# High Efficiency Rooftop Unit (HE RTU) Focused Pilot

## Final Report

ET24SWE0066

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December 11, 2025

# Acknowledgements

We extend our appreciation to the manufacturers, distributors, and contractors who contributed their time and expertise through market interviews. Their insights were instrumental in defining pilot design parameters, identifying key product features, and shaping market-based intervention strategies to advance high-efficiency rooftop unit adoption.

Special thanks to the ET23SWE0073 and ET24SWE0066 Focused Pilot Midstream Incentive participants for providing recent data on equipment specifications from 2024–2025 installations. These contributions informed our understanding of current market conditions, adoption barriers, and opportunities for continued efficiency improvements.

We acknowledge the California Market Transformation Administrator for its leadership in advancing market transformation plans that prioritize development of the heat pump rooftop unit market and support long-term HVAC efficiency improvements.

We also thank the California Technical Forum (CalTF) for maintaining detailed measure documentation through the eTRM, enabling consistent evaluation and implementation of high-efficiency equipment across California.

Finally, we recognize the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) for maintaining the HVAC equipment directory and developing key standards—AHRI 920-2020 for DOAS and AHRI 340/360-2022 for rooftop units—that ensure consistency and accuracy in performance evaluation.

We are grateful for the collaboration and dedication of all participants and look forward to continued partnership as this pilot advances.

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# Executive Summary

## Background

Packaged air conditioner rooftop-units (AC RTUs) with gas or electric resistance heating are installed in 64.5 percent of California's commercial buildings (California Commercial End-Use Survey (CEUS) 2024). Additionally, 63 percent of commercial building floor space is supported by gas heat (California Commercial End-Use Survey (CEUS) 2024). As AC RTUs age and are replaced, they present a significant decarbonization opportunity through installation of heat pump rooftop units (HP RTUs).

## Objectives

This Focused Pilot (ET24SWE0066) aimed to:

- Determine and define high-efficiency product characteristics for HP RTUs and dedicated outdoor air systems (DOAS).
- Establish advanced measure criteria and incentive levels for HP RTUs and initial measure criteria and incentives for DOAS.
- Test and assess the effectiveness of measure criteria and incentive levels through a midstream incentive pilot and participant feedback.
- Provide information on incremental costs for high-efficiency HP RTUs and DOAS.
- Deliver recommendations for light commercial HVAC measures to guide future program design.

## Methodology

The project team conducted a multi-faceted analysis to characterize high-efficiency HP RTUs and DOAS and assess market readiness, including evaluating common components associated with higher-efficiency commercial HVAC units:

- **Market Interviews:** Engaged manufacturers, distributors, and contractors to understand efficiency, performance characteristics, and market adoption barriers such as cost.
- **Midstream Incentive Pilot:** Tested incentive readiness for high-efficiency HP RTU and DOAS equipment through pilot participation, using HP RTU efficiency levels using the, SWHC046 fuel substitution HP RTU measure, past ET23SWE0073 Focused Pilot program data, and California Energy Data Reporting System (CEDARS) data from Existing California RTU Programs.
- **Efficiency Tier Matrix:** Defined high-efficiency measure tiers based on energy performance metrics, physical equipment characteristics, or a combination of both. Efficiency requirements were based on a 10 percent to 20 percent increase from Title 24, Part 6 minimum efficiency levels.
- **Savings Impacts Model:** Modeled expected energy savings for HP RTU efficiency tiers across representative building types in California Climate Zone 4. Energy modeling using EnergyPlus, DEER prototype models, and ModelKit.
- **Product Characterization Study:** Analyzed HP RTU and DOAS equipment catalogs, documenting components associated with higher efficiency. A summary product catalog,

found in  and , demonstrates HP RTU and DOAS high-efficiency product availability across various manufacturers.

- **Marketing Collateral:** Developed a concise summary document of high-efficiency product features and recommendations for stakeholder and market communication (see ).

## Findings

The Focused Pilot and associated market analysis revealed key insights regarding the adoption, performance, and market barriers of high-efficiency HP RTUs and DOAS systems, which inform program design, incentive structures, and future measure development:

- **Midstream Incentive Pilot Participation:** The pilot received 50 project submissions (845 cooling tons), including 49 HP RTU installations and 1 DOAS installation. 18 projects qualified for a Tier 2 incentive, reflecting higher costs of high-efficiency equipment.
- **Product Characterization:** Identified key high-efficiency features and differences between HP RTUs and DOAS and evaluated common components associated with higher-efficiency units. Findings were summarized in a product catalog provided in the appendices. Measure tiers were developed based on increases in Integrated Energy Efficiency Ratios (IEER) and seasonal efficiency metrics per Title 24, Part 6, targeting systems primarily without backup resistance heating.
- **Upfront Costs and Incentive Coverage:** Incentives for Tier 1 HP RTUs covered 81% of incremental costs, within the recommended range for effective market influence. Other offerings, including higher-tier HP RTUs and DOAS, showed significant gaps in cost coverage, indicating a need for higher incentives.
- **Operating and Installation Considerations:** Installation costs can vary based on labor rates and electrical service requirements. Operating costs can vary based on utility rates and presence of advanced product features. Avoiding unnecessary electric resistance heating reduces costs, peak electricity demand, and improves operating efficiency. Backup heating remains important in colder climates or extended runtime applications.
- **Compressor Efficiency and Technology Adoption**: Compressor performance drives HP RTU system efficiency (IEER). Variable speed and multi-stage compressors offer more flexible part-load operation than single-capacity units but carry a cost premium (~$500–$750 per ton), limiting adoption. Most HP RTU sales (85–90%) remain at Title 24 minimum efficiency levels, highlighting the role of incentives in promoting higher-efficiency models.
- **Market Availability and Stocking Practices:**
  - HP RTUs (<15 tons) are generally available for light commercial applications, though higher-tonnage and higher-efficiency units are limited in stock.
  - Stocking limitations reflect market structure and design practices rather than distributor reluctance. Short-term strategies should focus on increasing availability of lower-tier units and preparing for higher-tier adoption (~2027) as variable-speed and multi-stage units become more common.
  - Larger HP RTUs and DOAS systems (>25 tons) and DOAS units are typically custom-built, made-to-order, and not stocked due to size, weight, cost, and long lead times, requiring program planning to accommodate order-to-installation timelines.

- **DOAS Efficiency Ratings Availability:** AHRI listing information for DOAS equipment is not yet widely available, limiting current program participation and necessitating upstream manufacturer engagement for future incentive alignment.
- **Stakeholder Input:** Feedback from distributors, manufacturers, and other market actors informed measure design, efficiency tier development, and identification of adoption barriers, reinforcing the need for appropriately sized incentives and early-stage program engagement.

## Recommendations

Based on the findings from the Focused Pilot and market analysis, the following recommendations aim to support the adoption of high-efficiency HP RTUs and DOAS, improve program effectiveness, and guide future measure development.

**1) Optimize Fuel Substitution Opportunities**

a) Encourage installation of HP RTUs without supplemental electric resistance heating, leveraging California's mild climate to reduce costs and improve efficiency.

b) Recognize high-efficiency features not captured by energy efficiency metrics, such as demand-controlled ventilation, to support additional energy savings.

c) Support adoption of high-efficiency solutions that avoid unnecessary backup heating while gathering data to inform future program design.

**2) Add Higher Efficiency Measure for HP RTUs**

a) Introduce a higher efficiency tier to California's HP RTU measure portfolio.

b) Use appropriately sized incentives (>70 percent of the increased cost from code minimum) in midstream program design to increase adoption of units with higher IEER ratings to enhance energy savings and program impact.

**3) Implement Variable Capacity HP RTUs Measure**

a) Explore inclusion of variable speed and multi-stage compressors for HP RTUs, like successful AC RTU deemed measure , to maximize Total System Benefit (TSB) even if volume is lower.

**4) Establish the First DOAS Measure or Program**

a) Begin baseline assessments and program preparation for high-efficiency DOAS units.

b) Capitalize on energy savings potential from high-moisture removal loads in coastal cities.

c) Plan for certification database availability to reduce implementation barriers and accelerate program readiness.

## Abbreviations and Acronyms

| Acronym | Meaning |
|---|---|
| AC | Air conditioning |
| AC RTU | Air conditioning rooftop unit |
| AHRI | Air-Conditioning, Heating, and Refrigeration Institute |
| AIM | American Innovation and Manufacturing Act |
| ANSI | American National Standards Institute |
| ARC | Advanced rooftop controllers |
| ASHRAE | American Society of Heating, Refrigeration, and Air-Conditioning Engineers |
| Btu | British thermal unit |
| CalMTA | California Market Transformation Administrator |
| CARB | California Air Resources Board |
| CalTF | California Technical Forum |
| CEC | California Energy Commission |
| CEDARS | California Energy Data and Reporting System |
| CEE | Consortium for Energy Efficiency |

| Acronym | Meaning |
|---|---|
| CEUS | California Commercial End-Use Survey |
| COP | Coefficient of performance |
| CPUC | California Public Utilities Commission |
| CZ | Climate Zone |
| DC | Direct current |
| DCV | Demand controlled ventilation |
| DOAS | Dedicated outdoor air system |
| DOE | Department of Energy |
| DX | Direct expansion |
| DX-DOAS | Direct expansion-dedicated outdoor air systems |
| EA | Exhaust air |
| ECM | Electronically commutated motors |
| EE | Energy efficiency |
| EER | Energy Efficiency Ratio |
| ECM | Electronically commutated motor |
| EM&V | Evaluation, measurement, and verification |

| Acronym | Meaning |
| --- | --- |
| ER | Electric resistance |
| ERV | Energy recovery ventilation |
| eTRM | Electronic Technical Reference Manual |
| FDD | Fault detection and diagnostics |
| GIS | Geographic Information System |
| GWP | Global warming potential |
| HE | High efficiency |
| HE RTU | High efficiency rooftop unit |
| HGR | Hot gas reheat |
| HP | Heat pump |
| HP RTU | Heat pump rooftop unit |
| HRV | Heat recovery ventilation |
| HVAC | Heating, ventilation, and air conditioning |
| IDC | Inverter driven compressor |
| IEER | Integrated Energy Efficiency Ratio |
| IMC | Incremental measure cost |

| Acronym | Meaning |
|---|---|
| IOU | Investor-owned utility |
| ISCOP2 | Integrated Seasonal Coefficient of Performance |
| ISMRE2 | Integrated Seasonal Moisture Removal Efficiency |
| IVEC | Integrated Ventilation, Economizer and Cooling Efficiency |
| IVHE | Integrated Ventilation and Heating Efficiency |
| kBtuh | 1,000 British thermal units |
| kW | Kilowatt |
| kWh | Kilowatt-hours |
| MCEE | Minnesota Center for Energy and Environment |
| MRE | Moisture removal efficiency |
| MWh | Megawatt-hour |
| NEEA | Northwest Energy Efficiency Alliance |
| NYSEG | NYSEG New York State Electric and Gas |
| OA | Outside air |
| OEM | Original equipment manufacturer |

| Acronym | Meaning |
| --- | --- |
| PA | Program administrator |
| PNNL | Pacific Northwest National Laboratory |
| POU | Publicly owned utility |
| RH | Relative humidity |
| RTU | Rooftop unit |
| SCE | Southern California Edison |
| SW | Statewide |
| TSB | Total System Benefits |
| VAV | Variable air volume |
| VC | Variable capacity |
| VCC | Variable capacity compressor |
| VFD | Variable frequency drive |
| Wh | Watt-hour |

# Contents

# Tables

## Figures

# Introduction

The High Efficiency Rooftop Unit (HE RTU) Focused Pilot builds off the recently concluded ET23SWE0073 Focused Pilot (Fosberg, et al. 2025). The goal of the ET23SWE0073 Focused Pilot was to streamline the incentive process and increase program participation above the lower documented levels in the existing statewide heating, ventilation, and air conditioning (HVAC) program. The eligibility of HP RTUs was limited to efficiency and capacities that qualified for the current fuel substitution measure.[1] In addition to addressing known participation barriers, supply chain interviews aimed to identify additional barriers to entry for HP RTU technologies.

