Next-Generation Commercial Heat Pump Pilot: Advancing Efficiency and Adoption

Caitlyn Fosberg, Energy Solutions
Carey Oster, Energy Solutions
Curtis Harrington, UC Davis
Jenna Lusczynski, Mostafa Tahmasebi, TRC

ABSTRACT

Decarbonizing commercial space conditioning is a critical pathway to reducing building-sector emissions, yet adoption of high-efficiency heat pump technologies remains limited by cost and market barriers. A pilot program on high-efficiency heat pump rooftop units (HP RTUs) generated new insights into the costs, technical performance, and market barriers associated with the next-generation commercial packaged heat-pump systems. Space heating and cooling account for 41% of total commercial energy consumption nationwide (EIA 2022). In California, 64.5% of heated commercial buildings are served by packaged unitary systems (CEC 2025), indicating that enhancements to this product class are central to achieving large-scale building-sector energy and emissions reductions.

This paper presents results from HP RTU piloted programs and related projects and leverages those findings to recommend scalable program design that supports commercial building electrification and improves cost-effectiveness. High-efficiency HP RTUs are defined as models equipped with variable-speed or multi-stage compressors and efficiency ratings, including integrated energy efficiency ratio (IEER) and coefficient of performance (COP), that exceed both federal code minimums and existing California measure package performance levels.

Through product characterization, market interviews, peer-reviewed research, and midstream incentive program implementation, we assessed distributor-reported equipment costs, key performance features, program barriers, and market adoption readiness. While detailed cost data are not presented, insights from distributor pricing informed the analysis and resulting incentive recommendations. Results show that market-aligned program design can effectively engage the HVAC supply chain and support increased adoption of higher efficiency HP RTUs, with recommendations to enhance advanced efficiency HP RTU measure offerings in California.

Introduction

Since RTU projects are highly prevalent, there is a high impact opportunity for decarbonizing this market segment with the addition of HP RTUs. Gas is commonly used to heat commercial buildings in California. According to the State Energy Data System (SEDS), California's commercial sector consumed 266 trillion Btu in natural gas in 2023 (EIA 2025). Since space heating accounts for 21% of natural gas consumption in the Pacific West (EIA 2022), an estimated 56 trillion Btu of natural gas was consumed by space heating in commercial California buildings. Based on EPA conversion metrics, full electrification of natural gas heating would equate to an annual 3 million metric tons CO_2e in greenhouse gas (GHG) savings (EPA 2024). As gas RTU equipment is phased out, there will be greater installation opportunities for higher efficiency HP RTU equipment. Energy efficiency measures[1] that incentivize high efficiency HP RTU products could expedite commercial decarbonization.

With cost being the primary driver of customer decision-making, current California measure requirements are often too restrictive to support market adoption. Current program participation rates suggest incentive levels do not sufficiently offset the added costs of higher-efficiency features. Offering greater granularity in efficiency tiers, including adding an advanced HP RTU measure tier, would capture a broader range of the HP RTU market without pricing customers out – enabling higher savings and supporting appropriately increased incentives that improve overall cost-effectiveness.

The CalNEXT Program sponsored two HP RTU Focused Pilot programs to conduct measure research and design process for HP RTUs in the California market. The first focused pilot, Supply-Chain Engagement for Increasing Packaged Unitary Heat Pump System Adoption (ET23SWE0073), operated from October 2024 through March 2025 and focused on simplifying the midstream[2] program participation process for distributors to increase market engagement. The second focused pilot, High Efficiency Rooftop Unit Focused Pilot (ET24SWE0066), operated from July 2025 through October 2025 and focused on increasing market adoption of higher efficiency HP RTUs. Both CalNEXT projects identified product trends applicable to the larger market such as building types, size, and available product efficiency. Their findings provide concrete evidence of measure readiness for the next generation of HP RTUs across the country and support advanced commercial heat pump market adoption to reach state and national decarbonization goals.

Methods

To assess the commercial heat pump market, including market available technologies and market actor perspectives, the team conducted the following analyses, as outlined in the sections that follow.

[1] The term "measure" and "measure package" are used to refer to the equipment and project eligibility requirements for use by energy efficiency programs to improve efficiency in commercial heat pumps.

[2] In this paper, "midstream" refers to the program delivery channel through which products are incentivized. Midstream programs are defined by the Northeast Energy Efficiency Partnerships (NEEP) as ". . . initiatives that target the middle of the supply chain, such as distributors and contractors, rather than end-use consumers" (NEEP 2025).

Review HP RTU Performance Metrics

Product efficiency for HP RTUs is based on performance ratings for integrated energy efficiency ratio (IEER[3]) and coefficient of performance (COP[4]), calculated per AHRI Standard 340/360-2022 (I-P), which measure seasonal cooling and heating performance. (AHRI 2022a). These industry-standard metrics simplify program implementation by providing a clear measurement to compare high efficiency and baseline products.

Updated federal efficiency ratings for HP RTUs will apply to products manufactured on or after January 1, 2029, with voluntary manufacturer certification starting on May 15, 2025 (DOE 2025). These updated efficiency metrics will enhance future measure offerings by addressing gaps such as ventilation and control impacts. Unlike IEER and COP, integrated ventilation, economizer, and cooling (IVEC) and integrated ventilation and heating efficiency (IVHE) address high turndown supply fan VFDs, economizer fault detection, and low power ventilation sequences. This improvement in performance data will strengthen cost-effectiveness and claimable energy savings in the future.

Existing HP RTU Measure Efficiency Requirements

Federal and CA SW Program HP RTU minimum efficiency requirements are shown in Table 1 below for the three applicable size categories (IECC 2021; CalTF 2024). While cooling requirements for HP RTU measures are typically based on part load IEER requirements, EER requirements are the basis for the SWHC013 measure.

