This "imbalance" resulted in the single, somewhat weak proposal being conditionally approved because of "a lack of other applications which might have been a better use for the funds," according to the internal report about the project's ultimate cancellation. In the end, the conditionally approved QSG failed to demonstrate sufficient, early progress, and the grant was cancelled after a few months with the vast majority of its budget unspent. The internal report for this first failed QSG articulated the following lessons learned and improvement opportunities:

- Explore how funds may be flexibly used under the current statutory framework;
- Establish a process to identify unsuccessful projects and terminate them early;
- Set clear and specific expectations after grantee project scope changes;
- Increase scrutiny of grantees' past performance and commitment to the project;
- Keep support for struggling grantees to a reasonable level to avoid prolonging apparently unsuccessful projects.

Although the evaluation team was unable to include VEIC's internal report on the second failed QSG in this analysis, VEIC staff revealed that QSG yielded similar lessons learned as the earlier failed grant. The failed grants generated lessons learned for QSG implementation, though they did not contribute to TECH Initiative goals and therefore, all QSGs yielded at least some tangible benefits for the TECH Initiative. **The QSG solicitation process was generally effective at recruiting and selecting grantees.**

5. CONCLUSIONS AND RECOMMENDATIONS

Our conclusions and recommendations about the TECH Initiative as a strategy are:

- Conclusion: As a strategy, the pilots have provided many lessons learned, potentially valuable information, and useful data to support TECH Initiative goals. However, the lack of detailed information about implementation challenges and inconsistent inclusion of evidence to back up accomplishments claimed in pilot and QSG reports and other documentation are missed opportunities to provide insights for course corrections, program improvements, and scaling plans.
  - **Recommendation:** Continue producing briefs, case studies, and other media that distill and share key learnings and findings from pilots and QSGs, but also support VEIC in documenting comprehensive and cross-cutting information about the pilots and QSGs through more detailed final summary reports and other feasible means. These summary reports should be specific enough that TECH Initiative and other program staff can take concrete actions for both new and existing programs. Identify any information gaps regarding what the QSGs learned, including from the two failed QSGs, as the lack of information from these important experiences limit the lessons learned and implementation of beneficial adjustments in other projects. If needed, conduct additional interviews or outreach with the QSG teams to gather more detailed information so VEIC and Energy Solutions staff have a complete picture of what to continue and what to modify going forward. Consider compensating QSG team members for their time spent addressing these information gaps.
  - **Recommendation:** Our current understanding is there will be additional QSG funds for 3-5 existing QSGs to scale up (the third cohort). For these scale-up fund recipients, increase the amount of data and evidence QSGs must include in their reports to back up their claims. Require that QSG reports clearly distinguish between information the QSG teams had in advance of the grant and information gained by grant implementation. Ensure that QSG reports are detailed enough to provide actionable insights to other stakeholders.
  - **Recommendation**: Given their long timeframes, augment the distribution of information, findings, and lessons learned from the six large-scale pilots as they are ongoing, rather than using their final reports as the primary means of public dissemination. Periodic dissemination beyond the TECH Initiative team and CPUC stakeholders aligns with the spirit of TECH Initiative Goal 3 and may accelerate market transformation by making vital information accessible to more people and organizations who support decarbonization. Mechanisms for dissemination to the broader public could include webinars, videos, articles, or other media that make clear what pilots are accomplishing and learning as they go. Key considerations for dissemination are depth of detail so that another similar team could learn from or replicate something the pilot is doing, and availability. Information stored behind gatekeepers, like conference presentations, should also be posted to easily located public places, like the pilot webpages on the TECH Clean California website.
- Conclusion: Some of the tested approaches have begun to scale, but the degree of scaling isn't yet clear, and success isn't guaranteed given changes in the national policy and funding landscapes.
  - **Recommendation**: Create a framework or plan for scaling promising approaches uncovered by the pilots. Dedicate resources to their expansion, including by vehicles outside of the TECH Initiative such as CalNEXT, CalMTA, and the nascent California Heat Pump Partnership. Look for and, if needed, eliminate redundancies across programs. For scale-up grant recipients, clearly define which approaches are expanding and the reasons behind their expansion. Study the scaling results and improve the approaches iteratively. Direct resources to

areas with lower heat pump adoption, such as Southern California. Ensure that scale up activities support the removal of market barriers to further market transformation.

