Opinion Dynamics

TECH CLEAN CALIFORNIA ENGINEERING DESK REVIEWS

FINAL REPORT

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I. EXECUTIVE SUMMARY

The Technology and Equipment for Clean Heating (TECH) Initiative incentivizes the installation of space-conditioning heat pumps (HVAC HPs) and heat pump water heaters (HPWHs) to displace existing fossil-fueled equipment. TECH does this through market incentives, supply chain engagement, workforce development, consumer education, regional pilots, and Quick Start Grants. The Initiative's overall goal is the full-scale transformation of the residential heat pump market in California.

This report summarizes the findings from engineering desk reviews[1] conducted for a sample of TECH projects by Opinion Dynamics (from here on referred to as 'the Team') for the TECH Clean California program. The Team completed 81 engineering desk reviews for a sample of TECH-incentivized HVAC HP and HPWH projects; This document presents the methodology and results associated with our review. The engineering desk reviews were used to validate the approach and estimated energy and greenhouse gas (GHG) impacts claimed by the program implementer, Energy Solutions. The implementation team currently maps TECH (HPWH and HVAC HP projects to existing eTRM[2] deemed fuel substitution measures and some conventional same-fuel energy efficiency measures, to calculate the deemed energy impacts used for claims reporting. However, per the program implementation plan, these values are only temporary placeholder values and will eventually be replaced by values derived from consumption data analysis. In addition, the TECH program is focused on decarbonization not energy efficiency, so the TECH measures are not subject to the eligibility nor other implementation requirements of conventional EE fuel substitution measures.

For each of the 81 desk reviews, the Team reviewed the project documentation, program tracking data, and the mapping approach used by the implementation team to validate the ex-ante savings being claimed by the program.

I.I KEY FINDINGS FROM ENGINEERING DESK REVIEWS

Table 1 summarizes our most significant desk review findings and recommendations, while Table 2 summarizes overarching decarbonization program framework issues. Section 3 details our sample frame, sample design, and desk review methodology. One overarching recommendation from the desk reviews is to ensure that ex-ante savings estimates are updated based on advanced metering infrastructure (AMI) consumption analyses and end-use metering (EUM) study results once they are available. The key findings followed by Opinion Dynamics' recommendations are summarized below. Due to the ever-evolving nature of the TECH program, and based on responses to a preliminary review of this report by the program implementer, we recognize that some of these findings and recommendations may have already been considered by the program.

[1] An engineering desk review is an in-depth review of the tracking data and all documentation provided for each project. It includes verification of the methodology used to calculate energy impacts, validation of equipment specifications, and other independent verification such as web searches or phone/email questions posed to the participant. Desk reviews do not include a physical visit to the project location.

[2] California's eTRM (Electronic Technical Reference Manual) is an online repository of California's deemed energy efficiency measures. It also includes supporting documentation.

Table 1. Key Findings and Recommendations

Key Finding	Recommendation
1. A significant number of ducted unitary HVAC systems used the energy savings for a ductless mini-split measure (SWHC044-02) because all ducted unitary measure baseline scenarios included pre-existing cooling, and only the ductless measure had at least one baseline scenario with no pre-existing cooling (see Table 8)	1A. The TECH team should develop TECH-specific measure specifications and requirements based on the TECH program data, and deemed energy and GHG reduction impacts based on the consumption data analysis. TECH measures focus on decarbonization through GHG reductions and do not require source energy savings like conventional EE fuel substitution measures, which limits the application of existing eTRM measure packages to the existing condition scenarios common in TECH installations.
2. Data values are removed and replaced with a comment "removed…".	2A. Original data should be retained, and a flag or other notation should be used to note the discrepant values. 2B. Alternatively, the data could be moved to a comment field, and a code could be used (e.g., -9, -99, etc.) to indicate a discrepancy.
3. The variety and quality of documentation provided with each project varied significantly across projects.	3A. Improve project documentation completeness and consistency by providing a more specific checklist of the required documents (e.g., invoices, certifications, signed contracts, pre- and post-install photos, etc.) and more explicit descriptions of what each required photo should capture.[3]
4. The claim form does not provide any explicit requirements for photos, and some photos were missing or unreadable due to poor resolution.	4A. Provide more specific requirements for the photos so that they can be used to verify pre- and post-equipment types, configurations, and model numbers. 4B. Also, ensure that photos are high-quality and that labels are readable if they are provided. This will support make, model, and serial number validation. For example, ideally, two photos would be provided for the pre- and post-install conditions: 1) A macro-photo of the equipment and 2) A clear, readable close-up of the nameplate. The photos should also be reviewed for readability before approval.[4]

[3] Energy Solutions indicated that to strike a balance between mandating a fixed format and recognizing that contractors had their own forms and approaches, only the specific information needed was specified but not the specific format.

[4] Energy Solutions has indicated that this suggestion has already been implemented for the recent HPWH relaunch, which added specific requirements for photos and two photo fields: one for a full view of the HPWH and one for a closeup of the nameplate. Photo requirements for HP HVAC will also be reviewed before relaunching the program under a new structure. However, HVAC installations can vary significantly so a specific list of photos may be difficult beyond a full shot of the condenser, the nameplate, and the capped gas line photo (recently added). A review of the installed unit serial number from the nameplate photo is a priority since it is used to confirm the same unit is not being submitted on multiple claims.

Key Finding	Recommendation
5. The set of documents provided for each project was inconsistent. In addition, CF2R forms (present 57% of the time) indicated a like-for-like sizing approach despite the conversion to a heat pump.	5A. The program application and quality control review should clarify which CF forms are needed and how they will be used. The CF2R issue should be investigated further to determine how to interpret "like-for-like" and what approaches are really being used to size the HP systems, especially when there is no existing AC equipment which is more likely in mild/cooler climate zones. The proper sizing of these systems is critical to ensuring they operate as intended and maximize achievable GHG savings.[5]
6. The reported HPWH UEF values in the tracking data differ from the AHRI Certification Directory values that were manually checked by the desk reviews for 50% of the projects. AHRI is a reputable source for HVAC and water heating efficiency values. These discrepancies suggest that savings for these projects could be overstated or understated.	6A. The TECH program is sourcing the AHRI Directory for equipment parameters and their qualified products list (QPL) so this discrepancy is puzzling but could be due to round-off errors or use of specification sheets instead of AHRI. This issue should be investigated further and/or add additional steps to the quality-checking process to ensure accurate UEF values are reported.
7. TECH HPWH project storage tank sizes do not align well with the eTRM HPWH measure tank size assumed in measure version SWWH025-05, so the claimed energy and GHG impacts may not be a good representation of project impacts. The wide variation in post-installation water heating tank size (45 to 83 gallon) versus the limited eTRM measure offerings (40-50 gallon) adds significant uncertainty to HPWH energy and GHG impact estimates. The storage tank size can impact the need for supplemental electric resistance heating.	7A. The TECH team should develop their own measure specifications and requirements using the TECH program data, and use the consumption data analysis to develop deemed energy impact and GHG reduction claims for TECH-specific measures.
8. Five percent of the sampled HVAC HP projects were dual-fuel (i.e., included emergency back-up gas heating). eTRM fuel substitution measures used by TECH (SWHC044-02 and SWHC045-01) do not cover dual-fuel heat pumps.	8A. The TECH team should further investigate these projects which are only partial decarbonization, and develop energy impacts and GHG reductions for this unique configuration using consumption data analysis and EUM study results when available.
9. The efficiency of some TECH-incentivized HVAC systems is at the Title 24 code-minimum efficiency 14 SEER value, which is below the minimum efficiency required for eTRM fuel substitution measures. Claimed savings for these units will be overstated, and also represents a "lost opportunity" to use a higher-efficiency heat pump.	9A. Consider adding higher-efficiency HVAC HPs (15 or 16 SEER minimum) as an eligibility requirement for TECH incentives, consistent with current same-fuel and fuel substitution EE program requirements, The latest eTRM measures also use the SEER2 equipment rating basis instead of SEER but the general recommendation is still applicable.[6]

[5] Energy Solutions indicated that they defer to the local authority having jurisdiction (AHJ) when determining what forms are needed. There was also some initial uncertainty about what HERS forms were required, but this was clarified in the relaunched program, so HERS form consistency should be improved. The program also did not examine the system sizing approach, but this is also being considered for the relaunch.

[6] Energy Solutions indicated that upping the efficiency requirements was considered but not adopted for the first TECH phase since the goal was GHG reductions via displacement of onsite gas use, and not energy savings. However, the next iteration of the HVAC program will increase emphasis on adopting higher efficiency HVAC systems.

Key Finding	Recommendation
10. TECH HVAC HP eTRM measure mapping is currently done based on cooling SEER, but the emphasis of electrification is on space heating, not cooling. This can create discrepancies between the eTRM and the tracking data in the alignment of HP heating efficiency values.	10A. Do not map TECH HVAC HP measures to eTRM measure packages. Instead, the TECH team should develop TECH-specific measure specifications and requirements based on the TECH program data, and energy and GHG reduction impacts based on the consumption data analysis. 10B. Prioritize mapping HVAC HP measures using heating efficiencies given the focus on decarbonizing space heating, though 11A can address the issue.
11. Only 7% of the sampled projects indicated a panel upgrade was needed. Typically, only a single photo was provided, rather than a pre- and post-photo. For one project, the tracking data was deleted and replaced with a note: "Removed during QA."	11A. For panel upgrades that occur as part of a TECH project, obtain both a pre- and post-photo and ensure the numbers on the circuit-breaker are readable. 11B. Also, retain original data values and add a flag if the contractor-provided values are out of range.
13. Panel size (amps) was missing from the tracking data for 11% of the projects.	13A. Given the impact of electrical panel size on electrification, electrical panel size should be a requirement for every project. 13B. A readable photo of the panel that shows the main breaker and breaker amperage should also be required.[7]

Source: Opinion Dynamics desk reviews of single-family TECH projects.