In contrast, this Focused Pilot seeks to examine the characteristics of HP RTUs that make them most efficient while maximizing decarbonization impacts for this technology. We hypothesize that the market will identify variable capacity capability as the primary efficiency driver but anticipate other characteristics—such as energy and/or heat recovery and controls—to be identified as additional drivers of system efficiency. Through the ET23SWE0073 Focused Pilot, the project team learned that at least two manufacturers are already producing and selling variable capacity HP RTUs in the California market with limited uptake.

This Focused Pilot aims to develop higher efficiency requirements for heat pump rooftop units and dedicated outdoor air systems (DOAS), with the goal of informing the development of a higher tier to be added to California's prescriptive measure portfolio.[2] This work also supports the addition of a measure for DOAS, which are not currently included in California's RTU measure portfolio. Additionally, this research supports California's Market Transformation Administrator's (CalMTA's) current market transformation initiatives (MTI), which prioritize commercial RTU installations in California to leverage increased energy savings (CalMTA 2024).

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[1] Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution (SWHC046-05), https://www.caetrm.com/measure/SWHC046/03/

[2] https://www.caetrm.com/

# Background

## Gas Heating in Commercial Buildings

Gas is commonly used to heat commercial buildings in California. According to the 2018 U.S. Energy Information Administration (EIA) Commercial Buildings Energy Consumption Survey (CBECS), space heating accounts for 108 trillion Btu—roughly 51% of total natural gas use—in commercial buildings across the Pacific West, out of an annual regional total of 212 trillion Btu (EIA 2018). This portion of the market has potential for substantial decarbonization impacts, if commercial HVAC systems are replaced with high efficiency HP RTUs and DOAS products.

The California Energy Commission (CEC) analyzed commercial energy expenditures in the 2022 California Commercial End-Use Survey (CEUS): Final Report.[3] Appendix K of that document (CEC 2019) broke down energy expenditures by end use—the results for heating fuel types are shown in Table 1 below.

As gas RTU equipment is phased out, there will be greater installation opportunities for higher efficiency HP RTU equipment. Measures that incentivize high efficiency HP RTU or HP DOAS products could expedite commercial decarbonization.

[3] 2022 California Commercial End-Use Survey (CEUS): Final Report. February 2024. https://www.energy.ca.gov/

Table 1: Fuel shares by building type for commercial building heating (CEUS 2022).

| Building Type | Percent of Heated Building Floorspace (%) | Electric Fuel Share (%) | Gas Fuel Share (%) | Other Fuel Share (%) |
|---|---|---|---|---|
| All Commercial | 76 | 29 | 69 | 2 |
| College | 98 | 13 | 86 | 1 |
| Food Stores | 81 | 36 | 63 | 1 |
| Health Care | 99 | 17 | 81 | 1 |
| Lodging | 99 | 40 | 57 | 3 |
| Miscellaneous | 67 | 26 | 70 | 4 |
| Office, Large | 92 | 13 | 86 | 2 |
| Office, Small | 91 | 43 | 56 | 1 |
| Ref. Warehouse | 18 | 74 | 23 | 4 |
| Restaurant | 90 | 34 | 65 | 2 |
| Retail | 79 | 41 | 58 | 0 |
| School | 98 | 24 | 74 | 2 |
| Warehouse | 29 | 49 | 51 | 0 |

## DOAS versus RTU

The scope of this Focused Pilot includes high efficiency (HE) HP RTUs and DOAS products. RTUs are very common commercial HVAC equipment that moderate indoor temperatures via a refrigeration compression cycle and are available in air conditioner/furnace or heat pump configurations. DOAS units have similar housing and functional components to HP RTUs but are primarily optimized for removing humidity from air, rather than heating or cooling air. to meet building ventilation demands. Often, DOAS units use the exact same cabinets as HP RTU products from the same manufacturer. However, DOAS units must process more incoming moisture from accommodating up to 100 percent OA. Outdoor air often has higher relative humidity (RH), or water content, than indoor air, making the HVAC system work harder and use more energy to condition the air.

The necessity for moisture removal in DOAS units increases the presence of energy recovery ventilation (ERV) or heat recovery ventilation (HRV) systems compared to HP RTUs. ERV and HRV may be included in HP RTU design schemes but are often less prioritized in the market. Common DOAS energy saving features have the potential for implementation in RTU manufacturing if there was a marketable need for them. In this Focused Pilot, both HP RTUs and DOAS products were evaluated via a product characterization catalog, where efficiency data for both system types were reviewed to determine which HE HVAC equipment features are higher priority for decarbonization efforts in California.

## Efficiency Standards

The efficiency standards differ between RTU and DOAS equipment. The following sections describe the efficiency ratings used to describe the two system types.

### Performance Ratings for RTUs and AHRI Standard 340/360-2022 (I-P)[4]

The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 340/360-2022 prescribes the test methodology for RTU equipment, which is used to evaluate the heating and cooling efficiency of AC and HP RTUs. Cooling efficiency is described by its full load value—Energy Efficiency Ratio (EER)—and its part load value—Integrated Energy Efficiency Ratio (IEER)—both of which are expressed in British thermal units per watt-hour (Btu/Wh). The EER represents the performance of the equipment running at full cooling capacity, representative of a 95°F day, and the IEER represents the performance of the equipment in seasonal conditions meant to describe the average efficiency of the unit throughout the cooling season (AHRI 2022).

The heating coefficient of performance (COP), expressed as the ratio of heating watts to power input watts, is the efficiency rating prescribed by the standard. COP is only determined for HP RTUs, since electric resistance heating included in AC RTUs cannot exceed the value of 1. COP is calculated at 47°F and 17°F to represent moderate and more extreme seasonal heating conditions. Other rating standards are used for commercial gas furnaces but utilize the same COP rating for easy comparison across equipment types; all gas furnaces have a COP less than 1.

Commercial packaged HP RTUs greater than or equal to 65 thousand British Thermal Units per hour ($kBtuh^{-1}$) are rated under the American National Standards Institute (ANSI) and AHRI 340/360-2022

[4] AHRI Standard 340/360-2022 (I-P). June 2023. https://www.ahrinet.org/system/files/2023-06/AHRI%20Standard%20340-360-2022%20%28I-P%29.pdf

("Performance Rating of Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment"). The team investigated the laboratory test conditions, instrumentation accuracy, calculation methods, and required performance metrics to understand what features of the high efficiency RTUs are covered as part of the current ratings and what features are above and beyond the test conditions.

### CURRENT RTU EFFICIENCY METRICS

The primary metrics to measure HP RTU efficiency are EER for full load cooling performance, IEER for part load cooling performance, and $COP_H$ (47 °F)/$COP_H$ (17 °F) for heating performance. AHRI 340/360 is referenced by both the Department of Energy (DOE) 10 CFR Part 431 Subpart F, which covers federal minimum standards for packaged equipment, and ASHRAE Standard 90.12022, also known as the commercial model energy code, which is used to anchor all utility programs in the United States. The AHRI 340/260 rated IEER and COP minimums are provided in Table 2. Smaller HP RTUs (< 65 $kBtuh^{-1}$) fall under AHRI 210/240, while AHRI 1230 covers variable refrigerant flow multi-split systems.

The IEER is a weighted average of four part-load points intended to approximate an annual cooling season as shown in Equation 1, where A, B, C, and D are net EER values measured at 100 percent, 75 percent, 50 percent, and 25 percent compressor capacity, and outdoor dry bulb temperatures of 95 °F, 81.5 °F, 68 °F, and 65 °F, respectively.

**Equation 1: IEER**

$$IEER = 0.020 \times A + 0.617 \times B + 0.238 \times C + 0.125 \times D$$

Supply fan power is included at the airflow rate required to meet the load, so equipment with a variable frequency drive (VFD) fan receives partial credit, but economizer energy and ventilation penalties are not captured. Heating performance is assessed separately as COP 47 °F (and optional COP 17 °F), with the same sectional airflow, but no latent component.

**Table 2: IEER code minimum baselines.**

| Cooling Capacity (Btu/h) | Title 24, Part 6 (2022) IEER / $COP_H$ (47 °F) | DOE / ASHRAE 90.1 (2023) IEER / COP |
|---|---|---|
| 65,000 – 134,999 | 14.1 / 3.4 | 14.1 / 3.4 *(electric resistance)*<br>13.9 / 3.4 *(non-electric)* |
| 135,000 – 239,999 | 13.5 / 3.3 | 13.5 / 3.3 *(electric resistance)*<br>13.3 / 3.3 *(non-electric)* |
| 240,000 – 759,999 | 12.5 / 3.2 | 12.5 / 3.2 *(electric resistance)*<br>12.3 / 3.2 *(non-electric)* |

### NEW RTU EFFICIENCY METRICS

In May 2024, the DOE finalized a major rule (Direct Final Rule, 89 FR 42006) that will replace IEER for federal compliance, with two new integrated metrics for products manufactured on or after January 1, 2029. Manufacturers could begin voluntarily certifying their products on May 15, 2025. The two new integrated metrics are:

1. **IVEC: Integrated Ventilation, Economizer and Cooling Efficiency.** The sum of the space cooling provided in Btus is divided by the sum of energy consumed in Whs. This includes mechanical, supplementary electric resistance, cooling season ventilation cooling types, and operating modes. IVEC adds explicit fan power at the airflow required to satisfy ASHRAE 62.1 ventilation, plus the economizer mixing penalty. Five outdoor air bins are evaluated—95°F, 81.5°F, 73°F, 65°F, 55°F—with fan power prorated; weighting factors are derived from nationally representative weather data.
2. **IVHE: Integrated Ventilation and Heating Efficiency.** The sum of the space heating provided in Btus is divided by the energy consumed in Whs. This includes mechanical, supplementary electric resistance, heating season ventilation heating types, and operating modes.

For an analogous heating season metric incorporates supply fan, crankcase, defrost and supplemental heat loads, four test points (47°F, 35°F, 20°F, 0°F) are weighted to reflect annual heating hours.

By adding ventilation and economizer control programming, IVEC and IVHE metrics reward high turndown VFD fans. DOE analysis shows the 2029 IVEC and IVHE minimums are approximately 15 percent stricter than today's IEER bases for 5- to 20-ton HP RTUs. Unlike IEER, IVEC and IVHE give explicit credit for high turndown supply fan VFDs, economizer fault detection, and low power ventilation sequences. Programs that incentivize these controls will be future proof.

ASHRAE 90.1 is expected to correspond with IVEC and IVHE metrics when the full 2025 edition is published. Title 24, Part 6, will also adopt new federal test metrics within one or two cycles after DOE; therefore, these metrics could become code minimum baseline.

## Performance Ratings for DOASs: AHRI Standard 920-2020 (I-P) (AHRI 2021)[5]

AHRI Standard 920-2020 prescribes the test methodology for DOAS equipment, which evaluates both the moisture removal efficiency (MRE) and the temperature change efficiency of the unit. Cooling efficiency is measured by its Integrated Seasonal Moisture Removal Efficiency (ISMRE2) rating, which is expressed in pounds (lb) of moisture per kWh. ISMRE2 is calculated by weighing the MRE at prescribed seasonal conditions of temperature and humidity to represent different seasonal levels of use. Heating efficiency is measured by its Integrated Seasonal Coefficient of Performance (ISCOP2) rating, expressed in W/W. W/W is the heating capacity in watts to the power input values in watts at 47°F and 17°F (ASAP 2022).[6] ISCOP2 is calculated by taking a weighted average of the equipment's COP at prescribed seasonal conditions of temperature and humidity (AHRI 2020).