- Conclusion: The market barriers facing households in Disadvantaged Communities (DACs), including limited access to capital and the substantial remediation needs of housing stock for electrification, are deeply entrenched and difficult to overcome. Although pilot projects and QSGs have demonstrated some small-scale solutions to address these challenges, they have yet to provide a clear pathway for scaling these efforts to larger markets. Activities such as funding building remediation projects, which are critical to addressing these issues, currently lack the necessary long-term and robust funding streams required for widespread implementation. This underscores the need for sustainable financial mechanisms and policy frameworks to overcome these persistent barriers and support the broader electrification of households in DACs.
  - Recommendation: To the extent feasible with available resources, TECH Clean California should prioritize forming long-term partnerships with additional funders who can continue to address market barriers in DACs. At the same time, TECH Clean California should focus on continuing to evolve their equity-driven market strategy to include more tactics than rebates and funding building remediations residence by residence, as such activities may be unsustainably expensive and limited to benefiting direct recipients rather than removing market barriers at the scale needed to meet California's decarbonization goals.
- Conclusion: The evaluation team lacks sufficient evidence to determine if the large-scale pilot strategy is worthwhile because four of the large-scale pilots have not yet produced their final reports and information about their learnings and successes is thus not yet widely distributed. However, the completed pilots generated useful data and information for furthering market transformation and the ongoing pilots show potential to do the same.
  - Recommendation: Assess the value of the pilot strategy when all pilots have concluded. Consider the value of the knowledge, data gained, and scaling potential compared to the cost and time needed to carry out the pilots. Also, the CPUC may opt to define reasonable expenses for pilots and QSGs and require VEIC and Energy Solutions to adhere to the definition in future efforts.
- Conclusion: The QSGs in particular may provide more strategic value in the near-term given their fast pace, quick results, and low cost.
  - Recommendation: If the TECH Initiative receives additional funding to support a new cohort of QSGs, dedicate resources to identifying additional organizations that could carry out QSGs in areas that have lacked QSG applicants to date. Consider if successful QSG organizations could partner with new organizations to cross-pollinate ideas and support implementation of QSGs in new geographic areas.
- Conclusion: VEIC effectively implemented the pilot strategy, with the majority of interviewed and surveyed respondents pleased with their management and support.
  - Recommendation: Document lessons learned about overall pilot strategy management and implementation. Include feedback from this report in continuous improvement processes and work with Energy Solutions to adjust oversight processes as needed.