Table 2. Overarching Decarbonization Program Framework Findings and Recommendations

Key Finding	Recommendation
1. The conventional EE program "savings" nomenclature does not work for decarbonization, GHG-focused programs.	1A. Use an "impact" based metric to avoid the confusing discussion of "negative savings" for increased electricity use. The impact approach refers to "increased electricity use" and "displaced (not just decreased) gas use," which are positive and negative energy impacts, respectively. This approach also facilitates the straightforward calculation of GHG reductions.
2. eTRM fuel substitution measures do not align completely with TECH program measure offerings, which contributes to uncertainty in TECH savings claims.	2A. The TECH team should develop TECH-specific measure specifications and requirements based on the TECH program data, and deemed energy and GHG reduction impacts based on the consumption data analysis.
3. A significant number of TECH participants (38% to 55%) have PV or PV/battery systems, which can significantly affect customer bills and grid energy and GHG impacts.[8]	3A. Energy impact estimates for decarbonization programs, regardless of how they are generated (e.g., eTRM, consumption data analysis, or metering studies), should account for both PV and battery systems to provide the most accurate estimate of energy and GHG impacts.

[7] Energy Solutions indicated that the importance of this data is understood and appreciated. There was an early discussion with Opinion Dynamics where we suggested dropping the panel photo as it was not providing value. In addition, initially if poor panel size data was the only deficiency, we processed claims as-is rather than holding them up for corrections to clear the extensive claim backlog. However, the need for this data to be accurate and complete is understood and will be reiterated to our staff.

[8] We found that 31 (38%) of the desk review sites had PV systems, four of which also have battery systems. The systems were distributed relatively evenly between northern and southern climate zones, though slightly more PV systems are located in Southern California. For the full recruitment sample (431 projects), about 55% (235 projects) had PV, and 21% (92 projects) had a PV-plus-battery system.

Key Finding	Recommendation
4. Recent fuel substitution measure evaluation reports show extremely low realization rates (about 2%) for claimed gas space heating savings. This is most likely due to these systems being used primarily to add cooling rather than displace existing gas heating, which could be a similar situation for TECH.	4A. Take an immediate and focused look at this concern as part of the AMI consumption data analysis, and also explore this issue with future customer surveys for participants who implemented mini/multi-split projects. The results of this exploration will inform TECH program requirements and any ex-ante savings updates for future mini/multi-split installations.

Source: Opinion Dynamics desk reviews of single-family TECH projects.

2. INTRODUCTION

The TECH Initiative, publicly known as TECH Clean California, launched in December 2021. TECH Clean California is an initiative designed to help advance the state's mission to achieve carbon neutrality by 2045 by driving the market adoption of low-emissions space and water-heating heat pump technologies for existing single-family and multifamily residential homes. The Initiative was created as part of California Senate Bill 1477. Through a combination of market incentives, supply chain engagement, workforce development, consumer education, regional pilots, and Quick Start Grants, the Initiative installs low-emissions space and water-heating heat pump technologies in existing homes across California.

The Initiative's overall goal is full-scale market transformation of the heat pump market in California to ensure a thriving market for clean heating technologies in the next ten years. To do so, the Initiative is designed to be a centralized program used to create best practices for statewide implementation for all existing and potential heat pump HVAC and HPWH programs. To achieve lasting scale, the Initiative will pave a path for a favorable decarbonization policy that makes heat pumps cost-competitive with incumbent technologies.

Opinion Dynamics is responsible for evaluating the TECH Initiative. Utilizing our Whole Independent Systems Evaluation (WISE™) framework, we maintain our third-party independent voice as we walk alongside Energy Solutions, the prime implementer for the Initiative, and its team of sub-contractors so that we can infuse real-time evaluation insights into every step of program design and implementation. This approach creates effective feedback loops to help all parties better understand complex market adoption patterns, program strategies' effectiveness, and course correction opportunities.

This report summarizes the findings from a series of engineering desk reviews conducted by Opinion Dynamics for the TECH Clean California program. The Team completed 81 engineering desk reviews for a sample of TECH projects and heat pump technologies; this document presents the methodology and results associated with our review.

3. BACKGROUND, METHODS, AND RESULTS

This section of the report presents a summary of the background, methodology, and results from our engineering desk reviews.

3.1 BACKGROUND

The Team used the engineering desk reviews to validate the approach used to estimate energy and greenhouse gas (GHG) impacts claimed by the program implementer, Energy Solutions. The implementation team currently maps TECH heat pump water heater (HPWH) and HVAC heat pump (HVAC HP) projects to existing eTRM deemed fuel substitution measures (and some same-fuel measures) to calculate the energy impacts used for claims reporting. For each of the 81 desk reviews, the Team reviewed the project documentation, program tracking data, and the mapping approach used by the implementation team to validate the ex-ante savings being claimed by the program.

The desk review sample was initially designed to be integrated with the TECH end-use metering (EUM) study.[9] The thought behind this approach was that it would allow us to contextualize the results of the EUM data and AMI consumption analysis results for these sites. However, the CPUC requested a change in the EUM approach, which delayed the fielding of the EUM study. After coordinating with the CPUC, the Team decided to move ahead with the desk reviews and separate them from the EUM study sample. The desk reviews may still be used to contextualize the results of the EUM data, though the extent to which there will be an overlap in the samples is unknown at this point.

This engineering desk review process highlighted a key issue related to the implementation and evaluation framework for the TECH program. The key issue is that a decarbonization framework requires a paradigm-shift away from the conventional energy efficiency "savings" metric to an "impact" metric to avoid confusing discussions of "negative savings". For a decarbonization program framework, there will always be an increase in electricity use and displacement (not just a decrease) of gas use, which are positive and negative site energy impacts, respectively. Using an energy impact approach also facilitates a more straightforward calculation of GHG reductions since the sign of the energy impacts is correct once fuel-specific GHG factors are applied. For this reason, we use an "impact" approach for all energy and GHG discussions in this document and have converted traditional "savings" values from the eTRM measures and TECH tracking data system to energy impact values.

KEY EM&V FRAMEWORK NOTE

The decarbonization framework requires a paradigm-shift away from the conventional energy efficiency "savings" metric to an "impact" metric to avoid the confusing discussion of "negative savings". In a decarbonization framework, there will instead be increased electricity use and displaced (not just reduced) gas use. This document uses an impact approach for all energy and GHG discussions.

[9] The end-use metering element of the TECH evaluation plan employs electrical panel circuit-level metering for a sample of single-family TECH program participants. The heat pump equipment, whole-building use, solar generation, and other significant electric loads will be monitored.

3.1.1 DESK REVIEW OBJECTIVES

The detailed objectives for the desk reviews, as outlined in the original version of the TECH impact evaluation work plan,[10] are listed below:

- Develop an understanding of the pre-installation state through a review of program tracking data and AMI data for each of the sampled sites,
- Capture contextualizing information to support our end-use metering analysis,
- Assess whether the assumptions in the current Statewide Deemed Measure Lists are appropriate for fuel-substitution measures from both a planning and evaluation perspective based on empirical household data,
- Provide the implementation team with feedback on their analytical approach, and
- Inform the development of the EM&V framework.

For each sampled project, we will review an array of primary and secondary data, including:

- TECH program tracking data and project documentation to determine the make/model of pre- and post-retrofit equipment to validate the tracking data values and energy impact estimates.
- Participant survey data captured by the evaluation team, including post-installation customer survey data (where present) and a pre-installation survey for end-use metering participants, which will be used to gather additional contextual site and heat pump operation information.
- Assigned deemed measure packages and assumptions used by Energy Solutions to develop their ex-ante impacts. In cases where deemed measures were not used, we will request the energy impact estimation methods from Energy Solutions.

This list formed the basis of our desk review approach but was modified and limited due to separating the desk reviews from the EUM installation process. In addition to the original desk review objectives, we also reviewed the electrical panel photos provided with the TECH project documentation for the potential to inform the CPUC infrastructure upgrade work that Opinion Dynamics is also supporting.[11]

3.1.2 DESK REVIEW TARGETS

The desk review sample was initially designed to be integrated with the EUM study. As such, the Team used the EUM sample targets to develop the desk review targets by technology type. The preliminary technology-level EUM and desk review sample targets from the evaluation plan are presented in Table 3. Although this table was intended for use with the originally planned EUM study, these high-level quotas were repurposed for the separated, independent desk review study.

To develop these preliminary targets, we used the TECH tracking database version from August 2022 and focused exclusively on single-family homes. The TECH tracking data is continuously cleaned and updated with new projects by Energy Solutions, so it is essential to note the vintage of TECH tracking data used for any analysis. For example, Opinion

[10] "Impact Evaluation of Technology and Equipment for Clean Heating (TECH) Initiative Workplan". Opinion Dynamics. March 3, 2023. https://pda.energydataweb.com/api/view/2795/Opinion%20Dynamics%20Final%20TECH%20Impact%20Plan_2023-03-03.pdf. Note that the workplan is currently being updated to incorporate the additional phases of the TECH Clean CA program funding.

[11] The "Fuel Substitution Infrastructure Market Study Research" for the CPUC is currently underway. It will assess the costs of residential and commercial upgrades needed to support decarbonization/electrification and support the development of the Viable Electric Alternative (VEA) concept for phasing out gas measures.

Dynamics receives updated databases every two weeks. There have also been major overarching updates like the addition of multifamily projects to the primary database, which had previously been tracked separately.