### CURRENT DOAS EFFICIENCY METRICS

Title 24, Part 6 Residential, Nonresidential, and Multifamily Buildings currently outlines the minimum efficiency requirements for DOAS units,[7] which is defined as direct expansion (DX)-DOAS in the standard rather than a DOAS unit from the ASHRAE standards. The Title 24, Part 6 standard includes two efficiency metrics, pulling from definitions in AHRI 920 – Performance Rating of Direct Expansion-Dedicated Outdoor Air System Units.

1. **ISCOP2** is a seasonal efficiency number, which is a combined value based on the formula listed in the AHRI Standard 920 of the two COP values for the heating season of a DX-DOAS unit water or air source heat pump, expressed in the ratio of heat output (W) to the electrical energy input (W), or W/W.
2. **ISMRE2** is a seasonal efficiency number that measures how effectively a system removes moisture from the air during a particular season. The ISMRE is a combined number based upon the formula listed in AHRI Standard 920 of the four-dehumidification MRE ratings required for DX-DOAS units, expressed in pounds of moisture per kWh.

During the manufacturer review, there was no mention of these metrics within the product literature, and there are also no DOAS that are included in the AHRI-certified product performance directory. The project team is unsure why there are so few DOAS systems certified or documented, but that is beyond the scope of this effort. The limited available options for DOAS products make it difficult to document in publicly available product data sheets.

[5] AHRI Standard 920-2020 (I-P)

[6] Direct Expansion-Dedicated Outdoor Air Systems | ASAP Appliance Standard Awareness Project

[7] Table 110.2-K, 2022 Building Energy Efficiency Standards (final version)

## California RTU Measures

The existing RTU measures within California's energy efficiency (EE) portfolio are illustrated in Figure 1 below. Some of the efficient product features included in this study are also found in these measures, though their applicability in the HP RTU market is limited.

The measure for like-for-like installations—e.g., an HP RTU replacing an HP RTU—under SWHC013-06 incorporates the highest efficiency criteria through a tiered approach. However, HP RTUs replacing AC RTUs are not eligible for this measure. This scenario is addressed by the California Electronic Technical Reference Manual (eTRM) fuel substitution HP RTU measure, SWHC046-05.

Variable capacity compressors (VCCs) are a criterion included in the SWHC043-07 measure, which applies to AC RTUs. However, HP RTUs are excluded from the scope of this measure.

Heat recovery air conditioning (AC) RTUs are likewise included in the portfolio under the measure SWHC048-04. However, its application is limited, as it is only relevant to installations in fast food restaurants with gas-heated hot water service.

Expanding the scope of the existing AC RTU measures could be a beneficial addition to the HP RTU measure portfolio. However, findings from the Midstream Incentive Pilot indicate that the market is not yet prepared for this change. Future results may prompt a revision of this recommendation.

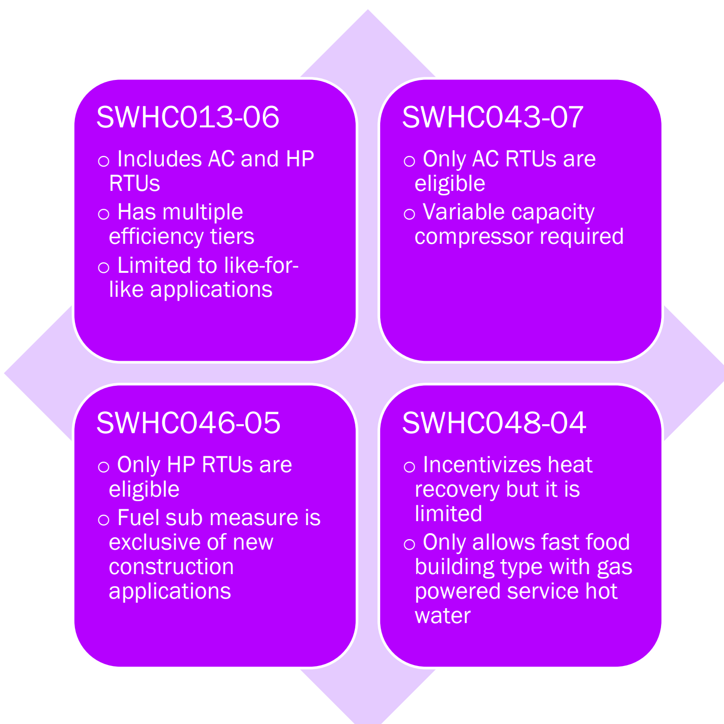


**Figure 1: Existing California EE RTU measures.**

## Past and Present Programs

### Consortium for Energy Efficiency RTU Program Tiers

The Consortium for Energy Efficiency (CEE) tiered structure supports consistent incentive design and highlights clear efficiency performance targets across the market. Table 3 below summarizes the CEE efficiency tier criteria for air-cooled RTUs across different cooling capacity ranges.

CEE defines a four-tier framework for commercial unitary HVAC equipment in the following way:

- **Tier 0** represents equipment that meets federal minimum efficiency standards but does not qualify for higher tiers.
- **Tier 1** marks the entry-level for high-efficiency equipment.
- **Tier 2 and Tier 3** include models that exceed Tier 1 performance, often used in utility incentive programs.
- **Advanced Tier** represents the highest-performing units, typically incorporating features like variable-speed components, integrated economizers, and demand-response capability.

The CEE four-tier framework was applied to the HP RTU product category and full CEE℠ Commercial Unitary Air Conditioning and Heat Pumps Specification[8] document can be found on the CEE website (CEE 2023).

[8] CEE Commercial Unitary Air-conditioning and Heat Pumps Specification. November 2023. Accessible at: https://cee1.my.site.com/s/resources?id=a0V2R00000sUQbj

**Table 3: CEE tier matrix framework for standard test conditions.**

| Tier | Description |
| --- | --- |
| Tier 0 | 1. A level with planned obsolescence. This could be at a specific date (e.g., when new federal minimum standards go into effect), or open to a point which the Committee deems the specification no longer necessary (e.g., market saturation reached a given level).<br>2. Intending to enable program administrators to obtain high product volume in order to meet product volume in order to meet their energy savings goals. |
| Tier 1 | 1. Cost-effective for programs when CEE Tier 1 aligns with ENERGY STAR*.<br>2. Top 25% of models.<br>3. Cost-effective for the customer.<br>4. Multiple manufacturers make products widely available. |
| CEE Tier 2 and Tier 3 | 1. Tiers above ENERGY STAR minimum when performance merits differentiated incentives.<br>2. Typically, three or more manufacturers in a category.<br>3. Cost-effective for customers with incentive.<br>4. Cost-effective for most market transformation programs. |
| CEE Advanced Tier | 1. Reserved for stretch target.<br>2. Truly exceptional, aspirational energy efficiency performance.<br>3. Attracts early adopters.<br>4. Ideally, two mor more manufacturers.<br>5. Brings attention to top performers.<br>6. Cost-effective in the future. |

* There has been discussion around whether the ENERGY STAR program will be sunset or privatized (Salmonsen 2025)[9] (Brady 2025).[10]

[9] How the potential end of Energy Star could affect apartment operators | Smart Cities Dive

[10] The Trump administration seeks to eliminate or privatize the Energy Star program: NPR

### DOE Commercial Building HVAC Technology Challenge Specification

The DOE has developed a Commercial Building HVAC Technology Challenge to motivate development of innovative RTUs that meet their advanced specification (National Renewable Energy Laboratory 2025). The challenge adopts the updated efficiency metrics via the standards below, listed in order of precedence:

1. Appendix A1 to Subpart F of 10 CFR 431 ("Appendix A1")
2. Air Conditioning, Heating, and Refrigeration Institute (AHRI) 1340-2024
3. American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ANSI/ASHRAE) 37-2009.

The minimum capacity and efficiency requirements for heating are provided in Table 4 below. Optional capacity and efficiency requirements for improved cold climate performance are like the performance outlined in Table 2 but the minimum capacity ratio is increased from 0.7 to 1 for outdoor air temperatures equal to -10°F and increased from 1 to 1.4 for outdoor air temperatures equal to 5°F.

**Table 4: DOE Commercial Building HVAC Technology Challenge efficiency requirements.**

| Nominal Capacity [Btu/h] | Outdoor Air Temperature: -10°F | | Outdoor Air Temperature: 5°F | | Minimum $IVHE_c$ |
|---|---|---|---|---|---|
| | COP2 | Minimum Capacity Ratio | COP2 | Minimum Capacity Ratio | |
| ≥65,000 and <135,000 | 1.3 | 0.7 | 1.7 | 1 | 7.1 |
| ≥135,000 and <240,000 | 1.3 | 0.7 | 1.7 | 1 | 6.9 |
| ≥240,000 and <760,000 | 1.3 | 0.7 | 1.7 | 1 | 6.7 |

### ET23SWE0073 Focused Pilot

The ET23SWE0073 Supply-Chain Engagement Focused Pilot is the most recent program dataset the project team has access to, aside from the current incentive pilot, which is a good assessment tool for where HP RTU market efficiency trends currently stand. The team calculated the weighted average efficiency of all AHRI listed equipment[11] and qualifying HP RTU submissions from the ET23SWE0073 Focused Pilot. The average efficiency was weighted by the equipment cooling capacity in tons since there is a direct positive correlation between cooling capacity and efficiency impact on energy savings.

The weighted average efficiency for ET23SWE0073 Focused Pilot equipment did not exceed the average for AHRI-rated HP RTUs in any efficiency category, such as IEER, EER, and COP. Variance in average efficiency ranged between 0.6 to 2.0 for IEER, with decreasing average efficiency performance as equipment size increased. Like IEER, the difference in EER between AHRI and the ET23SWE0073 Focused Pilot went up as the equipment size increased. Variance in EER average performance differences ranged from 0.3 to 0.6, and average heating efficiency did not vary much for any size category between AHRI and ET23SWE0073 Focused Pilot equipment. The one difference shown between COP averages was for the smallest HP RTUs—5.4 to 11.3 tons. The AHRI average was only 0.1 COP higher than the ET23SWE0073 Focused Pilot average.

The sample size of the ET23SWE0073 Focused Pilot data compared to the AHRI dataset was much smaller, which means the average efficiency for HP RTUs for this data may not be fully representative of the HP RTU market. The ET23SWE0073 Focused Pilot data only contained 11 units in the 11.3- to 20-ton range. The average for this size bin is statistically less significant than the averages calculated for other size bins from the ET23SWE0073 Focused Pilot. The unit and ton volumes for Figure 2 are provided in Table 5. For a more in-depth view of the efficiency populations included in Figure 2, please refer to Appendix E.

[11] There are duplicate equipment models in the AHRI directory since manufacturers sell equipment under multiple brand names. This may impact the AHRI average efficiency results. Normalizing and consolidating the AHRI data to exclude double counting of similar models is a good next step for this analysis.