Table 1. Minimum HP RTU Efficiency Requirements

Program	Source	Cooling Efficiency			Heating Efficiency		
		5.4 to 11.3 tons	11.3 to 20 tons	20 to 63.3 tons	5.4 to 11.3 tons	11.3 to 20 tons	20 to 63.3 tons
Federal Minimum	IECC 2021	13.9 IEER	13.3 IEER	12.3 IEER	3.4 COP (47 °F)	3.3 COP (47 °F)	3.2 COP (47 °F)
SWHC013-06	CAeTRM	11.5 EER	10.8 EER	9.7 EER	3.5 COP (47 °F)	3.48 COP (47 °F)	3.3 COP (47 °F)
SWHC046-03	CAeTRM	16 IEER	15.5 IEER	14 IEER	3.4 COP (47 °F)	3.2 COP (47 °F)	3.2 COP (47 °F)

Product Characterization Catalog

Product catalogs were collected and summarized based on 7 key high efficiency features. The catalog was used to demonstrate the prevalence of different features in the market. Features less common in product lines might be less advantageous to include in the measure package unless they present substantial energy savings benefits. The catalog was provided as an appendix of the final report for the ET24SWE0066 CalNEXT program (Fosberg et al. 2025b).

[3] Integrated Energy Efficiency Ratio (IEER) is defined by AHRI Standard 340/360-2022 as "a weighted calculation of mechanical cooling efficiencies at full load and part-load standard rating conditions, defined in Section 6.2, expressed in Btu/(W·h)" (AHRI 2022a).

[4] Heating Coefficient of Performance (COP_H) is defined by AHRI Standard 340/360-2022 as, "a ratio of the heating capacity in watts to the power input values in watts at any given set of rating conditions expressed in W/W. For COP_H, supplementary resistance heat shall be excluded" (AHRI 2022a).

Market Interviews

The market interviews provided valuable insights and opportunities to validate market hypotheses. The program team interviewed supply chain actors, focusing on distributors due to their key role in midstream program participation. Market buy-in is critical in designing scalable programs, and the team's findings provided useful insights that informed both the design and analysis phases of the programs.

A key focus was HP RTU measure readiness. Distributors shared their difficulties with the CA statewide HVAC program, which had received less HP RTU participation than expected in the past three years (CEDARS 2025). Upon completion of each CalNEXT program, the participants gave additional feedback.

Contractors discussed design and installation strategies for replacing an AC RTU with an HP RTU. Compatible building ventilation systems were discussed as well, touching on single vs. multi zone systems. These discussions highlighted opportunities to optimize HP RTU measures, showing how local code development impacted consumer choices such as heat pumps being required for new construction buildings. They also discussed HP RTU installation limitations.

Trends in AC and HP RTU sizes and efficiencies were discussed to assess the market saturation of HP RTUs. Distributor sales data provided a metric to measure consumer awareness and opinions of HP RTUs. Market actors agreed that equipment cost and code requirements are key drivers for most installations. Stakeholders also identified impactful HP RTU features, which guided further research and informed the design of the product catalog and measure offerings for the second CalNEXT program.

Cost data, typically inaccessible due to proprietary quoting process, was collected anecdotally from as many market actors as possible. By including distributors in the incentive design discussion, the team was able to access otherwise highly guarded information. The cost data was used to assess cost driving components of HP RTUs and estimate incremental costs between code-compliant RTU equipment and high efficiency HP RTUs.

Program Logic Model

Barriers identified fell into multiple buckets including product barriers, market barriers, and policy/program barriers. The culmination of the barriers identified during the first CalNEXT program were summarized in a program logic model format. The logic model demonstrates the path towards increased uptake of measure qualified HP RTUs in California commercial buildings. The project's logic model may be found in Appendix B of the ET23SWE0073 Final Report (Fosberg et al. 2025a).

Midstream Incentive Pilot Programs

Two midstream incentive programs were piloted from October 2024 through March 2025 and July 2025 through October 2025. The pilots were designed to assess HP RTU program readiness and market conditions using real-world project data. The first program targeted products eligible for current California measures while the second program targeted higher efficiency tiers.

ET23SWE0073 CalNEXT Program – Measure Design

The first CalNEXT pilot (ET23SWE0073) aimed to identify barriers to HP RTU adoption through midstream programs in California. Measure equipment efficiency levels were set at the CA SWHC046-03 minimum required levels (CalTF 2024). Table 2 shows the minimum qualifying efficiency for equipment submitted to the ET23SWE0073 program.

Table 2. ET23SWE0073 Midstream Pilot Measure Requirements (Fosberg et al. 2025a)

Size Category Cooling Capacity (tons)	IEER	COP (47°F)	Incentive ($/ton)
5.4 to 11.3 tons	15.0	3.4	$300
11.3 to 20 tons	14.5	3.2	$300
20 to 63.3 tons	13.5	3.2	$300

ET24SWE0066 CalNEXT Program – Measure Design

The second CalNEXT pilot (ET24SWE0066) aimed to develop more advanced measure equipment efficiency levels than currently offered in the California measure package. The program's requirements reflect an increase from current CA measure requirements. Product features such as energy recovery ventilators (ERV), heat recovery ventilators (HRV), and variable speed compressors were required to qualify for the higher incentive tier. Table 3 shows the minimum qualifying efficiency for equipment submitted to the ET24SWE0066 program.