Table 3. Preliminary Sample Design for End-Use Metering from the TECH Evaluation Plan

System Type	Measure Category[12]	Anticipated Sample Frame (Number of Participants)	Anticipated Sample Needed for Onsite Metering Recruitment	Anticipated Survey Recruitment Sample	Anticipated Site Metering Sample	Participant Recruitment Census Attempt[13]
Heat Pump Water Heater	Heat Pump Water Heater	1,053	1,000	100	20	Yes
HVAC Heat Pump	Ductless Mini Splits	2,210	1,000	100	20	No
	Central Unitary Systems	6,629	2,000	200	40	No
Total		**9,892**	**4,000**	**400**	**80**	

Source: TECH Evaluation Plan, Table 4 and TECH program tracking data (August 2022)

3.2 SAMPLE FRAME AND SAMPLE DESIGN

Rather than sampling from the entire population as originally envisioned, we leveraged the Opinion Dynamics 6-month post-installation participant survey[14] to identify participants interested in the EUM study. This recruitment effort yielded more than 558 possible metering candidates, even more than the 400 envisioned in the preliminary plan. This dataset served as the sample frame for the desk reviews.

We conducted a follow-up survey of the 558 respondents to provide more detailed information about the EUM site visits and meter installation requirements and obtained additional contextual information to inform our analysis. This included, but was not limited to, information surrounding the number of occupants in the home, the presence of solar and battery storage, the presence of existing energy monitoring systems, and any upcoming plans that may affect energy consumption over the next year. Only 431 respondents expressed continued interest in the EUM study. Opinion Dynamics reviewed the responses and removed an additional 103 sites for various reasons, as documented in the TECH End-Use Metering Sampling Plan memo.[15] This left us with 328 viable participants for the EUM/desk review evaluation. Opinion Dynamics requested and received project documentation for all 328 of these projects from Energy Solutions. All but one of these 328 records were single-family homes and were initially selected to achieve diversity for geography and technology type. From these 328 records, we chose the following random sample for our detailed desk reviews: 21 single-family homes with heat pump water heaters, 20 with ductless mini/multi splits, and 40 with unitary central ducted air source heat pumps.

[12] The "Ductless Mini Splits" measure category maps to the "Mini/Multi Split" TECH Product Type. The "Central Unitary Systems" measure category encompasses both "Split Unitary Equipment" and "Packaged Unitary Equipment" TECH Product Types.
[13] This field denotes that the entire population was targeted for recruitment rather than a smaller sample of the population.
[14] "TECH Clean California Heat Pump Equipment: Insights into Customer Experience and Satisfaction". September 15, 2023. https://techcleanca.com/documents/2377/TECH_Customer_Experience_and_Satisfaction_Final_Report_9.15.23.pdf
[15] "TECH End-Use Metering Sampling Plan" internal memo. May 17, 2023. Opinion Dynamics for CPUC Abhi Wadhwa.

3.2.1 FINAL SAMPLE SELECTION PROCESS AND TARGETS

The desk review sample started with the high-level targets outlined in the original TECH End Use Metering Sampling Plan memo but attempted to use proportional allocation of the total quota to each technology group and to reflect the California climate zone distributions observed in the full single-family population dataset. However, in some cases, the resultant sample targets for a sample cell (technology and climate zone) exceeded the number of projects for which documentation was available from the 328 projects in the project documentation request. We redistributed sample points as needed into other climate zones for these cases but retained the same technology quotas (see highlighted cells). One extra desk review was also completed due to oversampling. Table 4 presents the final distribution of sampled projects by technology type and climate zone. The desk review sample does not have all technologies in every climate zone because there are also many gaps in the uptake and representation of technologies across the climate zones in the full single-family project population, as shown in the next section.

Table 4. Desk Review Target Quotas by Technology Group and Climate Zone

Climate Zone	Heat Pump Water Heater (HPWH) Projects	Ductless Mini/Multi Split (msHVHP) Projects	Central Air Source Heat Pump (cHVHP) Projects
CZ01	0	0	0
CZ02	2	2	1
CZ03	4	4	1
CZ04	1	1	0
CZ05	0	0	0
CZ06	0	2	2
CZ07	1	3	5
CZ08	1	0	4
CZ09	1	2	3
CZ10	1	1	6
CZ11	1	0	1
CZ12	9	5	8
CZ13	0	0	1
CZ14	0	0	0
CZ15	0	0	8
CZ16	0	0	0
Total	**21**	**20**	**40**

Source: TECH tracking data (dated 8.29.23) and evaluation team analysis

3.3 SINGLE-FAMILY POPULATION DATA ANALYSIS

To provide additional program-level context for the desk review results, the Team analyzed the most current version of the program tracking data available at the time of the analysis. We analyzed the August 2023 program tracking data, filtering on single-family projects, which are the focus of the desk review, and further excluding any projects that were missing energy and GHG savings values. Through this process, we verified that the 328 sites that constituted our desk

review sample frame were still present in the data. We used the Claim ID field as the unique identifier throughout the sampling and desk review process.

The distribution of single-family project types by technology type and climate zone is presented in Table 5. The "Unitary Systems" technology type includes both packaged and split-system HVAC HPs. The "Small Duct High Velocity" technology type is a new TECH Product Type, which was not present in the data when the evaluation plan was written. This new system type is not represented in the desk review sample, but these are a tiny fraction of the total projects. However, these projects potentially represent one of the most efficient HVAC HP solutions available, so they should be considered for a future evaluation or as a separate case study analysis.

Table 5. Distribution of Single-Family TECH Projects by Technology Type and Climate Zone

Climate Zone	Population (Number of projects)				
	Heat Pump Water Heater	Ductless Mini Split	Small Duct High Velocity	Unitary Systems	Total
1	5	31	0	6	42
2	124	355	2	153	634
3	537	709	3	253	1,502
4	98	185	1	112	396
5	9	17	0	5	31
6	38	159	2	487	686
7	63	356	2	694	1,115
8	61	132	2	712	907
9	79	191	1	721	992
10	75	157	2	984	1,218
11	86	149	0	223	458
12	897	559	3	1,630	3,089
13	32	35	0	550	617
14	11	177	0	68	256
15	2	20	0	1,498	1,520
16	13	28	0	38	79
Total	**2,130**	**3,260**	**18**	**8,134**	**13,542**

Source: TECH tracking data (dated 8.29.23) and evaluation team analysis

We also generated a high-level summary of the energy impacts by technology type and by eTRM Work Paper ID (the field name used in the TECH tracking data) to assess the coverage and representation of our desk reviews versus the population. Annual estimates of energy and GHG impact values, based on eTRM measure package assignments, were available in the project tracking data for all completed projects. These results are shown in Table 6 and Table 7, respectively.

Table 6. TECH Tracking Data Single Family Annual Energy and GHG Impacts Summary by Product Type

Product Type	Product Group	Total Annual GHG Reduction (Metric tons CO2e)	Total Annual Displaced Gas Use (therms)	Total Annual Increased Electricity Use (kWh)	Total Quantity of Heat Pumps	Number of Projects
Split Unitary Equipment	HVAC	6,976	-1,657,485	8,595,980	7,494	7,064

Product Type	Product Group	Total Annual GHG Reduction (Metric tons CO2e)	Total Annual Displaced Gas Use (therms)	Total Annual Increased Electricity Use (kWh)	Total Quantity of Heat Pumps	Number of Projects
Packaged Unitary Equipment	HVAC	1,045	-258,191	1,537,701	1,109	1,064
Mini/Multi Split	HVAC	3,041	-686,749	2,851,951	3,462	3,228
Heat Pump Water Heater	HPWH	1,527	-408,551	3,028,669	2,145	2,089
Small Duct High Velocity	HVAC	18	-4,302	24,585	20	18
	Total	**12,605**	**3,015,278**	**16,038,886**	**14,230**	**13,463**

Note: This table reflects negative or positive energy use impacts instead of a conventional "savings" metric, which changed the sign of the TECH reported values.
Source: TECH tracking data (August 2023) and evaluation team analysis

Key observations for single-family TECH projects from Table 6 include:

- There are a total of 13,463 projects accounting for 14,230 heat pumps, which shows that some TECH projects received more than one heat pump.
- Unitary HVAC HPs (split and packaged combined) account for the vast majority of projects, energy impacts, and GHG reductions. Packaged unitary systems are much less common than split-systems.
- Mini/multi-split (ductless) HVAC HPs account for the second largest share of projects and impacts.
- The GHG benefit per unit for HPWHs is substantially lower than that for Package Unitary HVAC systems. Heat pump water heaters were the third most common project type (2,145 units) which provided a GHG reduction of 1,527 MT CO2e for a per unit GHG reduction of 0.712 MT CO2e per project. Doing a similar calculation for Package Unitary HVAC HPs with a similar total GHG reduction of 1,045 MT CO2e and 1,109 units yields a per unit GHG reduction of 0.942 MT CO2e per project. About 30% more HPWHs (0.942/0.712=1.32)) are needed to achieve the same GHG reduction as achieved by the package unitary HVAC HPs based on the deemed measure impacts. Furthermore, the average HVAC system displaced 224.5 therms compared to 204.5 therms for the average heat pump water heater.
- Very few Small Duct High Velocity projects were incentivized.