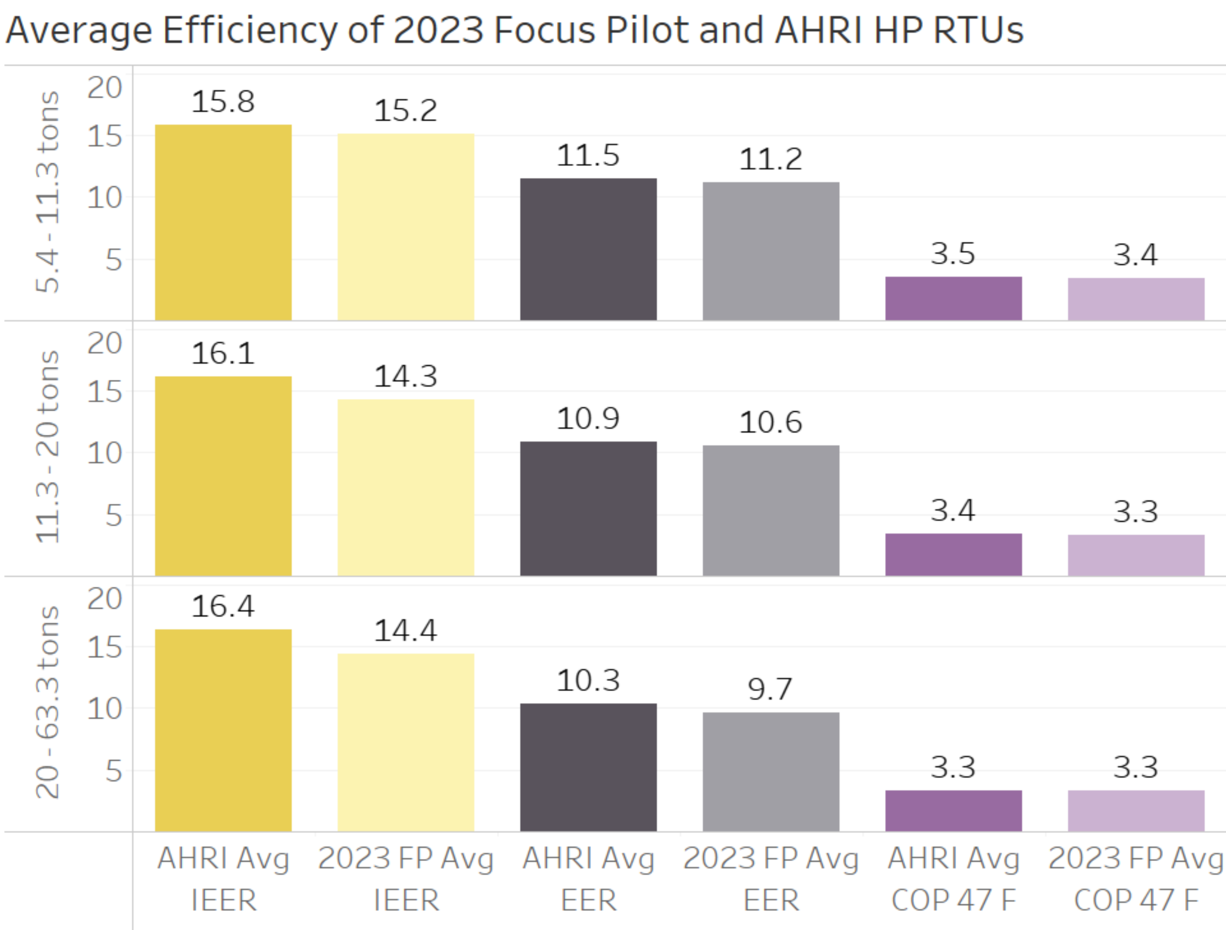


**Figure 2: Average efficiency of ET23SWE0073 Focused Pilot and AHRI HP RTUs.**

**Table 5: Sample size for average efficiency of ET23SWE0073 FP and AHRI HP RTUs.**

| Cooling Capacity Size Bin (Tons) | 2023 FP Total Unit Quantity | AHRI Total Unit Quantity | 2023 FP Total Cooling Capacity (Tons) | AHRI Total Cooling Capacity (Tons) |
|---|---|---|---|---|
| **5.4 – 11.3** | 114 | 1,473 | 914 | 11,303 |
| **11.3 – 20** | 11 | 834 | 148 | 12,033 |
| **20 – 63.3** | 47 | 2,076 | 1,072 | 65,602 |

### Existing California RTU Programs

RTU participation volumes for California RTU measures between the years 2022 and 2024[12] are documented in this section and in Table 6 below. The data was sourced from the California Energy Data Reporting System (CEDARS) database, which is updated regularly by the California Public Utility Commission (CPUC).

Program participation dropped in 2023 across all three measures, although the like-for-like RTU measure (SWHC013) had the highest participation. This aligns with the team's expectations, since customers are likely to replace an HVAC system with the same type of system, especially if it is the cheapest option, e.g., AC RTUs versus HP RTUs.

While the percentage of tons is highest for SWHC013, the percentage of Total System Benefit (TSB) shows that this measure has lower impacts per unit. For example, although in 2023, SWHC013 made up 86 percent of the RTU tons measured, the benefits only made-up 68 percent of the TSB for the year. In contrast, the fuel substitution HP RTU measure (SWHC046), which incentivizes HP RTUs replacing AC/furnace RTUs, incentivized 1 percent of RTU tons but made-up 6 percent of the year's TSB. The variable capacity AC RTU measure (SWHC043) made up 13 percent of the year's reported tons but contributed 26 percent of the year's TSB.

The average TSB per ton demonstrates the average value offered per installation for each measure. Based on these results, the measure packages SWHC043 and SWHC046 offer more cost savings per installation than SWHC013.

[12] 2024 volumes are likely not for the full year since CEDARS data is regularly updated.

Table 6: California RTU program benefits and volume (CEDARS 2022 to 2024).

| Year | Measure Package ID | Percent of Total Tons | Total Tons | Percent of Total System Benefit | Total System Benefit | TSB per Ton |
|---|---|---|---|---|---|---|
| 2022 | SWHC013 | 93% | 9,842 | 65% | 567,990 | 58 |
| | SWHC043 | 7% | 726 | 32% | 278,754 | 384 |
| | SWHC046 | 1% | 66 | 3% | 25,765 | 390 |
| | Total | 100% | 10,634 | 100% | 872,509 | 82 |
| 2023 | SWHC013 | 86% | 38,812 | 68% | 774,245 | 20 |
| | SWHC043 | 13% | 5,738 | 26% | 299,450 | 52 |
| | SWHC046 | 1% | 494 | 6% | 64,241 | 130 |
| | Total | 100% | 45,044 | 100% | 1,137,936 | 25 |
| 2024 | SWHC013 | 86% | 9,535 | 58% | 195,972 | 21 |
| | SWHC043 | 12% | 1,372 | 35% | 118,531 | 86 |
| | SWHC046 | 2% | 167 | 7% | 23,938 | 143 |
| | Total | 100% | 11,074 | 100% | 338,442 | 31 |

### DOAS Efficiency Programs

Given that the AHRI 920-2020 standard is new, no DOAS energy efficiency (EE) programs were discovered. We suspect that with the AHRI directory beginning to catalog efficiencies for these units, programs will become more common. We will continue to research DOAS programs throughout the timeline of the Focused Pilot in case the team finds new examples.

## Drivers and Barriers

Market drivers—factors that help a business succeed—for HP RTU adoption include incentives, education, marketing, electrification policies, and promotions of product by distributor sales engineers. Market barriers are obstacles that prevent businesses from accessing a particular market, or in this case, HE HP RTUs.

In the ET23SWE0073 Focused Pilot, higher costs were identified as the most significant barrier to HP RTU adoption for commercial building owners, while lowered costs appeared to be a significant driver for the HP RTU market. This was demonstrated by the increased program engagement in the midstream CalNEXT HP RTU pilot due to significantly higher incentives compared to the statewide HVAC program. Since the conclusion of the ET23SWE0073 Focused Pilot, no uptake of lessons learned has been observed. Incentive levels have not increased for the SW CHVAC program thus far.

In addition to cost, other barriers remain prevalent in the HP RTU and DOAS markets, including reduced stocking practices, lack of contractor and consumer understanding of highly efficient RTU product capabilities, lack of consistent terminology describing product features in the market, and a lack of standardization and documentation of benefits associated with HE product features.

The barriers are listed below for ease of reference throughout the report:

- Low market availability of HE RTU/DOAS equipment.
- Lack of characterization of HE RTU/DOAS product feature benefits.
- Lack of contractor and customer awareness and understanding of HE RTU/DOAS capabilities and characteristics.
- Lack of consistent language surrounding various HE RTU/DOAS product features across manufacturers.
- Increased measure costs associated with HE RTUs over minimally compliant HE RTUs/DOASs.

## Objectives

The HE RTU Focused Pilot aims to provide clear, actionable recommendations for increasing efficient RTU and DOAS installations in California. This section outlines the project's completed outcomes, activities, and technology transfer plans.

**Table 7: Progress to date toward objectives.**

| Objective | Measure of Progress | Percent Completion (%) |
| --- | --- | --- |
| **Determine and define high efficiency product characteristics for RTUs and DOAS.** | The product characterization study defined high efficiency product characteristics for RTUs and DOAS. | 100 |
| **Determine appropriate advanced measure criteria and incentive levels for HP RTUs.** | HP RTU advanced measure criteria have been designed. The advanced measure criteria born from the product characterization study differ slightly from the Midstream Incentive Pilot's criteria but will still benefit from pilot participant feedback. | 100 |
| **Determine appropriate initial measure criteria and incentive levels for DOAS.** | DOAS initial measure criteria have been designed and are currently being evaluated via the Midstream Incentive Pilot. | 100 |
| **Test measure criteria and incentive levels via midstream pilot.** | Incentive pilot design is complete. Participants are fully enrolled, and applications are actively being submitted. Applications will be reviewed on an ongoing basis through the program term. | 100 |
| **Assess effectiveness of measure criteria and incentive levels via pilot participant feedback.** | Effectiveness of measure criteria and incentive levels are currently being evaluated. Findings from the Midstream Incentive Pilot participation rates will inform the pilot's measure design. | 100 |
| **Provide incremental cost (IMC) information pertaining to high efficiency RTUs and DOAS.** | The team collected IMC information provided in the Upfront Cost section. It is currently being refined. | 100 |

| Objective | Measure of Progress | Percent Completion (%) |
|---|---|---|
| **Provide recommendations for light commercial HVAC measures.** | Measure tier recommendations are complete and may be found in the Findings section of the report. Representative energy savings estimates were modeled for the recommended HP RTU measure tiers. | 100 |

## Activities

In support of these objectives, the project team engaged in many activities, as detailed below.

### Completed Activities

- Interviewed manufacturers, distributors, and contractors to understand efficiency and performance characteristics of available HP RTU and DOAS equipment.
- Conducted a midstream pilot testing incentive readiness for HE HP RTU and DOAS characteristics.
- Conducted a product characterization study of HP RTU and DOAS equipment.
- Created a product characterization catalog, based upon characterization study findings.
- Defined high efficiency tier requirements for HP RTUs and DOAS units based on efficiency metrics, physical equipment characteristics, or a combination of both.
- Provided measure recommendations for HP RTUs and DOAS within the Final Report.
- Assess market penetration of HE HP RTUs and DOAS equipment.
- Create one-to-two-page marketing collateral summarizing Focused Pilot findings.

## Technology Transfer

The stakeholders listed in this section are groups or entities with which the project team plans to share the following conclusions and recommendations.

- **California Technical Forum (CalTF)**: Measure package recommendations (which high efficiency features to prioritize).
- **CALMTA**: Measure package recommendations (which high efficiency features to prioritize).
- **Energy efficiency program administrators and implementers**: Measure package recommendations and marketing collateral (which high efficiency features to prioritize).
- **Commercial building owners:** How HE HP RTUs can benefit them from a cost standpoint, along with the capability of these units (they can effectively heat your building).
- **Contractors and distributors:** What makes HP RTUs and DOAS more efficient—e.g., variable speed compressors, VFDs, demand-controlled ventilation (DCV), etc.—to address lack of product characteristic understanding.
- **HP RTU Working Group**: Technology transfer efforts were initiated in March with this working group, which is made up of attendees from the following organizations: Pacific Gas & Electric (PG&E), CLEAResult, 2050 Partners, Resource Innovations, McHugh Energy Consultants, and Brio. However, the working group was discontinued in April by the group leader.

### Coordination

During this Focused Pilot, the project team met with numerous stakeholders to gather their feedback regarding HE RTUs, including the Consortium for Energy Efficiency (CEE), the Minnesota Center for Energy and Environment (MCEE), the CalMTA, and the Northwest Energy Efficiency Alliance (NEEA).