Table 3. ET24SWE0066 Midstream Pilot Measure Requirements (Fosberg et al. 2025b)

Tier	Size Category Cooling Capacity (tons)	IEER	COP (47°F)	Feature Requirements (1 or more)	Incentive ($/ton)
1	5.4 to 11.3 tons	16.5	3.4	N/A	$375
1	11.3 to 20 tons	16.4	3.2	N/A	$375
1	20 to 63.3 tons	16.4	3.2	N/A	$375
2	5.4 to 11.3 tons	16.5	3.4	ERV, HRV, or VS-Compressor	$500
2	11.3 to 20 tons	16.4	3.2	ERV, HRV, or VS-Compressor	$500
2	20 to 63.3 tons	16.4	3.2	ERV, HRV, or VS-Compressor	$500

Results

HP RTUs Efficiency Drivers

HP RTUs consist of components with various optimization opportunities, including outdoor air mixing boxes that control the amount of outdoor air delivered to the building, fans on both the evaporator and condenser coils to facilitate heat transfer, refrigerant circuits with compressors, heat exchangers, and expansion devices, and controls for determining the sequence of operation. Some efficiency features (i.e. economizers) are considered standard for commercial heat pump RTUs in California and not detailed here.

Compressor Type

Standard RTUs often use single-speed compressors, which are either fully on or fully off. High-efficiency models feature two-stage, multi-stage (3+), or variable speed (inverter-driven) compressors (Bansal et al. 2024). Reducing compressor speed improves motor efficiency and refrigeration performance by creating oversized heat exchangers at the evaporator and condenser. Furthermore, the reduced capacity provided at lower compressor speeds allows the building temperature setpoint to be maintained without excessive cycling of the compressor, improving component longevity and efficiency. Inverter-driven compressors also offer other advantages that include advanced defrost cycles that can perform defrost without operating the indoor blower (Harrington et al. 2026), improved capacity at low ambient temperatures, and an over-speed feature to increase capacity during peak conditions.

While beneficial, variable speed compressors add approximately $500–$750 per ton to the cost of equipment (Fosberg et al. 2025b). Due to the increased cost associated with this product feature, the market has not adopted them at a high rate. Two-stage, and multi-stage compressors are more palatable on the pricing end and tend to be much more common. Costs are not likely to come down for variable speed units unless the feature becomes much more prevalent in the market.

Fan Motors

Fans represent a significant portion of HP RTU energy use, with supply fans alone estimated to contribute about 30% of total consumption (CaraDonna, Parker, and Meyer 2024). Supply fans operate continuously to meet minimum ventilation requirements. Fan affinity laws demonstrate that reducing fan speed results in a cubic reduction in energy use. Using variable speed fans to reduce fan energy use during ventilation-only periods can significantly reduce annual energy use for an RTU. Variable speed fan can reduce fan energy use when paired with single-speed compressors, but these savings are compounded when paired with a multi-speed compressor by allowing additional fan energy savings during part-load operation.

Electric Resistance Auxiliary Heating

Auxiliary heating systems in HP RTU installations provide additional heating during peak periods and manage comfort during defrost cycles when heat pump heating is temporarily disabled. These systems often consist of an electric resistance coil with a maximum COP of 1, compared to the heating performance of a heat pump that exceeds a COP of 3. Electric resistance heaters are not only less efficient but also require additional electrical capacity that can trigger panel upgrades for retrofits.

An analysis by NREL showed that California relies on supplemental for only 6% of heating hours – less than any other state (CaraDonna, Parker, and Meyer 2024). Many climate zones in California could avoid auxiliary heating systems by reducing nighttime temperature setbacks and initiating morning warmup earlier. Eliminating auxiliary electric resistance heating from heat pump installations could improve heating efficiency and reduce installation barriers and costs by avoiding electric panel upgrades. The climate for most of the state is considered mild and would likely transfer to analogous locations such as southern United States which do not need cold climate solutions. However, cold climate should be given additional consideration for heating load sizing. HP RTUs installed in colder climates may need higher heating efficiencies or larger capacities to realize cost and energy benefits while meeting heating requirements.

Advanced Controls

Advanced rooftop controls (ARC) can enhance RTU efficiency, especially with variable speed components, by enabling fault detection and diagnostics and providing an interface for continuous commissioning and monitoring. Pacific Northwest National Lab's six-state ARC demonstration logged three benefits: reduced fan energy by optimizing airflow, improved economizer reliability through fault detection, and strip heat lockouts to prevent unnecessary use of inefficient auxiliary heating systems (Wang et al. 2013).

HP RTU U.S. Market Trends

Incentive application data from the CalNEXT programs and the California statewide program from years 2023 to 2025 were analyzed and are presented in the following sections. Trends in equipment size, building types, and climate zones from the programs demonstrate the applicability of the measure type and the representative nature of the datasets themselves. The CalNEXT data was sourced directly while the California statewide program data was exported from the California Energy Data and Reporting System (CEDARS) maintained by the California Public Utility Commission (CEDARS 2025).

Equipment Size

Cooling capacity was categorized into three size categories in accordance with federal and state regulatory authorities. Figure 1 shows a heat map of the sum of cooling capacity in tons and the percentage distribution across size categories, with darker colors indicating higher totals.

Most HP RTUs installed in California were in the 5.4-to-11.3-ton size category, followed by the 20-to-63.3-ton sized units. Equipment sized between 11.3 to 20 tons was least common in all three programs. The higher efficiency units from the ET24SWE0066 program tended to be the smallest, with 5.4-to-11.3-ton HPs making up 81% of applications in tons for the program term. These results suggest that smaller units in the packaged unitary heat pump market are more likely to achieve high efficiency than larger units.