Table 7. TECH Tracking Data Single Family Energy and GHG Impact Summary by Work Paper ID

Work Paper ID	Work paper Short Description	Product Group	Total GHG Reduction (Metric tons CO2e)	Total Displaced Gas Use (therms)	Total Increased Electricity Use (kWh)	Total Quantity of Heat Pumps	Number of Projects
SWHC044-02	Fuel Substitution, Residential Ductless HVAC	HVAC	6,386	-1,441,407	5,967,083	6,588	6,246
SWHC045-01	Fuel Substitution, Residential Heat Pump HVAC	HVAC	4,353	-1,083,400	6,595,663	4,975	4,669
SWWH025-05	Fuel Substitution, Residential HPWH	HPWH	1,420	-382,944	2,891,010	1,947	1,934
0	None (uses TECH default algorithm)	HVAC	338	-81,920	454,977	473	451
0	None (uses TECH default algorithm)	HPWH	90	-25,607	217,284	147	145
SWHC050-02	Residential Ductless HP (electric baseline)	HVAC	2	N/A	-7,505	49	46
SWWH014-04	Residential HPWH (electric baseline)	HPWH	17	N/A	-79,624	51	51
		Total	**12,605**	**-3,015,278**	**16,038,886**	**14,230**	**13,542**

Note: This table reflects negative or positive energy use impacts needed for GHG savings calculations instead of a conventional "savings" metric that is used in TECH reporting. This approach essentially changes the sign of the TECH-reported values.
Source: TECH tracking data (dated 8.29.23) and evaluation team analysis

Key observations for single-family TECH projects versus eTRM work papers from Table 5 include:

- For the HVAC HPs, only two fuel substitution Measure Packages are used: SWHC044 for ductless HVAC HPs and SWHC045 for central, ducted HVAC HPs.
- A majority of the energy and GHG impacts are attributed to the ductless HVAC HP Work Paper ID SWHC044, which differs significantly from the summary by Product Type in Table 6.
- The number of HVAC HP projects by Work Paper ID does not line up with those provided in Table 6 by unitary and mini-multi split system type. For example, Work Paper ID SWHC044 shows 6,246 projects, but Table 6 for mini\multi splits shows only 3,228 projects. This issue was investigated for the desk reviews.
- Only a single eTRM Work Paper ID (SWWH025) is used for HPWHs.
- A small portion of both HVAC and HPWH projects are not aligned to any Work Paper ID, yet energy and GHG impacts are claimed. This discrepancy was investigated for the desk reviews.
- A small number (19) of HPWH (SWWH014) and HVAC HP (SWHC050) projects are not fuel substitution measures but are instead conventional energy-efficiency, same-fuel measures that use an electric resistance baseline as noted. This is illustrated by the N/A values in the reduced gas use column and a reduction (negative sign) instead of an increase in electricity use. The TECH program incentivizes projects with existing electric resistance heating systems that are not eligible for fuel substitution site-level decarbonization measures, but there are only a small number of these projects, and we excluded them from the evaluation sample.

Because eTRM measures are periodically updated, we also checked the eTRM for the current-active versions of each Measure ID and found the following:

- **Fuel Substitution Ductless HVAC.** A newer version of SWHC044 (-03 versus -02) is available. It has an effective start date of Nov. 13, 2023, and no end date, indicating it is indefinitely valid.

- **Fuel Substitution Heat Pump HVAC (Central, ducted).** A newer version of SWHC045 (-02 versus -01) is available. It has an effective start date of Nov. 13, 2023, but an end date of Dec. 31, 2023. Given this end date, we assume a newer version must be under development.
- **Fuel Substitution HPWH.** A newer version of SWWH025 (-06 versus -05) is available. It has an effective start date of Apr. 25, 2023, and no end date, indicating it is indefinitely valid.
- **Electric baseline Ductless HP.** A newer version of SWHC050 (-03 versus -02) is available. It has an effective start date of Nov. 08, 2023, and no end date, indicating it is indefinitely valid.
- **Electric baseline HPWH.** SWHC014-04 is the most current version. It has an effective start date of Jan. 01, 2023, and no end date, indicating it is indefinitely valid.

The TECH program claims began circa 2021/2022, but all eTRM fuel substitution measures were updated in 2023. Therefore, the deemed savings values are technically out of date for those cases where an updated eTRM version exists. However, rather than using the updated fuel substitution values for future claims, the planned AMI consumption data analysis should be used to develop more accurate estimates of energy impacts for decarbonization-electrification measures.

3.4 ENGINEERING DESK REVIEW APPROACH

The evaluation team used a two-step approach to evaluate Energy Solutions' process of mapping TECH decarbonization projects to CA eTRM deemed fuel substitution and same-fuel measures. The first step was to review and understand the Python code that was used to match TECH program measures to eTRM measures[16] to obtain the energy impacts used for interim reporting claims. The second step was to compare individual project documentation and tracking data to the eTRM measure offering details and evaluate the correctness of the application to the specific project. The engineering review was conducted in an Excel workbook that included manual and automated lookups and checks.

The primary TECH tracking data fields that identify the eTRM measure used for each project are the Work Paper ID and Measure Offering ID. Work Paper ID identifies the highest-level eTRM measure characterization document that comprehensively describes the measure. The term "workpaper" was superceded by "measure package" for the eTRM, but Work Paper ID is the TECH data field name so we did not change it. The Measure Offering ID field represents "a unique combination of measure determinants that are specifically defined for each measure"[17] and is the record-level source for the energy impacts (i.e., increased electric use and displaced/reduced gas use). The primary characteristics, in addition to building type, that are used to determine which measure offering and permutation is applicable for a specific project are measure application type, delivery type, climate zone, baseline technology configuration, unit size/capacity, and efficiency of the new equipment. The eTRM measure package and associated measure offerings encompassed by this evaluation are discussed in the subsequent sections.

3.4.1 REVIEW OF ETRM MEASURE MAPPING APPROACH

The evaluation team reviewed the approach used by Energy Solutions to map TECH heat pump projects to eTRM measures. The single-family claims, which comprise the bulk of the TECH claims, are assigned deemed electricity, therms, and GHG claimed values using a Python script matching them to CA eTRM measure offerings. The evaluation team first reviewed all supporting documentation provided by Energy Solutions to ensure that the code was consistent with the assumptions and their proposed methodology. Energy Solutions provided a secondary Excel sheet[18] , which

[16] The eTRM measure used for each project is noted in these TECH data fields: "Work Paper ID" and "Measure Offering ID".
[17] "eTRM User Guide for Base Users". Version 2.2. August 25, 2021.
[18] "TECH All Measures Mapping to eTRM.xlsx" dated 4/21/2023.

was populated with measure descriptions and used by the code to perform the eTRM matching. The evaluation team checked to ensure the measure descriptions and savings permutations included in the sheet were consistent with those found in the CA eTRM. We then stepped through and evaluated the mapping code to ensure that it was consistent with the methodology document provided by Energy Solutions. This code review also involved re-running the code on the tracking data to ensure outputs were the same as reported by Energy Solutions. As an additional test to understand the details of the eTRM measures, we also created our own dataset of mocked-up TECH claims and used this data, with an in-depth review of the eTRM measure characterization, to manually align each record to an eTRM measure and measure offering. We then ran this mocked-up data set through the Energy Solutions code and checked to see if the code delivered the same result as our manual review, and it did.

Due to the limited number of measures in the eTRM, not all the claims fall perfectly within a measure category definition, but Energy Solutions outlined their prioritization of fields for mapping within the methodology document. The code accurately reflects the prioritization outlined in the methodology documentation, but the validity of those assumptions is discussed in detail in the sections below.

Once claims are mapped to a measure offering, the electricity and gas energy impacts associated with the measure offering are then scaled by the cooling capacity in the case of an HVAC claim and the count of units installed for a HPWH claim. Annual GHG emissions reductions are calculated by multiplying electricity and gas energy impacts by the California Air Resources Board (CARB) statewide average annual GHG emissions factors in metric tons of carbon dioxide equivalent (MT CO_2e):

- For electricity energy impacts, the GHG factor is 0.00021182 MT CO_2e per kWh
- For natural gas energy impacts, the GHG factor is 0.0053072 MT CO_2e per therm

We verified the correct application of these factors by comparing our calculated GHG values to the claimed values, as described in the next section. The original reference source for these values was not provided in the Energy Solutions methodology document. However, we obtained a copy of the definitive source, a 2021 GHG workbook provided by CARB[19] to Energy Solutions, and we were able to review and confirm the GHG factors. Slightly different electricity and gas GHG factors are available from the latest version of the CARB tool (0.00021 and 0.005302, respectively), but Energy Solutions is maintaining the original values because they were used for the TECH program savings goals.

Of the 81 projects we reviewed, only one was not mapped to an eTRM measure in the tracking data. The code still produced electric and gas savings using a function to return default heat pump water heater gas and electric savings. The default function takes the building type, previous water heater type, and previous water heater fuel type, and returns the savings from an average of the savings for all measure offerings consistent with these key parameters.

3.4.2 PROJECT DOCUMENTATION AND TRACKING DATA REVIEW

The second and more rigorous step of the review process was comparing the project documentation with the tracking data records and the detailed baseline and efficient technology assumptions for the assigned eTRM measures. The project documentation required for TECH projects is specified and collected on the TECH application forms. [20] There are more documentation requirements for HVAC HPs than HPWHs. The proof of installation, contextual documents, and photo files required by TECH for each technology are summarized below:

[19] GHG factors are sourced from the *Emissions Factor* tab of the 2021 CARB GHG benefits estimation tool (*GHG_Benefits_Estimation_Tool - TECH 2021.xlsx*). The newest version is available at https://arb.ca.gov/cc/capandtrade/allowanceallocation/ghg_benefits_estimation_tool.xlsx.

[20] File "TECH HP HVAC Claim Form with menus.pdf" and "TECH HPWH Claim Form with menus.pdf" both dated 8/29/2022. We also referenced the checklists that provide the requirements for document and photos: "HVAC checklist app.docx" and HPWH checklist app.docx dated 7/15/2022.

- **HVAC Projects.** Project documentation requirements from the HVAC application form include a copy of the invoice, equipment pre- and post-installation photos, electrical panel photos, approved CF-3R forms, and Manual J/Manual D calculations. Optional (if completed) documents include the ASHRAE 221-2020 Heating System Performance Rating or Cooling System Performance Report and Form CF3R MCH-20-H Duct Testing Report.
- **HPWH Projects.** Project documentation requirements from the HPWH application form include a copy of the invoice, photos of the equipment pre- and post-installation, and photos of the electrical panel.