# Methodology and Approach

The Focused Pilot's project activities and deliverables are described in this section, along with associated barriers.

## Market Interviews[13]

Market interviews—which have included manufacturers, distributors, and a design engineer—were conducted throughout the pilot's duration to obtain industry knowledge from manufacturers and distributors.

For the purposes of this study, the term distributors refers broadly to both sales engineers and management or leadership personnel (e.g., general managers). This distinction is important, as these participants possess deep market knowledge and extensive experience—often spanning decades—providing valuable insight into sales practices, customer decision drivers, and opportunities for program intervention.

These interviews support all other pilot activities by serving as both a source of information and an opportunity to validate hypotheses about the market. The project team plans to coordinate with as many levels of the supply chain as is feasible, capturing a well-rounded perspective that will aid California's EE efforts.

Survey questions from the preliminary and final interviews are provided in Appendix D and Appendix I.

### Discussion Topics

Topics discussed over the course of the Focused Pilot during market interviews include:

- Equipment efficiency trends
- Prevalence of efficient HP RTUs and DOAS (product availability and demand)
- HP RTU and DOAS customer insights and sales strategies
- Incremental cost (IMC) of different equipment features
- High Efficiency Product Features
- Incremental Measure Cost (IMC)
- Program Readiness
- Existing and new design strategies
- Equipment limitations

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[13] This activity was designed to address these barriers, as listed in the Drivers and Barriers section:

- Low market availability of HE RTU/DOAS equipment.
- Lack of characterization of HE RTUs/DOASs product feature benefits.
- Lack of contractor and customer awareness and understanding of HE RTU/DOAS capabilities and characteristics.
- Lack of consistent language surrounding various HE RTU/DOAS product features across manufacturers.
- Increased measure costs associated with HE RTUs over minimally compliant HE RTUs/DOAS products.

## Midstream Incentive Pilot[14]

The Midstream Incentive Pilot tested the effectiveness of the defined measure criteria against RTU and DOAS products in the California market. The midstream pilot aimed to increase the number of HE HP RTUs and DOAS products stocked and sold by distributors in California and collect information on the prevalence of HE RTU and DOAS products. Additionally, the Midstream Incentive Pilot provides a touch point for the project team to discuss high efficiency equipment features with distributors and provide additional market insights.

### Product Eligibility and Incentive Design

The HE HP RTU and DOAS product feature requirements are defined in Table 8 and Table 9. Efficiency levels for RTUs were developed based on past program data in the CEDARS database, market feedback, and the ET23SWE0073 Focused Pilot. More details on the past program analysis can be found in the Existing California RTU Programs section of this report.

The team interviewed four manufacturers, six distributors, and one HVAC design engineer in support of defining which product features in HP RTU and DOAS units drive equipment efficiency. Manufacturers agreed with the project's hypothesis that DOAS can have higher efficiency features than RTU units due to the increased energy needed for processing up to 100 percent OA. Highlighted efficient system features include variable capacity compressors (VCC), variable air volume (VAV) systems, HRV, ERV, VFDs, ECM motors, DCV, and liquid desiccant systems—all of which could be applied to HP RTUs to increase their efficiency. The product characterization portion of the Focused Pilot further analyzed high efficiency system features. More information describing high-efficiency product features explored in the pilot can be found in the Product Characterization Study section of the report.

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[14] This activity was designed to address these barriers, as listed in the Drivers and Barriers section:

- Low market availability of HE RTU/DOAS equipment.
- Lack of characterization of HE RTUs/DOAS units product feature benefits.
- Increased measure costs associated with HE RTUs over minimally compliant HE RTUs/DOAS units.

### HP RTU

AC RTUs are not eligible for incentives. Variable capacity AC RTUs are fairly optimized in the market, and highly efficient AC RTUs are incentivized by the existing SWHC043-07 Multiple Capacity Air-Conditioner eTRM measure. Therefore, the pilot team did not see a need to target AC RTUs via a pilot midstream incentive. A more detailed description of existing RTU measures can be found in .

HP RTUs are eligible for Tier 1 if they meet the efficiency requirements alone, but Tier 2 HP RTUs must have a variable speed compressor or a heat recovery system to qualify. Equipment eligibility requirements for HP RTU equipment are listed in Table 8 below. Minimum IEER exceeds the minimums for existing measure package, SWHC046-Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution. AHRI defines equipment cooling capacity as its rated capacity, or design capacity at AHRI rating conditions for units without an AHRI rating. Equipment must be listed or tested to AHRI 340/360-2022 to qualify.

**Table 8: HE HP RTU midstream pilot product requirements.**

| System Type | Cooling Capacity (tons) | EER | IEER | COP 47 | Feature Requirements | Incentive Tier | Incentive ($/ton) |
|---|---|---|---|---|---|---|---|
| HP RTU | 5.4–11.25 | 11 | 16.5 | 3.4 | N/A | Tier 1 | $375 |
| | 11.25–20 | 10.6 | 16.4 | 3.2 | | | |
| | ≥ 20 | 9.5 | 16.4 | 3.2 | | | |
| | 5.4–11.25 | 11 | 16.5 | 3.4 | Energy Recovery (HRV or ERV) or Variable Speed Compressor | Tier 2 | $500 |
| | 11.25–20 | 10.6 | 16.4 | 3.2 | | | |
| | ≥ 20 | 9.5 | 16.4 | 3.2 | | | |

### DOAS

The project team has not discovered any existing DOAS measures thus far. Therefore, the midstream pilot design for these products has an expanded scope to include AC DOAS units if they contain the outlined high efficiency product features. The DOAS efficiency requirements found in Table 9 match the minimum requirements dictated by Title 24, Part 6 for DX-DOAS products (California Energy Commission 2022). The requirements were kept at a minimum for efficiency, since AHRI 920-2020 efficiency ratings are not well characterized at this time. AHRI does not currently offer listings for DOAS equipment, but AHRI is expected to collect DOAS equipment information in its directory by the end of 2025. Complete 2022 California building minimum efficiency requirements are provided in .

DOAS products are eligible for Tier 1 if they meet the efficiency requirements alone. DOAS that meet the efficiency requirements and that have a variable capacity compressor or heat recovery system qualify for a Tier 2 incentive. DOAS eligibility requirements are listed below; all equipment must be tested to AHRI 920-2020 to qualify.

**Table 9: HE DX-DOAS midstream pilot product requirements.**

| System Type | ISMRE2 | ISCOP2 | Has an Energy Recovery System? | Feature Requirements | Incentive Tier | Incentive ($/ton) |
| --- | --- | --- | --- | --- | --- | --- |
| AC DOAS | 3.8 | N/A | No | N/A | Tier 1 | $500 |
| | 3.8 | N/A | No | Variable Speed Compressor | Tier 2 | $600 |
| | 5 | N/A | Yes | N/A | | |
| HP DOAS | 3.8 | 2.05 | No | N/A | Tier 1 | $500 |
| | 3.8 | 2.05 | No | Variable Speed Compressor | Tier 2 | $600 |
| | 5 | 3.20 | Yes | N/A | | |

## Incentive Design

The IMC for different equipment tiers are critical to an effective program design to ensure strong participation. Incentives were developed based on IMC information collected during market interviews for both RTUs and DOAS.

The ET23SWE0073 Focused Pilot established a recommended incentive for HP RTUs of $370 per ton, ensuring at least 80 percent IMC coverage. The incentive for Tier 1 HP RTUs was set to $375 per ton, aligning with this recommendation, and the incentive for Tier 2 equipment was set to $500 per ton, accounting for the additional cost associated with variable speed compressors or energy recovery systems.

DOAS units are more expensive than HP RTUs and thus require a higher incentive than HP RTUs to influence the market. The incentive for Tier 1 DOAS was set to $500 per ton and the incentive for Tier 2 DOAS units was set to $600 per ton.

### Recruitment Status

Pilot recruitment has concluded. The project team recruited six distributors for the midstream incentive pilot, and five of the six participating distributors submitted incentive applications through October 31, 2025.

### Claim Submission Process

The team finalized and input the HP RTU and DOAS measures described above into the claim processing submission platform. As in the ET23SWE0073 Focused Pilot, we aim to require enough data to ensure accuracy of program influence and proof of installation. This evaluation, measurement, and verification (EM&V) approach will ensure maximum participation. Streamlining the midstream pilot is of the utmost importance, as this method has been proven to increase program participation and efficacy. Upon enrollment, participants receive access to the system and are able to submit claims immediately thereafter.

This process is subject to change dependent on insights collected from prospective participants, e.g., data field collection difficulties. The general process that a program participant follows when submitting an incentive claim is shown below:

1. The distributor logs into the designated portal.
2. The contractor provides the following project information on the portal:
    a. Project Information
        i. Installation address, city, zip code, and state
        ii. Project type
        iii. Invoice number
        iv. Sales date
        v. Estimated install date
        vi. Contractor
    b. Equipment Information
        i. AHRI reference number[15] (if applicable)
        ii. Quantity
        iii. Product type

[15] AHRI reference numbers are only applicable to AHRI-rated equipment. Some eligible products may not be in the AHRI directory and will be processed manually if needed.

iv. Model/condenser

v. Evaporator/indoor unit/ducting type

vi. Serial number

vii. Specification sheet[16] (if applicable)

viii. Energy recovery ventilator (ERV) / heat recovery ventilator (HRV) System Type (if applicable)[17]

ix. Compressor Type[18]

3. The project team validates the claim via automated and manual processes.
4. Claims that meet all pilot requirements, including territory and efficiency requirements, will be approved and paid out.

### Claim Evaluation Process

The program team evaluated customer addresses to verify that projects are within eligible investor-owned utility (IOU) territory, using the open-source Electric Load Serving Entities Geographical Information Systems (GIS) tool (CEC 2024)[19] developed by the CEC. Claims that met territory and efficiency requirements were approved.

[16] Specification sheets were only collected for equipment not rated on the AHRI Directory.

[17] Tier-1-eligible equipment does not have an energy recovery system. This field collects whether this is the case for a given installation.

[18] Tier-2-eligible equipment has a variable speed compressor. This field collects whether this is the case for a given installation.

[19] The California Electric Load Serving Entities GIS tool includes boundaries of IOU and publicly owned utilities (POU) territories. The tool may be accessed here: https://cecgis-caenergy.opendata.arcgis.com/

## Efficiency Tier Matrix[20]

The goal of this pilot was to establish a performance-based incentive tier structure for HP RTUs. Considering this objective, the project team combined multiple data sources and industry insights to develop a California- appropriate tier structure. This process leveraged the HE features identified in the Product Characterization Study section and a detailed product assessment of leading HP RTU manufacturers. Additionally, the team reviewed existing incentive programs and specifications, including those from national utilities, regional utilities, and organizations such as CEE—all of which educated us on the prevailing trends in high performance RTU design.

### Measure Tier Design

To understand where the proposed California incentive tiers should begin, the project team benchmarked the current CEE tier thresholds against three state-specific reference points: (1) the Title 24, Part 6 prescriptive efficiency table for heat pump RTUs, (2) the California Technical Resource Manual (TRM) default values used in utility workpapers, and (3) the Comfortably California program requirements. The comparison, summarized in Table 10 below, shows that CEE Tier 1 lines up almost exactly with the TRM default, while the Comfortably California target sits roughly halfway between CEE Tier 1 and CEE's Advanced Tier.