APPENDIX A. SUMMARY OF QSG PROJECTS

Table 9. TECH QSG Projects in Cohorts 1 and 2

QSG	Cohort	Grantee Organizations	Primary Barriers Targeted	Primary Strategies
Testing HPWH in Manufactured Housing	2021	AESC	Lack of field data on HPWH installation costs and non-energy benefits in manufactured and mobile homes.	▪ Install HPWHs in 10 manufactured homes. ▪ Study effect of cool HPWH exhaust air on air conditioning costs and resident comfort. ▪ Quantify energy, cost and GHG impacts.
Bridging the Gap to Heat Pump Adoption: Water Heater Loaner Program	2021	Barnett Plumbing	Customers often cannot wait for permits and electrical work needed to switch from a gas water heater to a HPWH.	▪ Test gas water heater loaner program to allow time for permits and upgrade work without customers needing to go without hot water. ▪ Study impacts of incentive availability and long-term cost savings.
Better Buildings San Luis Obispo Program	2021	▪ Bloc Power ▪ City of San Luis Obispo	Retrofitting existing buildings to become all-electric is an ongoing challenge.	▪ Complete electrification projects in 10-12 affordable multifamily housing units. ▪ Establish a community advisory board to support equitable rollout.
Addressing Home Repair Barriers in Marin Clean Energy's Home Energy Savings Program	2021	Franklin Energy	Deferred maintenance and needed repairs often prevent LMI single family homeowners from upgrading to heat pumps.	Fund home repairs in tandem with Marin Clean Energy's Home Energy Savings Program, which funds heat pump installations, completing 47 home upgrades.
Visual Service Software	2021	Institute of Heating and Air Conditioning Installers (IHACI)	Lack of trained and qualified personnel to service and install HVAC equipment.	Test Visual Service software for remote technician support and system operation and performance monitoring.
Statewide 120-Volt HPWH Field Study	2021	▪ New Buildings Institute (NBI) ▪ Richard Heath and Associates (RHA) ▪ kW Engineering	▪ Higher upfront and installation expenses for HPWHs. ▪ Higher installation complexity for HPWHs. ▪ Frequent lack of 240V electrical supply for standard HPWHs. ▪ Installer and consumer bias towards conventional water heaters. ▪ Lack of confidence in HPWHs. ▪ Lack of understanding of long-term cost savings and environmental benefits of HPWHs.	Install and monitor 120V HPWHs in 32 homes.
Addressing Non-Standard Fuel Switching Through	2021	Redwood Coast Energy Authority (RCEA)	High upfront cost of heat pump space conditioning and water heating.	▪ Target customers within gas service territory but who are not

QSG	Cohort	Grantee Organizations	Primary Barriers Targeted	Primary Strategies
Heat Pump Incentives in Rural, Northern. California				connected to the natural gas grid and use delivered fuels. ▪ Layer contractor and customer rebates to support 19 heat pump installations.
Alameda County Green and Healthy Homes	2021	Revalue.io	▪ Typical outreach about home electrification Is not persuasive to low-to-middle income (LMI) households. ▪ LMI households often have significantly deferred maintenance that prevent equipment upgrades and present health hazards. ▪ Shortage of contractors serving the LMI segment.	▪ Test an approach to electrifying single-family LMI housing while eliminating home health hazards. ▪ Develop and provide training to contractors from underrepresented backgrounds.
Packaged Central Heat Pump Boiler System	2021	Small Planet Supply	▪ Lack of industry knowledge in designing and installing central HPWHs. ▪ Complexity of central HPWH design.	▪ Develop a standardized, modular, pre-packed central HPWH. ▪ Install the packaged central HPWHs in 5 buildings in an apartment complex.
Basset Avocado Heights Advanced Energy Community HPWH Initiative	2021	▪ The Energy Coalition ▪ Day One ▪ Water Heater Warehouse ▪ Enso Building Solutions	▪ High first cost of HPWHs. ▪ Complexity of fuel switching. ▪ Lack of confidence and trust in new technologies. ▪ Lack of awareness about household and community benefits of electrification.	▪ Community outreach to educate and build trust. ▪ Add HPWH assessments and installations to existing California Energy Commission Electric Program Investment Charge (EPIC) project. ▪ Install 20 HPWHs in project homes. ▪ Create energy champions to foster diffusion.
Electrifying the Green Affordable Housing Program	2021	▪ US Green Building Council-LA (USGBC-LA) ▪ AEA ▪ VCA Green	Lack of funding and financing options for multifamily housing within disadvantaged communities.	▪ Perform electrification feasibility assessments and engagement sessions with management and residents. ▪ Install 11 heat pump retrofits in naturally occurring affordable multifamily housing properties.
Aligning Community Allowances with Electrification	2022	▪ Bright Power ▪ Climate Action Campaign	Inaccurate utility allowances discourage electrification in subsidized rental housing because of increased operating costs to property owners.	▪ Research utility allowances and related conditions for public housing authorities. ▪ Develop and disseminate resources on how utility allowances effect heat pump installations and how affordable housing owners can access accurate utility allowances.