The basic approach used to compare documentation to the tracking data for all sampled projects was as follows:

- Request and obtain all available project documentation, including signed contracts, invoices, pre- and post-installation pictures, HERS compliance forms and certification reports, and, in some cases, Manual J calculations. These documents were submitted to meet TECH incentive application requirements. The TECH documentation requirements varied by project type, and the documents and quality of photos provided by contractors varied significantly across projects.
- Use the AHRI Directory of Certified Performance (https://www.ahridirectory.org/) and manufacturers' specification sheets to verify the performance specifications of existing and new equipment from the make/model numbers.
- Verify the address, building type, and climate zone using project documentation and Google Maps.
- Review project information in the program tracking data and verify the information is consistent with the project documents and photos.
- Use the verified information to map to an eTRM measure for each project and compare the energy impacts to the claimed values.
- Run the eTRM measure mapping code to ensure that our results align with the program tracking data. Note any projects where the evaluated eTRM measure differed from the tracking data.

We developed an engineering review workbook to ensure a systematic review of each project. One tab of the workbook contains the list of questions that guided the engineering review. The reviewer used the program tracking data along with the documentation submitted with the claim to answer these questions. The primary objective of the review was to validate the electric and gas energy impacts and identify any issues with the documentation, tracking data, or eTRM measure assignments. The desk review checklist elements and questions are summarized below:

Project Documentation Review. This set of questions was used to validate basic and essential characterizations of the site and project:

- Is the assigned climate zone correct for the zip code?
- Can the building type be verified using Google Maps and the provided customer address?
- Can the data baseline equipment and fuel type be verified from photos?
- Can the installed equipment make/model be verified (using post-install photos/invoice?

TECH Data Validation. This set of questions was used to compare basic tracking data information versus project documentation:

- Can you verify the nominal and rated capacity of the installed system from a spec sheet or AHRI directory?
- Can you verify the efficiency rating of the installed system through a spec sheet or the AHRI directory?

PTD and Measure Review Comments. This checklist is the most extensive set of review questions and compares the TECH program tracking data (PTD) values to the eTRM measure characteristics, and includes the following checks:

- Can you verify the indicated project description using the available data?

- Through manual mapping, can you verify that the correct eTRM measure was mapped for savings calculations (Replacement type, building type, minimum efficiency, climate zone, installed equipment, baseline equipment)?
- Can you use the permutations and formulas in the manual savings calculation tab to replicate the ex-ante electricity and gas savings and GHG savings?
- Can you replicate your above results using the TECH eTRM measure mapping Python script?

Panel Upgrade Investigation. This checklist was used to validate electrical panel whole-house capacity (amperage) and panel upgrade information. We compared the tracking data values versus the photo(s) included with the project documentation. The checklist items were as follows:

- If the project required a panel upgrade, does the documentation include baseline and installed panel board information?
- Review and disposition of panel photo: do they confirm the program tracking data values?
- If the pre and post-panel size values differ, can we verify that the project is flagged for a panel upgrade?

We also reviewed and summarized the distribution of post-installation electrical panel amperages in conjunction with the panel upgrade assessment.

Check for the presence of solar/PV and battery systems. The presence of solar photovoltaic (PV) and battery systems at a home will significantly impact both overall and time-varying energy use, which can directly impact GHG impacts. The TECH tracking data does not currently flag the onsite presence of these systems, but we did ask about the presence of these systems as part of our EUM recruitment survey and noted this information for the projects in our desk review sample. We found that 31 (38%) of the desk review sites had PV systems, four of which also have battery systems. The systems were distributed relatively evenly between northern and southern climate zones, though slightly more PV systems are located in Southern California. For the full recruitment sample (431 projects), about 55% (235 projects) had PV, and 21% (92 projects) had a PV-plus-battery system.

3.5 DESK REVIEW RESULTS

Our engineering desk review evaluation findings are summarized in the sections below.

3.5.1 ETRM WORK PAPER ID MATCHING

A summary of the eTRM measure Work Paper IDs and specific measure offerings by TECH product type for the completed desk reviews is presented in Table 8. Each Measure Offering ID represents a unique savings value and specific application. For example, measure offering parameters might include building type, climate zone, baseline system type, etc. The desk review sample covered only a small subset of Measure Offering IDs. Key observations and findings from Table 8 include:

- The Work Paper IDs included in our desk review sample are a good representative sample of the Work Paper IDs in the full TECH participant population (Table 7) that account for the majority of program energy and GHG impacts.
- HPWHs are covered by a single eTRM measure (SWWH025), but there are eight different measure offerings. One project was not assigned to an eTRM measure because the base case used propane, which is outside the scope of

the fuel substitution measure. The energy impacts for this project were estimated using the Energy Solutions default approach previously described.

- There are three HVAC heat pump product types, but only two eTRM measure Work Paper IDs (SWHC044 and SWHC045). Work Paper ID SWHC045 covers both packaged and split unitary system types.
- Almost half of the Split Unitary Equipment projects (15 of 31) and one of the packaged unitary systems were assigned to the *ductless* HVAC eTRM measure (SWHC044), which appears to be an incorrect mapping since the unitary systems are central *ducted* systems and quite different from ductless systems. We learned that this mapping was intentional, though it has the potential for claimed savings discrepancies:
  - The Energy Solutions methodology document explained that the eTRM central ducted system measure (SWHC045) does not include energy impacts *for a baseline scenario where there is no existing air conditioning (AC) system*. However, existing AC is an *eligibility requirement* for the fuel substitution measure; that is, the measure cannot be applied to a project that does not have an existing AC system. This requirement is needed to ensure source energy savings for the fuel substitution measure. However, the TECH program is not subject to these criteria, and the energy impacts are just placeholder claim values. That said, energy impacts for a ductless versus a ducted system are likely significantly different due to the fan energy for the ducted system.
  - This scenario is a prime example of where conventional energy-efficiency fuel substitution measures are not entirely applicable to decarbonization program measures as the TECH program implements them. TECH claimed energy impacts should be developed for TECH-specific measures using either the AMI consumption data analysis, or alternatively a detailed building simulation analysis of the ducted measure reconfigured to include a no AC baseline scenario. The consumption data analysis will also need to consider this split Work Paper ID application for unitary HVAC HP systems when truing up the claims.

Table 8. Distribution of Desk Review Sample by Product Type and eTRM Measure

TECH Product Type	eTRM Work Paper ID and Measure Description	Measure Offering ID	Number of Projects	Total Projects by System Type
Heat Pump Water Heater	SWWH025-05 Heat Pump Water Heater, Residential, Fuel Substitution	AB	1	21
		AG	2	
		AH	1	
		AJ	2	
		AK	1	
		AL	7	
		AP	3	
		AO	3	
	MISSING	0	1	
Mini/Multi Split	SWHC044-02 Ductless HVAC, Residential, Fuel Substitution	A	1	20
		C	4	
		I	1	
		J	2	
		K	3	
		L	9	
Split Unitary Equipment	SWHC044-02 Ductless HVAC, Residential, Fuel Substitution	I	5	15
		J	4	
		K	2	
		L	4	
	SWHC045-01 Heat Pump HVAC, Residential, Fuel Substitution	A	3	16
		B	2	
		C	5	
		D	6	
Packaged Unitary Equipment	SWHC044-02	J	1	1
	SWHC045-01 Heat Pump HVAC, Residential, Fuel Substitution	A	4	8
		B	1	
		D	3	
		TOTALS	**81**	**81**

Source: TECH tracking data (dated 8.29.23) and evaluation team analysis

The evaluation team replicated and confirmed the measure mapping for all of the desk review projects using the Python script provided by Energy Solutions. The Team found discrepancies between the program tracking data and other sources, such as the site photos and AHRI database for many of the claims. However, most of these discrepancies were minor and did not impact the measure mapping and claimed savings. For example, in many cases, the Energy Solutions team rounded up the equipment efficiencies, contributing to a very slight overestimation of claimed savings. Specific instances of rounding and its implications are discussed in the next section.

3.5.2 GENERAL PROGRAM TRACKING DATA REVIEW

The evaluation team found that the program tracking data had minimal missing information and various discrepancies when compared to other sources of information, such as the AHRI database and the site photos. For the latest version

of the TECH tracking data available at the time of our review (8.29.2023), the few discrepancies we found on the full dataset of single family projects (a project is a single record in the dataset) included:

- 597 projects were missing a Work Paper ID (meaning no measure was mapped to the claim)
- 164 projects were missing an AHRI reference number
- 31 projects were missing claimed savings.
- 18 projects were missing the model number for installed equipment
- 2 projects had zip codes that did not match CA Climate Zones

However, these discrepancies were not a concern and filtering was expected because this is a dynamic dataset that is constantly being updated with new participant data including partially complete projects. The desk review sampled projects had the following discrepancies:

- Many fields had been changed, added, and/or updated since the original version of the TECH tracking data used for the evaluation and sample plans. But these changes are at least partially expected for a pilot program where the tracking data structure is constantly being re-evaluated, improved, and revised to accommodate new tracking data elements and findings such as those from the Opinion Dynamics participant and contractor surveys.
- Two HPWH projects reported a higher cooling capacity than found in the AHRI database, ten heat pump water heaters had unit energy factor (UEF) performance rating discrepancies, two had first-hour rating discrepancies, and two had rated storage volume discrepancies.
- Two HVAC HP projects were associated with AHRI reference numbers that could not be found in the AHRI database (Claim IDs: 1040110, 1043174)
- For the sampled projects, 17 of them (21%) had a discrepancy between the invoice and program tracking data. Most of these discrepancies involved dates, contractor information, or costs and did not impact the measure mapping. Sixteen projects (20%) had similar discrepancies between program tracking data and HERS reports, and four (5%) had discrepancies with the Title 24 CF3R or CF1R code compliance reports.