			Size Category (Cooling Capacity)			
Data Source	Measure ID	Number of Years	5.4 to 11.3 tons	11.3 to 20 tons	20 to 63.3 tons	Grand Total
CalNEXT	ET23SWE0073	~0.5	44.20% 887	2.39% 48	53.41% 1,072	100.00% 2,007
	ET24SWE0066	~0.33	81.41% 648	7.54% 60	11.06% 88	100.00% 796
CEDARS (2023 to 2025)	SWHC046	3	63.84% 196	13.03% 40	23.13% 71	100.00% 307

Figure 1. Size of HP RTU Equipment by CA Programs

Building Type

Figure 2 shows a heat map of eligible equipment tons by building type for the second, higher efficiency CalNEXT program. The most popular building types were installed in manufacturing light industrial buildings, followed by secondary school and primary school buildings, respectively. The three building types made up roughly 85% of the equipment cooling capacity tons submitted to the program.

There was less variety in building types in the high-efficiency HP RTU program (ET24SWE0066) compared to the first CalNEXT program (ET23SWE0073) (Fosberg et al. 2025b; Fosberg et al. 2025a). It's possible that only certain building owners pursue higher end

HVAC systems due to elevated cooling requirements or prohibitive costs. Evidence of a more restricted use case aligns with distributors' accounts some building owners, like higher education institutions, are more likely to adopt high efficiency equipment.

Assembly	32.5 Tons (4.5%)
Community College	24.7 Tons (3.4%)
Manufacturing Biotech	14.8 Tons (2.0%)
Manufacturing Light Industrial	326.2 Tons (44.8%)
Office - Small	7.8 Tons (1.1%)
Primary School	124.2 Tons (17.0%)
Retail - Small	26.3 Tons (3.6%)
Secondary School	171.8 Tons (23.6%)
Total	**728.3 Tons (100.0%)**

Figure 2. CalNEXT ET24SWE0066 Program applications by building type (Fosberg et al. 2025b; Fosberg et al. 2025a).

Climate Zone

The CA climate zones from both CalNEXT programs were determined based on zip code. The sum of total tons and percent of total tons were calculated across the two programs and California climate zones, as shown in Figure 3 heat map, below. These results highlight the distribution of HP RTUs across the state. Climate zones CA3, CA7, CA8, CA9, and CA10, which comprise a large portion of California's coast, make up 75.5% of the CalNEXT project submissions. No HP RTU projects were submitted for CA1, CA5, and CA11 during the either program (Fosberg et al. 2025a; Fosberg et al. 2025b).

California Climate Zone	ET23SWE0073	ET24SWE0066	Grand Total
CA2	12 Tons (0.6%)	28 Tons (3.9%)	40 Tons (1.5%)
CA3	71 Tons (3.5%)	175 Tons (24.1%)	246 Tons (9.0%)
CA4	109 Tons (5.4%)	25 Tons (3.4%)	134 Tons (4.9%)
CA6	54 Tons (2.7%)		54 Tons (2.0%)
CA7	159 Tons (7.9%)	119 Tons (16.4%)	278 Tons (10.2%)
CA8	239 Tons (11.9%)	235 Tons (32.3%)	474 Tons (17.3%)
CA9	217 Tons (10.8%)	25 Tons (3.4%)	241 Tons (8.8%)
CA10	832 Tons (41.5%)	18 Tons (2.5%)	850 Tons (31.1%)
CA12	114 Tons (5.7%)		114 Tons (4.2%)
CA13	149 Tons (7.4%)	19 Tons (2.7%)	168 Tons (6.2%)
CA14	9 Tons (0.4%)		9 Tons (0.3%)
CA15	43 Tons (2.1%)	8 Tons (1.1%)	51 Tons (1.9%)
CA16		75 Tons (10.3%)	75 Tons (2.7%)
Grand Total	2,005 Tons (100.0%)	728 Tons (100.0%)	2,734 Tons (100.0%)

0.4% 41.5%

Figure 3. Total Tons by CA Climate Zone, CalNEXT ET23SWE0073 and ET24SWE0066 Project Submissions

Market Efficiency Growth Over Time

Efficient HP RTU equipment is becoming more common, as shown in AHRI data from December 2024 to February 2026 (AHRI 2022b). Figure 4 and Figure 5 show the number of AHRI listed 5.4-to-11.3-ton models across 0.5 IEER and 0.05 COP bins, respectively, with cumulative share increasing from lower to higher efficiency levels. A declining share of lower-efficiency units over time indicates improving overall market efficiency.

Figure 4 shows modest shifts in IEER ratings between December 2024 and February 2026. Units below 13.5 IEER were effectively phased out by February 2026. Market share declined in the 14.0 and 14.5 IEER bins by 2% and 4%, respectively, while the 15.0 IEER bin increased by 3%. The largest decline occurred at 16.5 IEER, which decreased by 8%.

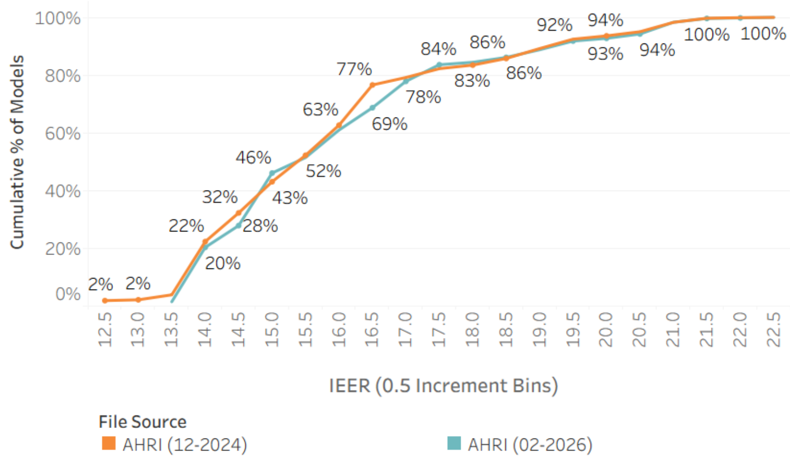

Figure 4. Cumulative Share of AHRI ULE-listed Packaged Unitary Heat Pumps (5.4 to 11.3 tons) by IEER (0.5 Increments; December 2024 vs. February 2026) (AHRI 2022b).