QSG	Cohort	Grantee Organizations	Primary Barriers Targeted	Primary Strategies
Heather Village: Decarbonizing a Multi-Owner Equity Community	2022	▪ Viridis Consulting ▪ Heather Village Homeowners Association (HOA) ▪ Introba ▪ Carbon Zero Buildings	▪ Fixed-income homeowners struggle to pay HOA fees to fund electrification. ▪ Maintenance of amenities in older multifamily communities competes with funding other upgrades. ▪ Homeowner lack of awareness of heat pumps. ▪ Older multifamily housing stock has significant deferred maintenance and often missing electrical plans. ▪ Multifamily complexes mix shared and individually metered areas/technologies, and sometimes few meters, which complicates upgrades and funding for them. ▪ Decision-making in HOAs is often lengthy and complex.	▪ Conduct a technical and economic feasibility analysis for heat pump domestic water heating, space heating, and pool heating. ▪ Conduct an educational campaign for HOA board members and homeowners about benefits of heat pumps. ▪ Co-fund a central HPWHA demonstration project. ▪ Develop best practices to facilitate switching to heat pumps in HOAs.
Scaling Heat Pump Retrofits in Housing with Cost Barriers	2022	▪ Climate Resolve ▪ USGBC-LA	▪ Lack of rigorous data analysis on GHG impacts of heat pump retrofit projects. ▪ Limited access to green financing for retrofits.	▪ Install and monitor 30 heat pumps replacing natural gas equipment. ▪ Calculate energy savings, cost savings, GHG emissions reduction, and cost per ton GHG emissions reductions from monitoring data. ▪ Develop a GHG calculator.
Developing Targeted, Inclusive Marketing Materials & Educational Materials for Equitable Electrification	2022	▪ Diversity Coalition of San Luis Obispo County ▪ RACE Matters SLO ▪ Central Coast Coalition for Undocumented Student Success ▪ BlocPower	Current messaging strategies on electrification and climate change often fail to consider the backgrounds and contexts of underserved communities.	Develop effective messaging and create marketing materials and recommendations to connect with BIPOC and LMI communities.
Fast Path to Clean Indoor Air	2022	▪ 350 Bay Area ▪ El Concilio of San Mateo County ▪ Redwood Energy ▪ Cal Poly Humboldt ▪ BlocPower	▪ Heat pump HVAC retrofits are prohibitively expensive for low-income renters. ▪ Renters lack decision-making authority to install heat pump HVAC. ▪ Low consumer awareness of heating capabilities of heat pumps.	▪ Distribute 26 portable heat pump HVAC units and air purifiers to renters. ▪ Investigate effects on household indoor air quality and temperatures, and cost effectiveness.
Career Pathways to Advance HVAC Trades in Heat Pump Services	2022	Goodwill Southern California	Lack of skilled workforce for maintenance and installation of heat pumps.	▪ Via the Career Tools program, provide workforce placement and preparation support for HVAC

QSG	Cohort	Grantee Organizations	Primary Barriers Targeted	Primary Strategies
				trades, with a focus on heat pumps. ▪ Provide instruments to qualified participants to help them get hired.
Sacramento Home Energy Equity Project	2022	▪ City of Sacramento ▪ Sacramento Municipal Utility District (SMUD)	▪ Limited awareness and confidence in heat pumps. ▪ High upfront costs for heat pump retrofits. ▪ Significant costs for home upgrades. ▪ Rebate complexity. ▪ Limited collaboration between groups seeking to advance home electrification. ▪ Whole-home electrification for low-income homeowners risks gentrification and neighborhood destabilization.	Complement existing housing stabilization project by providing heat pump installations in 20 low-income single-family homes, including full electrification of two homes.
Creating the Standard: HPWH Retrofit Best Practices	2022	Richards Health & Associates (RHA)	▪ HPWH retrofits are complex and contractors are thus less willing to install HPWHs. ▪ Lack of industry agreed-upon best practices and guidance for HPWH installations.	Create a Best Practices Manual and Job Aids via a broad subject matter expert advisory group.

Source: QSG final reports and QSG descriptions published at https://techcleanca.com/quick-start-grants/

Opinion **Dynamics**

CONTACT:

Lauren Bates
Associate Director
lbates@opiniondynamics.com

Ellen Steiner, Ph.D.
Vice President
steiner@opiniondynamics.com

BOSTON
PORTLAND
SAN DIEGO
SAN FRANCISCO