**Table 10: Title 24 and program requirements for HP RTUs in California.**

| Nominal Cooling Capacity (HP-RTU) (Btu $h^{-1}$) | T-24 Requirement | TRM Requirement (Fuel Substitution)[21] | Comfortably CA Requirement |
|---|---|---|---|
| 65,000 – 135,000 | 14.1 IEER / 3.4 COP | 15 IEER / 3.4 COP | 16 IEER / 3.4 COP |
| 135,000 – 240,000 | 13.5 IEER / 3.3 COP | 14.5 IEER /3.2 COP | 15.5 IEER /3.2COP |
| 240,000 – 760,000 | 12.5 IEER / 3.3 COP | 13.5 IEER / 3.2COP | 14 IEER / 3.3 COP |

To inform the development of incentive tiers for high efficiency HP RTUs, the project team reviewed the CEE Commercial Unitary HVAC program and its adoption across various utility providers in the

[20] This activity was designed to address these barriers, as listed in the Drivers and Barriers section:

- Lack of characterization of HE RTUs/DOAS product feature benefits.
- Lack of contractor and customer awareness and understanding of HE RTU/DOAS capabilities and characteristics.
- Lack of consistent language surrounding various HE RTU/DOAS product features across manufacturers.

[21] Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution | ETRM

United States. CEE aggregates upstream and downstream incentives from more than 40 North American utilities. We identified the following trends for 35 distinct HP RTU utility programs:

- IEER-only tiers have the most incentives, with 23 utility programs for a single high efficiency tier valued at 10 to 15 percent above the prevailing Title 24, Part 6 and ASHRAE 90.1 IEER table values presented in Figure 3.
- Seven programs specifically value and incentivize advanced controls. These members in the Midwest, Northeast, and West offer an adder or have requirements for Advanced Rooftop Controllers (ARC) that bundle fan VFDs, economizer fault detection, diagnostic (FDD), and demand-controlled ventilation (DCV).
- Only four programs have strip-heat prohibition. These Pacific Northwest utilities—Bonneville Power Administration participants—add an explicit $100 per ton for “no supplemental electric heat” installations.
- NEEA is the only pilot territory that formally rewards double wall R-12 construction or low-leak dampers; these measures remain invisible in most market actors’ tier definitions.

The bar chart in Figure 3 below presents the different types of utility program requirements, highlighting the prevalence of foundational efficiency standards compared to more specific mandates.

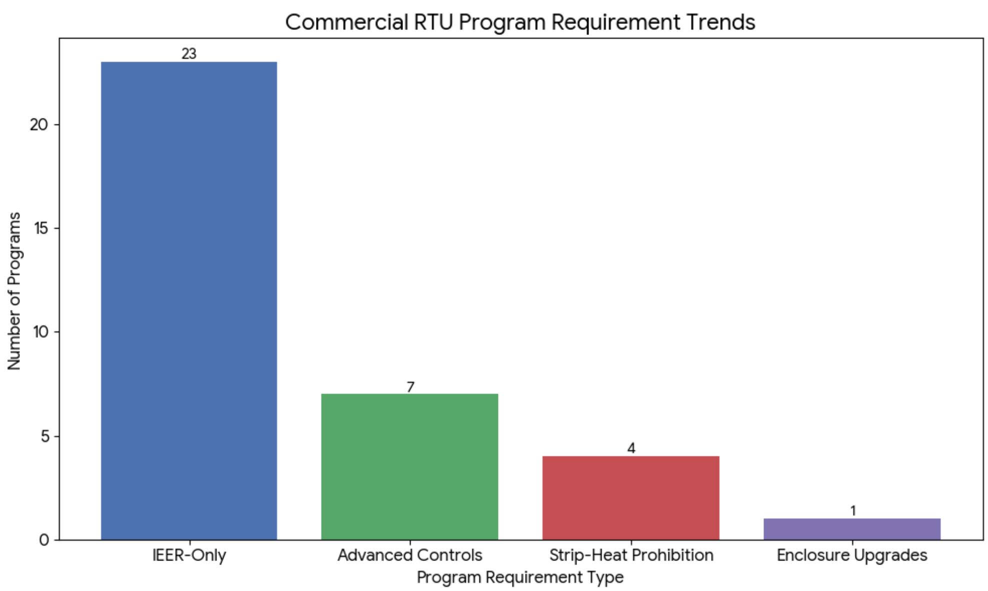


**Figure 3: Commercial RTU program requirement trends.**

In addition to the programs evaluated above, the state of New York has additional program offerings for DOASs.[22] New York State Electric and Gas (NYSEG) offers $500 per project incentives for HP DOASs that meet the minimum efficiency requirements as stated in both ASHRAE 90.1 and AHRI 920. The incentive amount is $70 per MMBtu of annual energy savings; the same amount of

[22] More information about this incentive program can be found here.

incentive is offered in another incentive program from NYSEG for multifamily buildings with over 100 units.

## Savings Impacts Model

The project team used physics-based energy modeling frameworks to simulate energy consumption for T24 baseline efficiency RTU and the three proposed measure tiers. The modeling approach utilized EnergyPlus and prototype models from the Database of Energy Efficiency Resources to generate energy performance. These models include VFD control capability and electric resistance auxiliary heating levers, which could be turned on or off. ModelKit was used in conjunction with EnergyPlus to simulate two commercial building types for analysis. Cooling capacity was autosized by the model to meet the building type to ensure cooling demands in the simulation were met.

### Efficiency Assumptions

EnergyPlus does not accept seasonal efficiency (such as IEER) as an input but rather uses the efficiency at the peak rated condition (EER or COP) along with a performance curve to describe the equipment performance at different conditions. Only the rated performance value for EER was adjusted for the different scenarios, whereas the original performance curves from the DEER prototypes remained unchanged.

The equipment efficiency model inputs were based on efficiency levels established in the 2022 Building Energy Efficiency Standards. The baseline scenario used Title 24, Part 6 HP minimum EER, as shown in Table 11. For the measure scenarios, the improved Cooling EER was based on the recommended performance tiers requiring 10 percent higher cooling performance for Tiers 1 and 2, and 20 percent higher cooling performance for Tier 3.

**Table 11: 2022 Title 24 heat pump, minimum efficiency requirement.**

| Equipment Type | Size Category | Efficiency | Test Procedure |
|---|---|---|---|
| Air cooled (Cooling Mode, both split system and single package) | ≥65 kBtuh and <135 kBtuh | 11.0 EER | AHRI340/360 |

### Climate Zone Assumptions

The proposed three-tier system mentioned in Table 8 includes disabling the back-up electrical resistance heating for Climate Zone (CZ) 1 through 13, and CZ 15. To simplify modeling assumptions, CZ 4 was selected to represent CZs which can disable electric resistance heating, due to the mild climate it represents in cities like Sunnyvale, California.

### Building Type Assumptions

The recent CalMTA study shows that warehouses make up the largest percentage of floor space conditioned by RTU to the total percent of California RTU floor space (CalMTA 2025).[23] However, the team selected small retail and small office building types to model since they commonly use RTUs (CalMTA 2025) and are represented in the DEER prototypes.

### Model Inputs

Table 12 presents the model input parameters for the simulated equipment scenarios. The scenario column indicates the efficiency level of the simulated equipment. The building type column indicates whether the scenario was calculated for small retail or small office buildings. The Heating $COP_h$ column represents the assumed heating performance by the DEER model. This model input was not adjusted for the simulation. The Cooling EER ($COP_c$) column shows the adjusted performance values representing the various cooling performance levels for each measure tier. The VFD columns represent the inclusion of VFDs in the system. The ER column indicates if electric resistance auxiliary heat is enabled.

- The baseline scenario, labeled T24, used the code minimum EER, disabled VFDs, and enabled electric resistance.
- Tier 1 used T 24 EER scaled up by 10 percent, disabled VFDs, and enabled electric resistance.
- Tier 2 used the same EER value as Tier 1, enabled VFDs, and disabled electric resistance.
- Tier 3 used T 24 EER scaled up by 20 percent, enabled VFDs, and disabled electric resistance.

[23] Market-Characterization-Report-Commercial-Rooftop-Units1.pdf

**Table 12: Model inputs for key parameters.**[24]

| Scenario | Building Type | Heating $COP_h$ | Cooling EER ($COP_c$) | VFD | ER |
|---|---|---|---|---|---|
| **T24** | Small Retail | 3.3 | 11 (3.22) | No | Yes |
| **Tier 1** | Small Retail | 3.3 | 12.1 (3.55) | No | Yes |
| **Tier 2** | Small Retail | 3.3 | 12.1 (3.55) | Yes | No |
| **Tier 3** | Small Retail | 3.3 | 13.2 (3.87) | Yes | No |
| **T24** | Small Office | 3.3 | 11 (3.22) | No | Yes |
| **Tier 1** | Small Office | 3.3 | 12.1 (3.55) | No | Yes |
| **Tier 2** | Small Office | 3.3 | 12.1 (3.55) | Yes | No |
| **Tier 3** | Small Office | 3.3 | 13.2 (3.87) | Yes | No |

[24] Energy modeling was performed for T24 Climate Zone CZ04.

## Product Characterization Study[25]

This product characterization study involved the documentation of high efficiency HP RTUs and DOAS units available in the market with the goal of assessing what equipment features are associated with higher efficiency units. The catalog served as a resource for developing the efficiency tier matrix.

### Product Feature Research

The project team was tasked with researching equipment efficiency drivers in the HP RTU and DOAS markets. We used heat pump research from UC Davis's cooling efficiency center[26] to pinpoint key technologies in the HP RTU and DOAS market.

Product features the project team researched are included in Table 13 and Table 14 below. For each product feature, the project team centralized the following information:

- Benefits and
- Potential Impacts
- Function

The cost and prevalence associated with product features was more difficult to locate. Some general assessments are provided in the report's Findings section, where available.

[25] This activity was designed to address these barriers, as listed in the Drivers and Barriers section:

- Lack of characterization of HE RTUs/DOASs product feature benefits.

- Lack of contractor and customer awareness and understanding of HE RTU/DOAS capabilities and characteristics.

- Lack of consistent language surrounding various HE RTU/DOAS product features across manufacturers.

[26] UC Davis's research on heat pumps is publicly available. For more information, see: https://wcec.ucdavis.edu/research/heat-pumps/

Table 13: HP RTU catalog product features.

| Product Features | Brief Description |
| --- | --- |
| Economizer | Provides more outdoor air than required when outdoor conditions are favorable, providing free cooling. |
| Demand Controlled Ventilation (DCV) | Reduces outdoor air in partially occupied hours by sensing how occupied the conditioned space is and reducing airflow to save energy. |
| Electronically Commutated Motor (ECM) | An ECM varies the motor speed based on internal programing and signals from the unit it is serving. |
| Variable Frequency Drive (VFD) | A VFD varies the motor speed based on external programing and signals from the unit it is serving. |
| Multi-Stage Compressor (MSC) | MSCs change their compressor stage to save energy by lowering compressor work and still meeting system requirements. |
| Inverter Driven Compressor (IDC) | IDCs use a variable speed drive to control the direct current voltage to the compressor |
| Defrost Strategy | A strategy to prevent a coil from frosting by reversing refrigerant, forcing hot refrigerant gas into the coil to melt frost. |

Table 14: DOAS catalog product features.

| Product Features | Brief Description |
|---|---|
| **Heat Recovery Ventilator (HRV)** | HRVs utilize exhaust air to heat or cool outdoor air, depending on outdoor air conditions. HRVs exchange sensible (dry) heat between the two airflows. |
| **Energy Recovery Ventilator (ERV)** | ERVs utilize exhaust air to heat or cool outdoor air, depending on outdoor air conditions. ERVs exchange sensible (dry) and latent (wet) heat between the two airflows. |
| **Economizer** | Provides more outdoor air than required when outdoor conditions are favorable, providing free cooling. |
| **Demand Controlled Ventilation (DCV)** | Reduces outdoor air in partial-occupied hours by sensing how occupied the conditioned space is and reducing airflow to save energy. |
| **Electronically Commutated Motor (ECM)** | An ECM varies the motor speed based on internal programing and signals from the unit it is serving. |
| **Variable Frequency Drive (VFD)** | A VFD varies the motor speed based on external programing and signals from the unit it is serving. |
| **Multi-Stage Compressor (MSC)** | MSCs change their compressor stage to save energy by lowering compressor work and still meeting system requirements. |
| **Inverter Driven Compressor (IDC)** | IDC use a variable speed drive to control the direct current voltage to the compressor |
| **Hot Gas Reheat (HGR)** | HGR uses generated heat from the refrigeration cycle to reheat the OA after it was originally cooled to provide a more acceptable relative humidity, which enhances comfort. |
| **Defrost Strategy** | A strategy to prevent a coil from frosting by reversing refrigerant, forcing hot refrigerant gas into the coil to melt frost. |

### RTU and DOAS Catalog Process

The project team researched RTUs and DOAS units to identify products available from major equipment manufacturers equipped with industry standard HE features. A breakdown detailing which features are available for the units, which manufacturers incorporate these HE features, and how these features contribute to higher efficiency is available in Appendix G and Appendix H.