Figure 5 shows a similar upward shift in HP RTU COP (47°F) ratings. Units rated below 3.4 COP are virtually nonexistent in the 5.4- to 11.3-ton market by February 2026. Market share increased in the 3.50 and 3.55 COP bins each increased by 5% each, while the 3.60 and 3.65 COP bins declined by 2% and 3%, respectively.

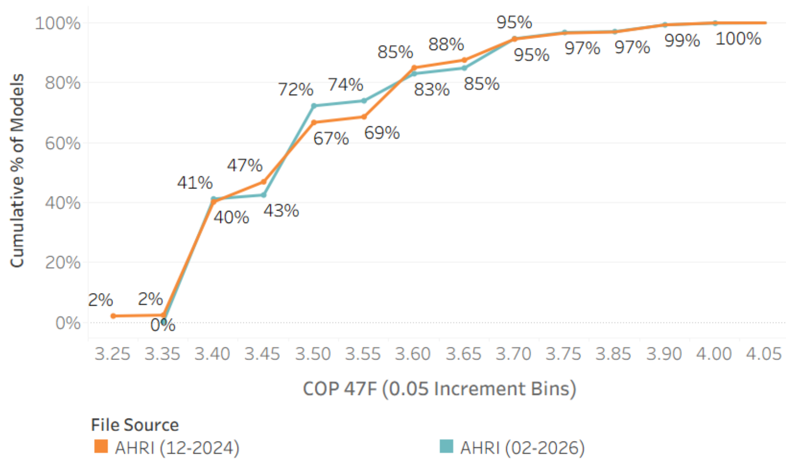

Figure 5. Cumulative Share of AHRI ULE-listed Packaged Unitary Heat Pumps (5.4 to 11.3 tons) by COP 47°F (0.05 Increments; December 2024 vs. February 2026) (AHRI 2022b).

Across both cooling and heating metrics, the market is consolidating around mid-range efficiency levels, with more limited adoption at the highest performance tiers. This pattern suggests that cost-performance tradeoffs continue to constrain uptake of top-tier equipment. To maximize participation and savings, programs should expand high-efficiency tiers while retaining lower and mid-tier options, aligning incentives to effectively capture the full market.

California HP RTU Program Participation

California HP RTU Fuel Substitution measure receives low participation

CA statewide program participation suggests that the fuel substitution measure may have a fundamental issue barring participation. Figure 6 shows the sum of cooling capacity tons submitted to the CA SW Program by measure ID; SWHC046 made up 7% of the tons in the CA SW program in 2025 – the most participation the measure had ever received. Despite upward trends in HP RTU market efficiency and lower COP requirements for SWHC046 compared to SWHC013, participation barriers remain, suggesting that a lack of qualified equipment is not the primary issue.

Since the SWHC046 measure requires knowledge of existing heating product type, the program is limited to the downstream program model. Market interviews from the CalNEXT focused pilots suggest that data collection difficulties impact program participation (Fosberg et al. 2025a; Fosberg et al. 2025b). The lower rate of engagement with the SWHC046 measure is at least partially attributed to the data collection requirements.

To address these barriers, the CalNEXT 2023FP project team conducted market interviews with various levels of the supply chain. Distributors reported difficulty determining and reporting the existing equipment type with a high level of confidence, presenting a barrier for fuel substitution (SWHC046) program participation (Fosberg et al. 2025a). They also reported a lack of incremental measure cost (IMC) coverage. Due to the mismatch of incentive level and efficiency requirements of the CA measure package, contractors could not justify installing HP RTUs to customers easily.

One strategy to address this issue is to develop a baseline equipment study to support existing equipment assumptions for various locations. The study would bolster the effectiveness of using a midstream program model by no longer requiring participants to know the existing equipment type while continuing to account for rates of electric and gas heating equipment in the state.

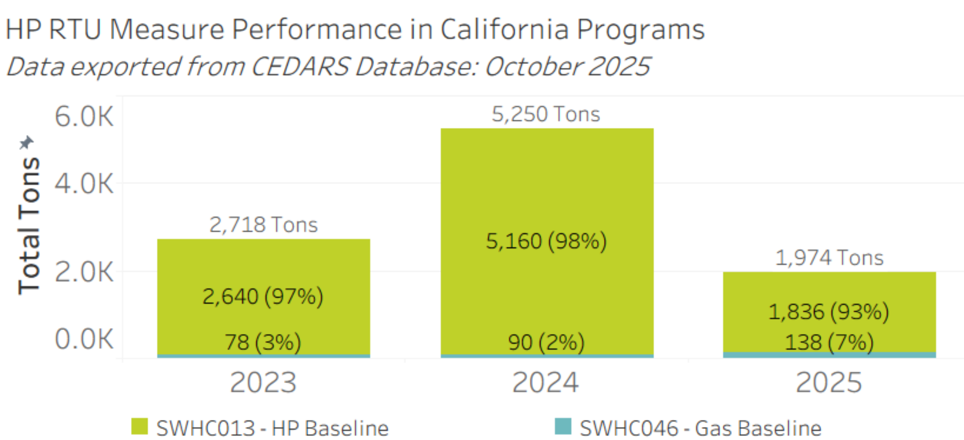

Figure 6. California HP RTU program participation over time (CEDARS 2025)

Rate of participation increased for CalNEXT programs

Participation rates for the CalNEXT and CA SW program were compared by scaling the volume of incentivized equipment (in tons of cooling capacity) by program term (in years). The program participation rates were estimated for CalNEXT and CA SW HP RTU measures in Table 4 (Fosberg et al. 2025a; Fosberg et al. 2025b; CEDARS 2025).