3.5.3 PROJECT DOCUMENTATION REVIEW

The tracking data and project documentation collected by TECH are much more extensive and detailed than other programs we have evaluated, especially midstream programs, and the Energy Solutions TECH team deserves recognition for this effort. However, the evaluation team found several issues that impacted the desk reviews where additional improvements should be considered:

- **Missing equipment pre-/post-install photos.** 10% of the sampled projects did not include a photo of the pre-install equipment, and 11% of the projects were missing photos of the post-install, TECH-incentivized equipment.
- **Missing or unreadable equipment pre-/post-install nameplate/model number photos.** 49% of the sampled projects did not include a photo of the pre-installation equipment that included the model number.[21] For the post-install equipment, 7% of the projects were missing a photo that included the model number. For seven projects (9% of the sample), the provided photos were blurry, hard to read, or illegible. The TECH claim form includes this note below the file upload box, “including equipment nameplate,” which emphasizes the need for this information. However, it does not specify that the photo must be readable, and we are unsure if this is a QC step for Energy Solutions.

[21] Energy Solutions noted that most replaced equipment is in such poor shape that a model number photo from the existing gas furnace is not required.

- **Pre-install equipment photos with tracking data discrepancies.** For two projects (2% of the sample), the program tracking data lists the previous AC as "None"; however, the project folder included a picture of an old compressor. The photos may show an old AC unit that was broken and not operational, but no explanation was provided in the project documentation. The presence of an existing AC system, working or not, is important for determining if a panel upgrade is needed. If no AC is present, then a 240V breaker has to be added to the panel, which would be considered a panel upgrade.

Although the primary focus of the desk reviews was to evaluate the claimed energy impacts for HVAC HP projects, we also scanned the Title 24 compliance documentation and had the following observations:

- **HVAC HP Title 24 compliance form (CF) packages are incomplete or missing.** Many of the projects (23/60, 38%) were missing a complete set of CF1R, CF2R and CF3R forms, and a majority only included the CF3R Certificate of Verification form. In addition, three of the HVAC HP projects (5%) did not include any CF forms but did have a copy of the "CHEERS Registry Product Status Report," which certifies the CF forms were completed.
- **HVAC HP CF2R Forms are not reporting a change in system type.** We also scanned the Title 24 CF2R forms, specifically the "Method Used to Calculate HVAC Loads" block of the form. For the projects that included CF2R forms (34/60, 57%), a "like-for-like" sizing approach was most typically indicated in spite of the conversion from gas furnace heating to a heat pump system. Eight of the "like-for-like" projects also included Manual J calculations, though it is unclear if the calculations were used to size the heat pump systems. If the homes for these projects previously had air conditioning (AC), then like-for-like could mean the heat pump was sized to the existing AC unit. Additional research outside the scope of our desk reviews would be needed to investigate this issue further.

A detailed list of project-level engineering review dispositions for each sampled project is provided in Appendix A.

3.5.4 HEAT PUMP WATER HEATER PROJECT REVIEW RESULTS

The sample of 21 desk-reviewed HPWH projects primarily replaced natural gas storage water heaters, but one project replaced a propane-fueled water heater. The pre-existing gas storage water heaters ranged in size from 29 to 50 gallons, but the majority were 40-to-50 gallons. The rated storage volumes of the new heat pump water heater tanks ranged from 45 to 83 gallons, showing a significant upsizing from the pre-existing water heaters. The newly installed heat pump water heaters have uniform energy factor (UEF) ratings of 3.34 to 3.85 UEF. Other desk review findings are discussed below:

Equipment UEF rounding can slightly affect energy impact estimates. We found three heat pump water heater mapping instances that resulted in a slight overstatement of claimed savings. The three claims highlighted in Table 9 had actual efficiencies of 3.45 or 3.46 UEF and were matched to a measure offering using a 3.5 UEF. But there is another measure offering equivalent in all aspects except having a lower 3.3 UEF. The Energy Solutions mapping methodology states, "*The matched measure's measure case UEF must not exceed the claim's UEF (for installed equipment) if there is another measure with otherwise equivalent measure case equipment features except for having a larger measure case UEF.*" In other words, Energy Solutions should round the UEF down, but that did not happen in these cases. When the evaluation team recalculated energy impacts for these three claims after mapping to the measure with a 3.3 UEF, the electricity impacts were 103%, and the gas and GHG impacts were 98-99% of the 3.5 UEF measure. This suggests that rounding up efficiency values has only a relatively minor impact on claimed savings and realization rates.

Imperfect matching to eTRM fuel substitution measures. Several heat pump water heaters could not be matched perfectly to an eTRM measure. In five cases, the rated storage volume of the new heat pump water heater was 80+ gallons, which is much larger than the 40-to-50-gallon replaced equipment. The eTRM did not have measure offerings that perfectly represented this scenario. The measure case storage capacities for the SWWH025-05 measure offerings did not exceed 55 gallons for the base case 40-to-50-gallon storage natural gas water heater. The Energy Solutions

measure mapping methodology prioritizes previous water heater size over new water heater size, and the evaluation team could replicate the measure matching using this prioritization approach. However, using the size of the storage tank installed with the heat pump is a more accurate approach. The most recent update to this eTRM measure addresses this issue and creates new measure categories that would allow all three claims to be matched perfectly to the new measure configurations. This situation illustrates the evolving nature of HPWH fuel substitution measures and the need for the eTRM to leverage the TECH program's actual installation data. But this also most poignantly illustrates the need to develop TECH-specific measure definitions, scenarios, and the associated energy and GHG impacts.

Rated UEF discrepancies. The Team identified discrepancies between an independent make/model lookup in the AHRI database UEF versus the UEF reported in the program tracking data for ten heat pump water heater claims, which is half of those sampled. These discrepancies ultimately did not impact eTRM measure mapping because the efficiencies still fell within the same range of equipment efficiencies represented by the eTRM measures, but it does suggest that additional QC of the UEF values may be warranted. There was also a discrepancy in the first-hour rating between AHRI and the program tracking data for three of the claims, yet the measure mapping was unaffected. Table 9 below presents the TECH tracking data UEF, the verified UEFs and the matched eTRM measure offering Minimum UEF for all sampled heat pump water heater projects. The UEFs were verified through project documentation, including nameplate photos, AHRI database lookup, and/or model specification sheets if needed. Equipment efficiencies that fell below the measure minimum efficiency threshold requirement are noted by the grey-shaded cells.

Table 9. Heat Pump Water Heater Efficiencies by Measure Offering

Claim ID	TECH Data UEF	Verified AHRI UEF	Percent Difference in UEF	Measure Offering ID Matched	Minimum UEF of Measure Offering
1059760	3.85	3.85	0%	AB	3.75
1032707	3.34	3.34	0%	AG	3.3
1033315	3.34	3.34	0%	AG	3.3
1046476	3.39	3.39	0%	AH	3.3
1019907	3.5	3.5	0%	AJ	3.5
1029668	3.42	3.46	1%	AJ	3.5
1070734	3.45	3.45	0%	AK	3.5
1052668	3.46	3.64	5%	AL	3.5
1046795	3.48	3.59	3%	AL	3.5
1017700	3.5	3.5	0%	AL	3.5
1068471	3.46	3.46	0%	AL	3.5
1048898	3.48	3.59	3%	AL	3.5
1052724	3.46	3.64	5%	AL	3.5
1039942	3.55	3.55	0%	AL	3.5
1067525	3.75	3.88	3%	AO	3.75
1049696	3.75	3.88	3%	AO	3.75
1052892	3.75	3.75	0%	AO	3.75
1061234	3.75	3.88	3%	AP	3.75
1040877	3.75	3.88	3%	AP	3.75
1028673	3.75	3.88	3%	AP	3.75
1041139	3.39	3.44	1%	N/A	N/A

Note: The highlighted rows indicate where HPWH UEF was matched to a slightly higher UEF measure offering.
Source: TECH tracking data (dated 8.29.23) and evaluation team analysis

3.5.5 HVAC HEAT PUMP PROJECT REVIEW RESULTS

The desk-reviewed HVAC heat pump project sample included 20 mini/multi-split HVAC heat pumps (msHVHP) and 40 unitary central HVAC heat pumps (cHVHP), including both packaged and split unitary equipment. Three of the HVAC HP projects (5%) appeared to be dual-fuel systems (e.g., emergency back-up gas furnaces), but the vast majority of projects indicated the pre-existing gas furnace was fully decommissioned. Dual-fuel heat pumps are not covered by the eTRM fuel substitution measures used by the TECH program, so the claimed reduction in gas use and increased electricity use for these three projects will be overestimated. This is another illustration of the need for TECH-specific measure definitions, scenarios, and the associated energy and GHG impacts for program claims.

HVAC HP desk review findings related to performance rating issues are presented in Table 10 and discussed below:

SEER efficiencies below eTRM fuel substitution measure requirements. Much like the heat pump water heaters, the HVAC heat pumps were also mapped in a way that resulted in an overestimation of claimed savings. Six of the central HVAC heat pumps (15%) had efficiency values below the 15 SEER/8.7 Heating Seasonal Performance Factor (HSPF) minimum efficiency eligibility requirement for the fuel substitution measure. Two of these claims had a 14.5 SEER, while the other four were at the code-minimum 14 SEER. The HSPF values for these units ranged from 8.0 to 8.7 HSPF. Deemed energy-efficiency measures only incentivize above-code measures, but this is not a requirement for the GHG-focused TECH program decarbonization measures. The 15 SEER fuel substitution measure was the only one available to Energy Solutions, but using this measure results in an underestimation of the increased electricity use for the TECH project code-minimum efficiency units. Allowing the use of code-minimum efficiency for TECH projects also represents a lost opportunity to install higher-efficiency units and further reduce the electrified load being added to the grid. This issue further demonstrates the incomplete matching of the eTRM measures to TECH decarbonization applications and also illustrates the need and immediacy for developing better energy impacts from the planned TECH consumption data analysis and EUM study.