## Marketing Collateral[27]

To educate end users and contractors alike, the project team developed a summary document sharing the findings of the Focused Pilot. The document briefly describes the advantages and features of higher efficiency HP RTUs and DOAS, addressing the barrier of lower contractor and customer understanding of product characteristics. The summary document may be found in Appendix J.

[27] This activity was designed to address these barriers, as listed in the Drivers and Barriers section:

- Lack of characterization of HE RTUs/DOAS product feature benefits.
- Lack of contractor and customer awareness and understanding of HE RTU/DOAS capabilities and characteristics.
- Lack of consistent language surrounding various HE RTU/DOAS product features across manufacturers.

# Findings

## Overview

The project team completed the focused pilot's objectives comprehensively, as demonstrated in the following subsections.

To inform the focused pilot findings, the project team initiated market interviews across three levels of the supply chain: manufacturers, distributors, and contractors, gathering perspectives from industry stakeholders. The topics covered by these interviews may be found in the Market Interview Results section. Results from the interviews are more predominantly represented in other sections of the Findings.

These activities, alongside technical literature review, supported the formulation of measure efficiency and product criteria for the incentive pilot, ensuring alignment with program goals. Participant enrollment for the Midstream Incentive Pilot is complete: We successfully launched the program on June 1, 2025, and received applications through October 31, 2025. Participation rates and participant feedback may be found in the Midstream Incentive Pilot Results section.

From the market actor interviews and literature review, we identified advanced product features to investigate in the product characterization study and catalogs, which were evaluated based on market prevalence, efficiency impacts, and cost implications. Summaries for each high efficiency product feature have been completed and are provided in the Product Characterization Study Results section.

The team used the product characterization research and review of existing RTU program design to determine the efficiency tier matrix, which prioritizes higher IEER ratings and removal of electric resistance strip heat. The matrix also provides comparisons between the proposed RTU measure tiers and existing California measures, which are available in the Efficiency Tier Matrix Results section. Modeled energy savings impacts, based upon the proposed tier structure, can be found in the Savings Impacts Model Results section.

We identified current market barriers and market opportunities during the project's activities; results for each of these areas are available in the Current Market Barriers and Gaps and Market Opportunities sections.

Stakeholder feedback from efficiency leading associations like NEEA and CEE are documented in the Stakeholder section. These meetings helped the team gain insight into where HP RTU and DOAS unit efficiency currently stands and will also inform measure design.

## Market Interview Results

The program aimed to drive market transformation through targeted interventions and leveraging incentives as a key sales enablement tool. While the education and engagement process required time to build awareness and shift sales practices, we achieved steady progress through collaboration with distributor sales engineers and other key market stakeholders.

The project team conducted interviews with four manufacturers, six distributors, and one HVAC design engineer. Survey questions from the preliminary interviews are provided in Appendix D and Appendix I, and basic themes characterizing the market for HP RTUs and DOAS systems are provided below; resulting barriers and market opportunities are described in the later Findings sections.[28]

### Program Readiness

The market for HP RTUs shows strong readiness for midstream program expansion, supported by established supply chains, contractor familiarity, and growing local code-driven demand. Current incentives ($375 to $500 per ton) are sufficient to influence stocking and sales, though higher-efficiency and variable-speed models will continue to require additional support until broader OEM availability in 2027. In contrast, HP DOAS systems remain early in market maturity—custom-engineered, high-cost, and dependent on design-stage specification rather than stocking. As such, HP RTUs are ready for near-term scale-up, while HP DOAS warrant longer-term, design-focused program strategies emphasizing technical assistance, performance-based incentives, and manufacturer engagement.

### Building Type Compatibility

Distributors identified commercial offices, educational facilities, and civic or governmental buildings as the most common applications for HP RTUs. One distributor noted that, despite differences in end use, the installation process for HP RTUs is functionally similar to that of conventional AC/furnace RTUs, making them suitable replacements across a wide range of standard commercial settings. HP RTUs are also commonly installed in schools, multifamily properties, and government facilities such as police stations, fire departments, and recreation centers.

For HP DOAS, distributors cited typical applications in larger buildings exceeding 20,000 square feet, particularly those using VRF systems or fan coils to serve internal loads while relying on the DOAS for ventilation air. HP DOAS systems are frequently used in facilities requiring 100 percent outside air, including laboratories, gymnasiums, and multifamily corridors, where ventilation demand justifies their use.

[28] The midstream incentive pilot measure criteria, product characterization, and identification of market gaps and opportunities were supported by market interviews in various capacities.

## Midstream Incentive Pilot Results

The objective of this Midstream Incentive Pilot was to document current sales practices and develop targeted intervention strategies that demonstrate how to effectively upsell higher-efficiency equipment—particularly models with variable-speed compressors—to the design community. These activities represent the core value proposition of the study and justify the associated program investment.

The Midstream Incentive Pilot launched for the program term on June 1, 2025, through October 31, 2025. The distributors were recruited to participate ahead of the program term and counseled when designing the efficiency metrics and criteria. The following subsections provide results from the enrollment timeline, participation rates, efficiency trends, and participant feedback.

### Distributor Enrollment

Upon program launch on June 1, 2025, and the approval of the advice letter on April 21, 2025, the team issued participation agreements to six distributors in California. We held kickoff meetings with each participant to complete the application process training and provide an overview of project eligibility requirements. After these meetings, participating distributors were able to submit HP RTU and DOAS equipment and apply for incentives. Five of the six enrolled distributors have submitted project applications to the Midstream Incentive Pilot; dates for these projects appear in Table 15 below.

**Table 15: Distributor enrollment timeline.**

| Distributors (anonymized) | Date of Enrollment | Date of Kickoff Meeting | Date of First Project Submission |
|---|---|---|---|
| **Distributor 1** | 6/4/25 | 6/10/25 | N/A |
| **Distributor 2** | 6/4/25 | 7/1/25 | 8/7/25 |
| **Distributor 3** | 6/11/25 | 6/11/25 | 9/5/25 |
| **Distributor 4** | 6/4/25 | 6/26/25 | 7/24/25 |
| **Distributor 5** | 6/4/25 | 6/26/25 | 7/24/25 |
| **Distributor 6** | 6/11/25 | 6/11/25 | 10/1/25 |

### Project Applications by Payment Status

The Midstream Incentive Pilot received 50 applications from participating distributors—25 of the projects qualified for an incentive, 3 of the projects were disqualified due to being outside IOU service territory, 62 projects exceeded the Tier 1 incentive limits for the pilot, and 1 project was flagged as a duplicate submission,[29] which was removed from the totals to reflect a more accurate count of submitted projects. The submitted versus approved participation statistics are provided in Table 16 below.

**Table 16: Project submissions by payment status.**

| | Submitted to Pilot[30] | Approved for Payment |
|---|---|---|
| **Number of Claims** | 50 | 22 |
| **Number of Units** | 90 | 25 |
| **Number of Tons** | 845 | 262 |
| **Total Incentive Value of Submitted Projects (Uncapped)** | $353,941 | $116,526 |
| **Total Incentive Value of Submitted Projects (Capped)** | $127,400 | $111,465 |

[29] The duplicate project was removed from the totals to reflect a more accurate count of projects submitted.

[30] Only equipment meeting minimum efficiency requirements was accounted for in the project submission totals.

### HP RTU Applications by Size Bin

Qualifying HP RTU units submitted for incentive and are reported by size category in Table 17 below. HP RTU units in the 5.4- to 11.25-ton cooling capacity range were submitted at 10 times the rate of the other size categories, and the ≥ 20-ton size category was not offered until early September, likely skewing the unit volume results. The limited participation in the 11.25- to 20-ton size bin aligns with the results from the previous ET23SWE0073 Focused Pilot.

**Table 17: HP RTU submissions by equipment size bin.**

| | 5.4–11.25 tons | 11.25–20 tons | ≥ 20 tons |
|---|---|---|---|
| Number of Claims | 41 | 4 | 4 |
| Number of Units | 81 | 4 | 4 |
| Number of Tons | 648 | 60 | 88 |
| Total Incentive Value of Submitted Projects (Uncapped) | $257,350 | $28,061 | $44,170 |
| Total Incentive Value of Submitted Projects (Capped) | $62,940 | $15,625 | $33,835 |

### DOAS Applications by Size Bin

Only one DOAS unit was submitted to the Midstream Incentive Pilot, as shown in Table 18 below. The size of this unit was greater than 240 kBtuh, falling into the largest cooling capacity range eligible for incentive. Although the sample size is too small for in-depth analysis of DOAS submissions, this one project does align with expectations that DOAS are often sold at higher cooling capacities.

**Table 18: DOAS submissions by equipment size bin.**

| | 5.4–11.25 tons | 11.25–20 tons | ≥ 20 tons |
|---|---|---|---|
| Number of Claims | 0 | 0 | 1 |
| Number of Units | 0 | 0 | 1 |
| Number of Tons | 0 | 0 | 49 |
| Total Incentive Value of Submitted Projects (Uncapped) | $0 | $0 | $24,360 |
| Total Incentive Value of Submitted Projects (Capped) | $0 | $0 | $15,000 |

### HP RTU Efficiency by Size Bin

Figure 4, Figure 5, and Figure 6 below illustrate the efficiency performance of both the pilot projects and the corresponding AHRI-listed models. The Midstream Incentive Pilot required compliance with previously established IEER thresholds, represented by the teal reference lines. Several efficiency benchmarks are shown in the background, ranging from lowest to highest: Title 24-2025 code minimum, proposed Tier 1 and Tier 2, the CAeTRM SWHC046 fuel-substitution measure, and proposed Tier 3.

All Midstream Incentive Pilot projects (purple) met or exceeded the proposed Tier 3 efficiency thresholds. This outcome aligns with program design expectations, as the pilot's required IEER performance levels were higher than the proposed Tier 1 and Tier 2 thresholds across all three capacity bins, and even surpassed the Tier 3 benchmark for systems larger than 11.25 tons.

The AHRI-listed HP RTUs (gold) show a concentrated market cluster at COP values between 3.4 and 3.5, representing the modal performance range for available models. The 5.4- to 11.25-ton size category displays the most advanced heating efficiency ratings. Raising COP requirements for this size category could enhance both cost-effectiveness and total system benefit (TSB) without substantially limiting market availability.

Conversely, participation in the larger size categories (>11.25 tons) was limited, reinforcing industry feedback that higher-capacity, high-efficiency units remain cost-prohibitive or less commonly stocked. Notably, the AHRI directory listings are sparse for the 11.25- to 20-ton segment, even compared with the >20-ton range. However, among the >20-ton listings, over 60 percent exceed the proposed Tier 3 thresholds, suggesting a positive correlation between equipment size and achievable IEER/COP performance. This trend implies that while larger systems are less common in the pilot data, they tend to deliver proportionally higher rated efficiencies when available. However, it is important to note that although these units are available, 85 percent of AHRI listed models in the >20 tons category come from the same manufacturer.