The ET23SWE0073 and SWHC046 measures shared similar requirements while the ET24SWE0066 program challenged participants to install higher efficiencies. The SWHC013 measure requires higher COPs and uses full load EER minimum efficiency requirements instead of IEER. Requirements for the CA SW measures are found in Table 1 earlier in the report.

The CalNEXT programs ET24SWE0066 and ET23SWE0073 prioritized distributor program participant experience to gain enhanced engagement, offering flexibility in reporting baseline variables like existing equipment type. For the SW Program to adopt a similar strategy, a baseline equipment study is recommended to estimate the rate of gas and electric heating equipment across building types and climate regions. By investing in such a study, accuracy of program energy and bill estimates are retained while reducing burden on midstream participants. CalNEXT programs offered a higher rate of incentives compared to the CA SW program rates to further enhance engagement and account for incremental increases in the cost of higher efficiency HP RTUs. Full incentive offering details are provided in Table 2 and Table 3.

The CalNEXT ET23SWE0073 program received the highest level of engagement, reporting 4,014 tons/year. The CA SW SWHC013 measure (PY 2023 to 2025) followed second in program participation, reporting 3,212 tons/year in HP RTU replacement installations. Surprisingly, the tons per year rate of the ET24SWE0066 program exceeded the performance of the SW SWHC046 measure, suggesting significant market potential for a higher efficiency HP RTU measure if implemented via market friendly midstream program design. Streamlining the incentive application process and addressing participation barriers could significantly improve outcomes, as shown by the higher rates of participation for the CalNEXT FPs.

Table 4. California SW Program and CalNEXT HP RTU Measure Performance (Fosberg et al. 2025a; Fosberg et al. 2025b; CEDARS 2025)

Program Name	Measure ID	Measure Description	HP RTU Installations (Tons)	Program Term (Years)	Tons per Program Year
CalNEXT	ET23SWE0073	SWHC046 Equivalent	2,007	0.5	4014
CalNEXT	ET24SWE0066	High Efficiency	796	0.33	2412
CA SW Program (2023 to 2025)	SWHC046	Gas Baseline	307	3	102
CA SW Program (2023 to 2025)	SWHC013	HP Baseline	9637	3	3212

Efficiency of Next Generation HP RTUs

Equipment installations submitted to the advanced efficiency CalNEXT program (ET24SWE0066) are shown in the following section (Fosberg et al. 2025b). COP versus IEER plots were generated for all eligible project applications. Efficiency trends demonstrate an active market for the next generation of HP RTUs.

CalNEXT High Efficiency HP RTU Efficiency Performance

In Figure 7, HP RTU in the 5.4-to-11.3-ton cooling capacity range is plotted by COP and IEER. The yellow marks show AHRI listed units and the purple marks represent CalNEXT

ET24SWE0066 projects (AHRI 2022b; Fosberg et al. 2025b). Many of the installed HP RTUs appear centralized along the 3.5 COP. Additionally, the AHRI directory indicates ample eligible units available in the market.

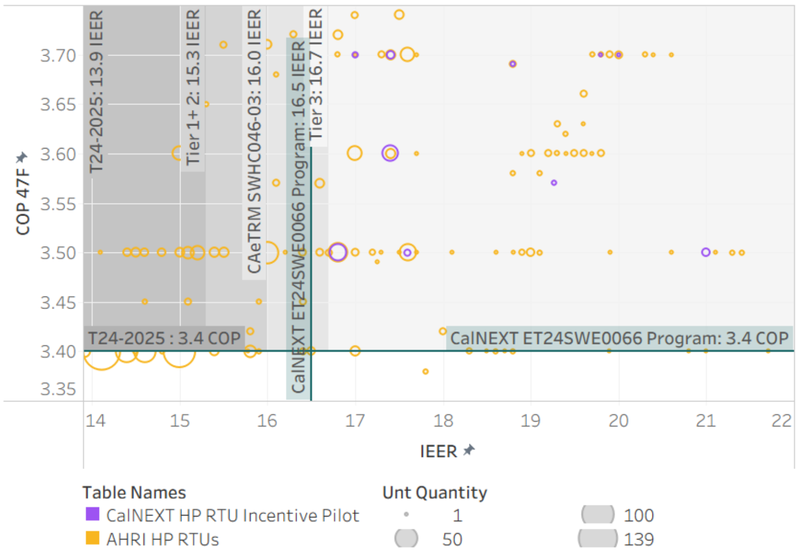

Figure 7. COP vs. IEER of CalNEXT ET24SWE0066 Program HP RTU applications (5.4–11.3 tons) (AHRI 2022b; Fosberg et al. 2025b).

HP RTU Efficiency Averages

HP RTU efficiency averages were calculated for three cooling capacity size categories across the CalNEXT and CA SW SWHC046[5] programs (Fosberg et al. 2025a; Fosberg et al. 2025b; CEDARS 2025). The advanced measure design of ET24SWE0066 effectively increased average program efficiency, compared to ET23SWE0073. For instance, the average heating efficiency of the 11.3-to-20-ton category increased by 0.3 COP, nearly 10%. The larger size category lagged in COP advancements, but the ET24SWE0066 projects still average 0.1 COP above the ET23SWE0073 projects. Cooling efficiency for the ET24SWE0066 projects performed well across all sizes. There was a 29% improvement in IEER for the largest category.