HSPF efficiencies below eTRM fuel substitution measure requirements. In addition to the six projects with both SEER and HSPF ratings below the eTRM measure requirements, there were an additional 16 projects (27%) for which the HSPF values fell below the eTRM measure required minimum efficiency value. The Energy Solutions mapping methodology does not even include HSPF as part of the mapping criteria.[22] Energy Solutions prioritized mapping the SEER and did not map to an equivalent measure with a lower SEER to meet the HSPF threshold, but we recognize this approach would have greatly complicated the algorithm. However, many of the HSPF values were below the eTRM measure threshold by only a minor amount, so the overestimation of claimed savings is likely small when viewed on a per-project basis. In addition, all of the HSPF values are at or well above code-minimum values (8.0-8.2 HSPF). However, since the primary new electrical load from HVAC HP conversion is due to space heating, perhaps more attention should be focused on the HSPF values and matching eTRM measures based on HSPF rather than SEER.

Table 10 shows the equipment SEER and HSPF discrepancies for the 22 projects (36%) discussed above. Equipment cooling and heating efficiencies that fell below the measure minimum efficiency threshold requirement are noted by the grey-shaded cells. We also reviewed the 2023 updates to the eTRM measures, which showed slight increases in the ductless heat pump (SWHC044) HSPF minimum relative to the same SEER minimum standards. In addition, for both of the HVAC heat pump eTRM measures (SWHC044 and SWHC045), the minimum SEER for the baseline scenario *increased* from 15 to 16 SEER. The eTRM measure updates also included additional measure offerings with even higher SEER values (categories up to ≥ 22 SEER for SWHC044, ductless HVAC, and ≥ 20 SEER for SWHC045, central heat pumps). These changes incorporate the continual improvements in heat pump technology, market availability, and standard practice represented by the base case change from 15 to 16 SEER. It also means that the overestimation of

[22] From the Energy Solutions methodology document: "The claim's installed equipment's SEER must not exceed the matched measure's measure case SEER by equal to or more than 1.0 units if there is another measure with otherwise equivalent measure case equipment features except for having a larger SEER". There is no mention at all in the document about checking the HSPF.

TECH claimed energy impacts could increase in magnitude if the TECH program continues to map to these eTRM measures without revising their own minimum efficiency requirements. The increased 15 to 16 SEER baseline makes the lost opportunity to encourage customers to install higher-efficiency HPs even greater if TECH measures continue to be allowed to just meet the code-minimum efficiency levels of 14 SEER and 8.0-8.2 HSPF.[23]

Table 10. HVAC Heat Pump Projects with SEER or HSPF Values Below eTRM Measure Minimum Efficiency Values

Claim ID	Desk Review Verified SEER	Verified HSPF	Work Paper ID matched	Measure Offering ID Matched	Minimum SEER of Measure Offering	Minimum HSPF of Measure Offering
1041126	14	8.0	SWHC045-01	A	15	8.7
1046906	14	8.0	SWHC045-01	A	15	8.7
1064039	15	8.2	SWHC045-01	A	15	8.7
1060331	14	8.0	SWHC045-01	A	15	8.7
1065964	15	8.4	SWHC045-01	A	15	8.7
1068877	16	8.2	SWHC045-01	B	16	9
1069024	16.5	8.75	SWHC045-01	B	16	9
1029285	17.5	9.0	SWHC045-01	C	17	9.4
1029564	18	9.6	SWHC045-01	D	18	9.7
1070125	18	9.6	SWHC045-01	D	18	9.7
1067404	18	9.6	SWHC045-01	D	18	9.7
1066743	18.5	9.0	SWHC045-01	D	18	9.7
1031197	18.5	9.0	SWHC045-01	D	18	9.7
1042374	15	8.5	SWHC044-02	I	15	8.7
1031274	14.5	8.5	SWHC044-02	I	15	8.7
1063037	15.5	8.5	SWHC044-02	I	15	8.7
1067101	14.5	8.2	SWHC044-02	I	15	8.7
1064143	14	8.2	SWHC044-02	I	15	8.7
1051216	16	8.7	SWHC044-02	J	16	9
1039758	16	8.2	SWHC044-02	J	16	9
1033208	18	9.6	SWHC044-02	L	18	9.7
1064399	18	9.6	SWHC044-02	L	18	9.7

Note: Highlighted cells indicate equipment efficiency falling below the measure threshold
Source: TECH tracking data (dated 8.29.23) and evaluation team analysis

3.5.6 ELECTRICAL PANEL UPGRADES AND SIZES

Electrical Panel Upgrades. As shown in Table 11, only six of the 81 sampled projects (7%) had a panel upgrade indicated in the TECH tracking data. For these projects, we reviewed the project photos and the tracking data pre- and post- panel amperage values. If the pre-/post- values were different, we verified that the panel upgrade flag was checked. We also attempted to validate the pre- and post- amperages in the tracking data versus the photos, but the project documentation typically only included a single photo of the panel, or the photos provided were too blurry to read

[23] For units manufactured on or after 1/1/2023, efficiency requirements are changing to SEER2 and HSPF2.The TECH tracking data system is configured to track both values.

the panel amperage. For one project, the pre- and post- panel amperages were noted as "Removed during QA," indicating that the values were discrepant and removed as part of Energy Solutions' quality assurance process.

Table 11. TECH Data Projects Flagged as a Panel Upgrade

Product Type	Pre-Panel Amps	Post-Panel Amps
Split Unitary Equipment	200	300
Mini/Multi Split	200	300
Mini/Multi Split	200	300
Heat Pump Water Heater	100	200
Mini/Multi Split	100	200
Heat Pump Water Heater	Removed during QA	Removed during QA

Source: TECH tracking data (dated 8.29.23) and evaluation team analysis

Post-Installation Electrical Panel Sizes. Due to the increased interest in assessing the need for panel upgrades, we also examined the post-installation panel sizes for the 81 desk review projects. Results presented in Table 12 show the majority of panels (54%) are 200 amps (A) or greater, with four projects as large as 300 A. Three of the four 300 A projects are the panel upgrade projects shown previously in Table 11. Only 2% of the projects have panels that are less than 100 amps. For 11 % of the projects, the electrical panel size was either not recorded or removed by Energy Solutions for unexplained quality assurance (QA) reasons.

Table 12. Post-Installation Electrical Panel Amperages for Desk Review Projects

Post-Panel Amps	Number of Projects	Percent of Projects
300	4	5%
220	1	1%
200	39	48%
180	1	1%
150	1	1%
145	1	1%
125	8	10%
120	1	1%
100	14	17%
60	1	1%
50	1	1%
Not provided	6	7%
Removed during QA	3	4%

Source: TECH tracking data (dated 8.29.23) and evaluation team analysis.

3.5.7 DECARBONIZATION PROGRAM FRAMEWORK CONSIDERATIONS

Our desk reviews illustrated several critical issues that will need to be considered and addressed for both the implementation and evaluation frameworks for decarbonization/electrification programs. Those issues include:

- **Conventional EE "savings" versus decarbonization "impact" metric.** The decarbonization framework requires a paradigm shift away from the conventional energy efficiency "savings" metric to an "impact" metric to avoid the confusing discussion of "negative savings." In a decarbonization framework, there will always be an increase in electricity use and complete *displacement* (not just a decrease nor "savings") of gas use, which are positive and negative energy impacts, respectively. This approach also facilitates the straightforward calculation of GHG reductions since the GHG factors can be applied directly to the positive and negative energy impacts and simply added together to get the GHG impact reduction.
- **Fuel Substitution measures are not compatible with decarbonization measures.** The imperfect matching of TECH program decarbonization measures with fuel substitution measures – especially efficiency and eligibility requirements – is not surprising. Fuel substitution measures have to deliver energy savings – which is only accomplished by employing a "source energy" rather than the historical "site energy" approach – versus a focus on GHG reductions. This concern is understood by the TECH program in that the eTRM fuel substitution measure savings values are referred to as placeholder values. However, our desk review results illustrate the urgent need for measure definitions, scenarios, and energy impact estimates that better represent the TECH-specific decarbonization measures. The AMI consumption data analysis, with additional insights provided from the Opinion Dynamics end-use metering study, will be the ultimate source of actual realized energy impact values. The result of this work will also likely support the need to develop a new set of TECH-specific decarbonization measures instead of continuing to use the energy-efficiency based fuel substitution measures beyond the TECH pilot program.
- **A significant percentage of participants have solar/PV systems, which impact the site-level realized energy impacts.** The presence of solar photovoltaic (PV) and battery systems at a home will significantly impact both overall and time-varying energy use, which directly affects customer bills and GHG impacts. We found that 31 (38%) of the desk review sites had PV systems, and four of these homes also had battery systems. For the full EUM recruitment sample (431 projects), about 55% (235 projects) had PV, and 21% (92 projects) had a PV-plus-battery system. The effect of solar and solar/battery is not typically considered for deemed measures because the saturation of PV is assumed to be low. PV homes are also often excluded from consumption data analysis due to the lack of a solar flag on utility billing frames, the unavailability of solar generation data (only net metered use is available from utilities), and the complexity of the required analysis. But for the TECH program – and this might apply to decarbonization programs in general –high PV saturations cannot be ignored. Developing separate PV and non-PV home energy and GHG impact values is imperative for decarbonization programs. The annual energy use and grid-impact electric load shapes can be significantly different especially during PV-generation hours, and the load shapes are used to determine the GHG impacts for the increased electricity consumption for the heat pumps. This is another reason for and critical aspect of the need to develop TECH-specific measures and energy impacts.
- **Low realization rate on gas displacement for mini-split heat pumps.** Recent evaluations of fuel substitution measures have found that a significant number of mini-split heat pumps are likely installed to add cooling rather than displace gas heating, as reflected in low electric and very low gas realization rates. For example, the 2020 CPUC fuel substitution measure evaluation found ductless mini-split gas and electric realization rates of 2% and 27%, respectively.[24] These findings were further reinforced by a CPUC evaluation of 2021 programs that found gas and electric realization rates of 2% and 34%, respectively.[25] We anticipate a reduction in the claimed energy impacts for these measures. However, without the site-level consumption data results, we cannot make such a significant adjustment to our results. But this is an issue that should be considered and accounted for in establishing a framework for decarbonization programs on either the implementation side via eligibility requirements (gas displacement and gas system decommissioning would be required) or on the claims or

[24] "Draft Impact Evaluation Report: Group A Impact Evaluation PY2020 HVAC Fuel Substitution". DNV for CPUC. May 20, 2022.