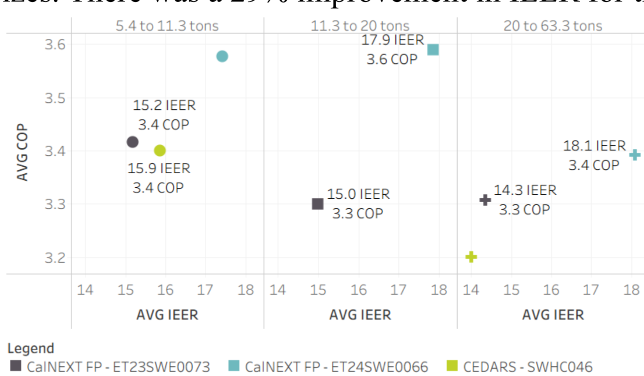

Figure 8. Average Efficiency of California Program Applications by Size Category (Fosberg et al. 2025a; Fosberg et al. 2025b; CEDARS 2025).

[5] SWHC046 efficiency levels were assumed due to lack of reported efficiency in the CEDARS database.

Proposed CA Measure Design

The measure design from the ET24SWE0066 CalNEXT program is presented in Table 5. The efficiency tiers span entry level and advanced models. Features like lack of ER heat, supply fan variable frequency drives (VFDs), and advanced rooftop control (ARC) are included in tiers 2 and 3 to account for energy savings features not credited by current IEER metrics. An exemption for climate zones CA14 and CA16 allows dual fuel or cold climate heat pump alternatives for areas with increased heating loads.

Unlike prior programs, heating COP is not used as a strict eligibility threshold. In California, program priorities are driven by cooling-related peak demand, and AHRI data show a strong correlation between IEER and heating COP across available models. As a result, a separate COP threshold would add limited value while potentially restricting eligible products. Instead, heating performance is indirectly captured through IEER-based tier differentiation, which correlates with COP, and through the inclusion of system features in higher tiers that improve overall heating efficiency and system performance.

This framework reflects product catalog research, market actor outreach, and test program results, presenting a market aligned approach to decarbonizing commercial heating. A prescriptive incentive level ($/ton) was not specified, as appropriate incentive values vary by location due to factors like climate, labor costs, and utility cost-effectiveness frameworks. Instead, programs should design incentives to cover at least 70% of incremental measure cost (IMC) to meaningfully offset cost and support program participation.

Table 5. ET24SWE0066 Proposed IEER three-tier HP RTU measure structure (Fosberg et al. 2025b).

Tier Level	Size Category (Cooling Capacity in tons)			Incentive	Additional Features	Climate Zone Notes
	5.4 to 11.3	11.3 to 20	≥ 20			
Tier 1	15.3	14.6	13.5	≥ 70% IMC	N/A	Applies statewide; Efficiency exceeds code but established easily attainable entry point.
Tier 2	15.3	14.6	13.5		No ER heat, Supply-fan VFD/ECM managed by ARC	ER heat only allowed in CA14 and CA16 under cold climate or dual-fuel path
Tier 3	16.7	16.0	14.8		No ER heat, Supply-fan VFD/ECM managed by ARC	ER heat only allowed in CA14 and CA16 under cold climate or dual-fuel path

Conclusion and Program Recommendations

There are opportunities to improve the effectiveness of heat pump rooftop unit (HP RTU) programs by optimizing both fuel substitution strategies and efficiency requirements. Measure efficiency requirements should be thoughtfully designed to balance impacts with market feasibility, ensuring they align with available product offerings. As baseline efficiency continues to improve across the HP RTU product category, there is a significant opportunity to leverage these installations to support broader U.S. decarbonization goals.

Incentive levels should be appropriately sized, targeting at least 70 percent of IMC to encourage adoption of higher-efficiency units and maximize energy savings and program impact. While IMC varies across equipment tiers and market conditions, available data from product catalogs, market actor outreach, and pilot results indicate that higher cost coverage is needed to meaningfully offset upfront premiums and drive participation. Higher IMC coverage improves customer return on investment and supports participation but must be balanced with program cost-effectiveness. A percentage of IMC approach provides flexibility to align incentives with local market conditions.

To drive broader adoption, programs should leverage a midstream delivery model, which has proven effective at reducing market friction and driving participation. Data collection requirements should be minimized wherever possible to streamline implementation, with targeted efforts such as a baseline equipment study to generate the supporting data needed to justify program assumptions.

California's HP RTU measure portfolio would benefit from the addition of advanced efficiency measures, including introducing a higher efficiency tier and implementing a dedicated variable-capacity HP RTU measure that explores the use of variable-speed and multi-stage compressors. In parallel, next-generation HP RTU characteristics should be identified and recognized, including high-efficiency features not fully captured by current energy metrics to unlock additional energy savings. Near-term efforts should focus on increasing the availability of lower-tier units while simultaneously preparing the market for higher-tier adoption around 2027, as variable-speed and multi-stage equipment options become more prevalent.

Program participation can be further strengthened by targeting building characteristics that are well-suited for HP RTU deployment. Mild-climate regions like much of California present a strong opportunity due to their low heating loads. In these climates, careful consideration should be given to whether auxiliary heating is truly necessary, as the cost implications are significant and avoiding unnecessary auxiliary heat can materially improve project economics. California's mild climate makes it well-suited for these systems, enabling cost reductions and improved operational efficiency without compromising performance. Coastal regions are especially well-positioned to benefit from this approach. Certain building types have also demonstrated strong engagement, with manufacturing light industrial and higher-education facilities representing some of the highest participation levels in the ET24SWE0066 CalNEXT program, indicating a clear opportunity for targeted outreach and program design.