[25] "PY2021 Plug Load and Appliance Program Impact Evaluation – Draft Report". DNV for CPUC. March 14, 2023. NOTE: The title appears to have been changed for the *final* report to "Final Impact Evaluation Report: Southern California Edison's Plug Load and Appliance Program, Program Year 2021". April 20, 2023.

evaluation side in adjusting the gas impacts. This issue must also be considered when creating a new set of TECH-specific measures and moving away from the use of eTRM EE program fuel substitution measure packages.

APPENDIX A. DESK REVIEW PROJECT DETAILS

The tables below summarize some of the specific details associated with each of the engineering desk review sites.

Table 13. Review and Dispositions of the Project Documentation for the Sampled Projects

Claim ID	Electrical panel photo	Pre-install photo of the equipment	Pre-install photo of the equipment nameplate	Post-install photo of the equipment	Post-install photo of the equipment nameplate	Final Invoice	HERS Report/ CHEERS Registry Certification	Signed Contract	Manual J Report/Calculations	Desk Review Notes
1032707	Yes	Yes	Yes	Yes	Yes	Yes	NA	No	NA	
1052668	Yes	Yes	No	Yes	Yes	Yes	NA	No	NA	1
1061234	Yes	Yes	Yes	Yes	Yes	Yes	NA	No	NA	2
1040981	Yes	No	No	Yes	Yes	Yes	Yes	No	No	1
1067877	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	1
1032726	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1063007	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	2
1063117	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
1041126	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1029441	Yes	Yes	No	Yes	No	Yes	Yes	No	No	1
1046795	Yes	No	Yes	Yes	Yes	Yes	NA	No	NA	
1040877	Yes	Yes	No	Yes	Yes	Yes	NA	No	NA	1
1067525	Yes	Yes	No	Yes	Yes	Yes	NA	No	NA	1
1064564	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
1026927	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	
1050196	Yes	No	No	Yes	Yes	Yes	Yes	No	No	
1048128	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	
1046906	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	1
1061708	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1
1017700	Yes	Yes	No	Yes	No	Yes	NA	No	NA	1
1019907	Yes	Yes	Yes	Yes	Yes	Yes	NA	No	NA	
1020362	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	
1021588	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1021877	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	7
1024246	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	2
1028673	Yes	Yes	No	Yes	No	No	NA	No	NA	1, 10
1029285	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1041139	Yes	Yes	No	Yes	Yes	Yes	NA	No	NA	1
1046476	Yes	Yes	Yes	Yes	Yes	Yes	NA	No	NA	
1059760	Yes	Yes	No	Yes	Yes	Yes	NA	No	NA	1
1068471	Yes	Yes	No	Yes	Yes	Yes	NA	No	NA	1
1070734	Yes	Yes	Yes	No	Yes	Yes	NA	Yes	NA	
1029337	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1
1029564	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	
1029668	Yes	Yes	Yes	Yes	Yes	Yes	NA	No	NA	4
1068877	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	

Claim ID	Electrical panel photo	Pre-install photo of the equipment	Pre-install photo of the equipment nameplate	Post-install photo of the equipment	Post-install photo of the equipment nameplate	Final Invoice	HERS Report/ CHEERS Registry Certification	Signed Contract	Manual J Report/Calculations	Desk Review Notes
1070125	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	1
1065821	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1033208	Yes	No	Yes	No	Yes	Yes	Yes	No	No	
1034801	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1036000	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	
1040685	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1
1042333	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1042374	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1
1042437	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1
1051216	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1
1064039	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	
1064399	Yes	Yes	No	No	Yes	Yes	Yes	No	No	
1031274	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1
1031276	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1
1039758	Yes	No	Yes	No	Yes	No	Yes	No	No	
1033315	Yes	Yes	Yes	Yes	Yes	Yes	NA	No	NA	
1048898	Yes	Yes	Yes	Yes	Yes	Yes	NA	No	NA	
1049696	Yes	Yes	No	Yes	Yes	Yes	NA	No	NA	1
1052724	Yes	Yes	No	Yes	Yes	Yes	NA	No	NA	1, 2, 9
1052892	Yes	Yes	Yes	Yes	Yes	Yes	NA	No	NA	
1039942	Yes	No	No	No	No	Yes	NA	No	NA	2
1039677	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1060331	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
1053051	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1040110	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	
1058310	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
1052007	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	2
1031280	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	6
1034490	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1
1043174	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1, 4, 6
1069024	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1
1063068	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	
1033337	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1040535	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	4
1063037	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1, 3
1065964	Yes	No	No	Yes	Yes	Yes	Yes	No	No	8
1067101	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1067404	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
1066400	Yes	Yes	Yes	Yes	Yes	Yes	Yes			
1066743	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1055232	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	1

Claim ID	Electrical panel photo	Pre-install photo of the equipment	Pre-install photo of the equipment nameplate	Post-install photo of the equipment	Post-install photo of the equipment nameplate	Final Invoice	HERS Report/ CHEERS Registry Certification	Signed Contract	Manual J Report/Calculations	Desk Review Notes
1070124	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	
1064143	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
1033577	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	2
1031197	Yes	Yes	No	Yes	No	Yes	Yes	No	No	
% No	0%	10%	49%	11%	7%	2%	0%	88%	60%	0%

Source: TECH tracking data (dated 8.29.23) and evaluation team analysis

Note:

1. *Although the model number is missing, we could verify the fuel type for the previous system.*
2. *The pictures are blurry.*
3. *The Panelboard picture does not show the open box and switches.*
4. *The project folder also includes an AHRI certification.*
5. *The model number is not included in the invoice.*
6. *The PTD is listing previous AC as none, but there is a picture of a compressor.*
7. *Claim Detail report and reviewer notes are also included.*
8. *The PTD listed the previous AC system as central- but the project folder is missing the AC picture.*
9. *One email regarding the incentive is also included.*
10. *Includes a note that they are missing some attachments because it is a resubmitted claim.*

Table 14. Complete Listing of HVAC Heat Pump Efficiencies by Measure Offering

Claim ID	Verified SEER	Verified HSPF	Work Paper ID matched	Measure Offering ID Matched	Minimum SEER of Measure Offering	Minimum HSPF of Measure Offering
1070124	15	9	SWHC044-02	A	15	8.7
1041126	14	8	SWHC045-01	A	15	8.7
1046906	14	8		A	15	8.7
1034801	15.5	8.7		A	15	8.7
1064039	15	8.2		A	15	8.7
1060331	14	8		A	15	8.7
1040535	15.1	9.6		A	15	8.7
1065964	15	8.4		A	15	8.7
1048128	16	9	SWHC045-01	B	16	9
1068877	16	8.2		B	16	9
1069024	16.5	8.75		B	16	9
1026927	17	10.5	SWHC044-02	C	17	9.4
1029337	17.6	10.1		C	17	9.4
1039677	17.8	10.6		C	17	9.4
1055232	17.7	12.2		C	17	9.4
1021588	17.5	10.5	SWHC045-01	C	17	9.4
1029285	17.5	9		C	17	9.4
1065821	17.5	9.6		C	17	9.4
1036000	17.5	9.6		C	17	9.4

Claim ID	Verified SEER	Verified HSPF	Work Paper ID matched	Measure Offering ID Matched	Minimum SEER of Measure Offering	Minimum HSPF of Measure Offering
1031276	17.5	9.6		C	17	9.4
1063007	18	10.5	SWHC045-01	D	18	9.7
1029564	18	9.6		D	18	9.7
1070125	18	9.6		D	18	9.7
1053051	19	10		D	18	9.7
1033337	19	10		D	18	9.7
1067404	18	9.6		D	18	9.7
1066400	19	10		D	18	9.7
1066743	18.5	9		D	18	9.7
1031197	18.5	9		D	18	9.7
1029441	15.5	9	SWHC044-02	I	15	8.7
1042374	15	8.5		I	15	8.7
1031274	14.5	8.5		I	15	8.7
1063037	15.5	8.5		I	15	8.7
1067101	14.5	8.2		I	15	8.7
1064143	14	8.2		I	15	8.7
1020362	16	11.7	SWHC044-02	J	16	9
1040685	16.5	9		J	16	9
1051216	16	8.7		J	16	9
1039758	16	8.2		J	16	9
1052007	16.5	11		J	16	9
1063068	16	9		J	16	9
1033577	16	9		J	16	9
1064564	17	10.2	SWHC044-02	K	17	9.4
1024246	17.5	10.8		K	17	9.4
1042333	17	9.5		K	17	9.4
1042437	17	10		K	17	9.4
1058310	17.5	10.8		K	17	9.4
1040981	19	11	SWHC044-02	L	18	9.7
1067877	18	12.6		L	18	9.7
1032726	18	13.6		L	18	9.7
1063117	18	9.6		L	15	8.7
1050196	22.4	10.2		L	18	9.7
1061708	19	10		L	18	9.7
1021877	19	10.6		L	18	9.7
1033208	18	9.6		L	18	9.7
1064399	18	9.6		L	18	9.7
1040110	18	8.5		L	18	9.7
1031280	19.2	11		L	18	9.7

Claim ID	Verified SEER	Verified HSPF	Work Paper ID matched	Measure Offering ID Matched	Minimum SEER of Measure Offering	Minimum HSPF of Measure Offering
1034490	23	10.3		L	18	9.7
1043174	18	10.4		L	18	9.7

Note: This is an expanded version of Table 8 found in the body of the report.
Source: TECH tracking data (dated 8.29.23) and evaluation team analysis

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