References

AHRI (Air-Conditioning, Heating, and Refrigeration Institute). 2022a. *AHRI Standard 340/360-2022 (I-P): Performance Rating of Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment.* Arlington, VA: AHRI. www.ahrinet.org/system/files/2024-09/AHRI%20Standard%20340-360-2022%20%28I-P%29%20ICS.pdf.

———. 2022b. *Unitary Large Equipment (ULE) Certification Program.* Arlington, VA. Accessed February 2026. www.ahrinet.org/certification/ahri-certification-programs/unitary-large-equipment-ule.

Bansal, P., S. Wang, B. Boyce, and S. Putlak. 2024. *Light Commercial Variable Speed Heat Pump Performance Map (ET23SWE0069).* Final Report, Oakland, CA: CalNEXT. www.calnext.com/wp-content/uploads/2024/12/ET23SWE0069_Light-Commercial-Variable-Speed-Heat-Pump_Final-Report.pdf.

CalTF (California Technical Forum). 2024. *Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution, SWHC046-03.* https://www.caetrm.com/measure/SWHC046/03/.

CaraDonna, C., A. Parker, and R. Meyer. 2024. *End-Use Savings Shapes Measure Documentation: Heat Pump Rooftop Units (NREL/TP-5500-86585).* Technical Report, Golden, CO: National Renewable Energy Laboratory (NREL). https://docs.nrel.gov/docs/fy24osti/86585.pdf.

CEC (California Energy Commission). 2025. *2018-2022 California Commercial End-Use Survey (CEUS) Data.* Sacramento, CA: CEC, Heating Equipment Types from the Heating dataset. www.energy.ca.gov/data-reports/surveys/california-commercial-end-use-survey/2018-2022-california-commercial-end-use.

CEDARS (California Energy Data and Reporting System). 2025. *Record-level Data for Years 2023 to 2025.* San Francisco, CA: CPUC (California Public Utilities Commission), October. www.cedars.cpuc.ca.gov/reports/record-level/all/.

DOE (U.S. Department of Energy). 2025. "10 CFR Part 431 Subpart F." *Energy Efficiency Standards.* Washington, DC, September. https://www.govinfo.gov/content/pkg/CFR-2025-title10-vol4/pdf/CFR-2025-title10-vol4-part431.pdf.

EIA (U.S. Energy Information Administration). 2022. "Commercial Buildings Energy Consumption Survey (CBECS) Table E1." December. https://www.eia.gov/consumption/commercial/data/2018/ce/xls/e1.xlsx.

———. 2025. *State Energy Data System (SEDS) Total end-use Commercial Consumption Data.* June. www.eia.gov/state/seds/sep_sum/html/pdf/sum_btu_com.pdf.

EPA (U.S. Environmental Protection Agency). 2024. *Greenhouse Gas Equivalencies Calculator - Calculations and References.* Washington, DC. www.epa.gov/energy/greenhouse-gas-equivalencies-calculator-calculations-and-references.

Fosberg, C., C. Oster, J. Hanna, G. Bennett, J. Lusczynski, A. Khanolkar, N. Stevens, and M. Tahmasebi. 2025a. *Supply-Chain Engagement for Increasing Packaged Unitary Heat Pump System Adoption (ET23SWE0073).* Final Report, Oakland, CA: CalNEXT. www.calnext.com/wp-content/uploads/2025/04/ET23SWE0073_Supply-Chain-Engagement-for-Increasing-Packaged-Unitary-Heat-Pump-System-Adoption_Final-Report.pdf.

Fosberg, C., C. Oster, J. Hanna, G. Bennett, J. Lusczynski, M. Tahmasebi, C. Battisti, and C. Harrington. 2025b. *High Efficiency Rooftop Unit (HE RTU) Focused Pilot*

(ET24SWE0066). Final Report, Oakland, CA: CalNEXT. www.calnext.com/wp-content/uploads/2025/12/ET24SWE0066_High-Efficiency-Rooftop-Unit-HE-RTU-Focused-Pilot_Final-Report.pdf.

Harrington, C., F. Meyers, G. Baumgardner, and A. Haynor. 2026. *Heat Pump Rooftop Unit Demonstration (ET23SWE0054)*. Final Report, Oakland, CA: CalNEXT. www.calnext.com/wp-content/uploads/2026/02/ET23SWE0054_Heat-Pump-Rooftop-Unit-Demonstration_Final-Report.pdf.

IECC (International Energy Conservation Code). 2021. "2021 International Energy Conservation Code (IECC). Table C403.3.2(2). Electrically Operated Air-Cooled Unitary Heat Pumps - Minimum Efficiency Requirements." Washington, DC. codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency#IECC2021P1_CE_Ch04_SecC403.3.2_TblC403.3.2_2.

NEEP (Northeast Energy Efficiency Partnerships). 2025. "Best Practice Guide: High-Performance HVAC Mid-Stream Programs." *Northeast Energy Efficiency Partnerships.* May. https://neep.org/best-practice-guide-high-performance-hvac-mid-stream-programs.

Wang, W., S. Katipamula, H. Ngo, R. Underhill, D. Taasevigen, and R. Lutes. 2013. *Advanced Rooftop Control (ARC) Retrofit: Field-Test Results (PNNL-22656).* Richland, WA: PNNL (Pacific Northwest National Laboratory). https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22656.pdf.