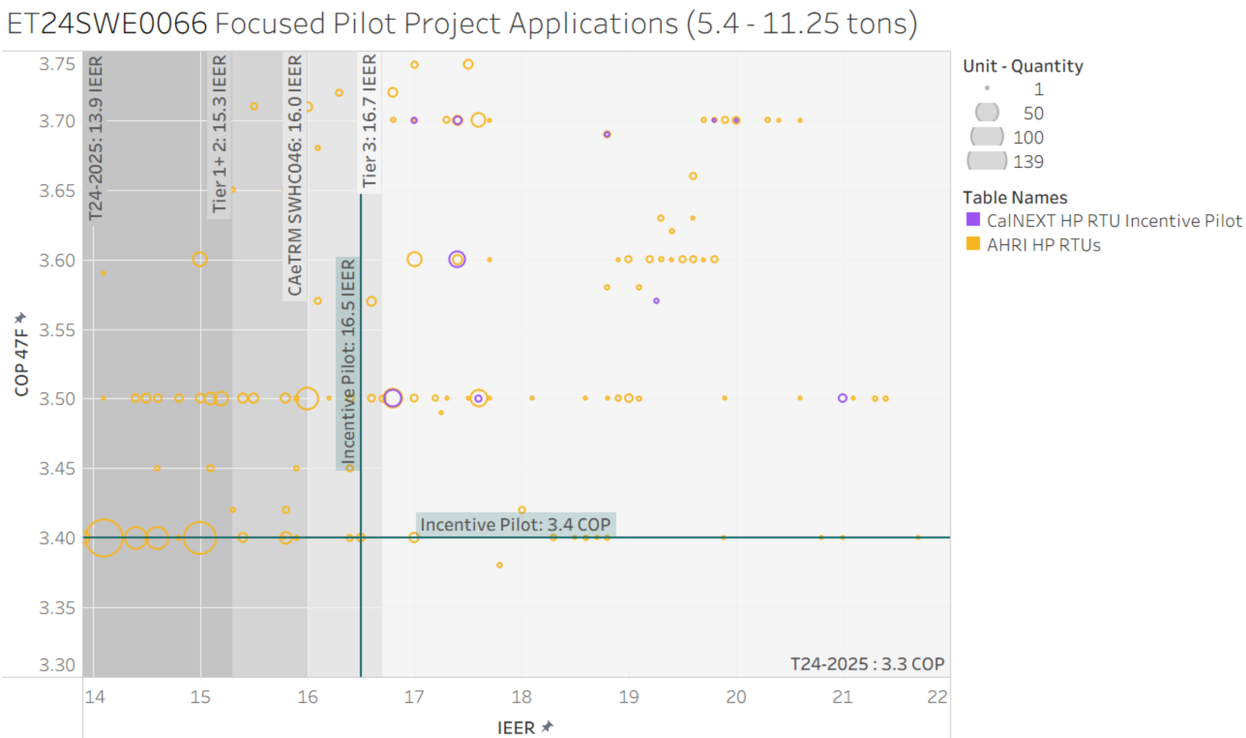


**Figure 4: Efficiency of ET24SWE0066 Midstream Incentive Pilot HP RTU submissions (5.4–11.25 tons).**

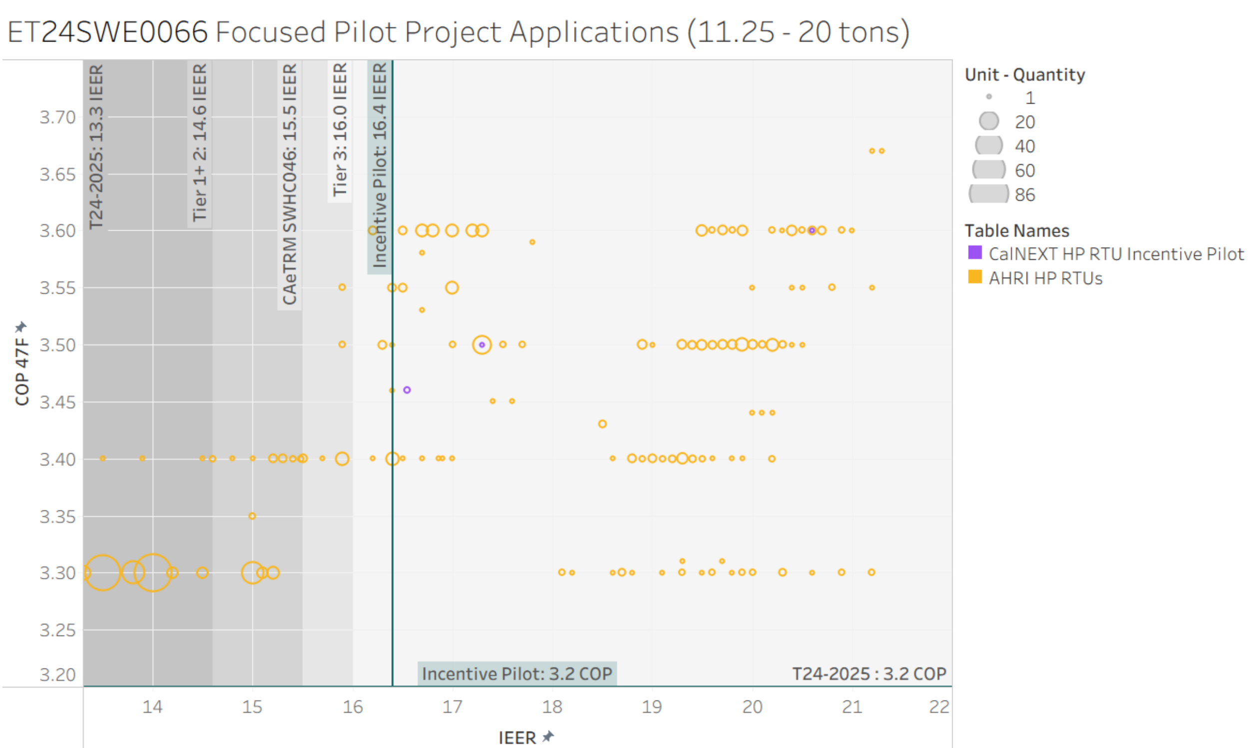


**Figure 5: Efficiency of ET24SWE0066 Midstream Incentive Pilot HP RTU submissions (11.25–20 tons).**

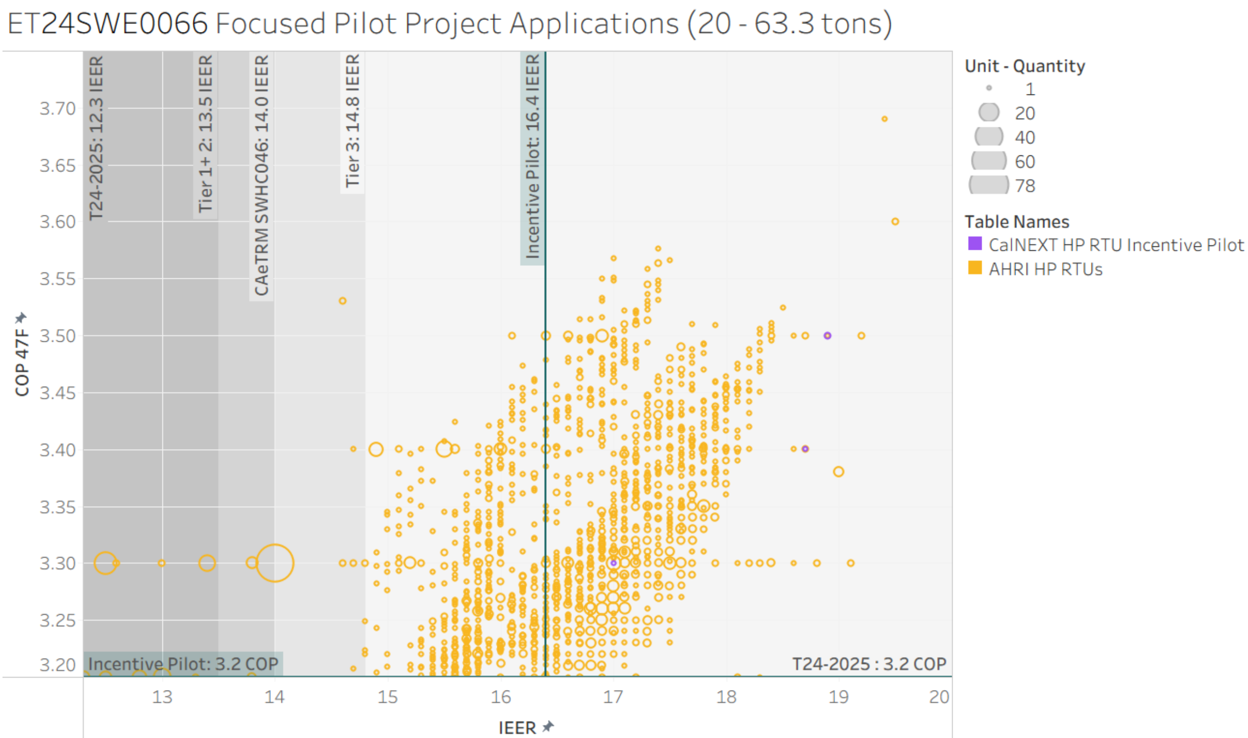


**Figure 6: Efficiency of ET24SWE0066 Midstream Incentive Pilot HP RTU submissions (20–63.3 tons).**

### HP RTU Applications by Building Type and Size Bin

In Figure 7, a heat map of building types for submitted HP RTU projects is shown. The heat map demonstrates the spread of building types where HP RTUs are installed. Manufacturing light industrial was the dominant building type by far, making up 44 percent of tons across all size bins. For HP RTUs in the 5.4- to 11.25-ton size category, the second and third most dominant building types were primary school and secondary school buildings. The 11.25- to 20-ton HP RTU projects were all in manufacturing light industrial buildings. 53.2 percent of >20-ton size HP RTU projects were in manufacturing light industrial buildings, and the remaining 46.8 percent were in secondary school buildings. These results suggest that primary and secondary school buildings are a targetable customer segment for HP RTU optimization.

| Building Type | 5.4 - 11.25 tons | 11.25 - 20 tons | 20 - 63.3 tons | Grand Total |
|---|---|---|---|---|
| Assembly | 7.4% | | | 6.0% |
| Community College | 3.8% | | | 3.1% |
| Manufacturing Light Industrial | 37.7% | 100.0% | 53.2% | 44.1% |
| Office - Small | 1.2% | | | 1.0% |
| Primary School | 24.6% | | | 20.0% |
| Restaurant - Fast-Food | 1.3% | | | 1.0% |
| Restaurant - Sit-Down | 1.2% | | | 0.9% |
| Retail - Small | 4.1% | | | 3.3% |
| Secondary School | 18.8% | | 46.8% | 20.5% |
| Grand Total | 100.0% | 100.0% | 100.0% | 100.0% |

% of Tons
1.2% 100.0%

**Figure 7: HP RTU submissions by building type and size bin.**

### Project Applications by Measure Tier

Tier 1 units were defined as IEER and COP minimums while Tier 2 units met the Tier 1 IEER and COP minimums and included either a VSC or an HRV or ERV system. Table 19 shows the HP RTU and DOAS unit submissions by unit quantity and cooling capacity tons. The submitted projects were largely dominated by Tier 1 qualified units, making up 74.4 percent of the units or 70.5 percent of the tons of cooling capacity. All Tier 2 equipment was submitted by a single participant and made by the same manufacturer. This feat suggests the higher efficiency market is still developing and is currently dominated by handful of manufacturers.

**Table 19: Project submissions by measure tier.**

| Measure Tier | Unit Quantity | % of Unit Quantity | Ton Quantity | % of Ton Quantity |
|---|---|---|---|---|
| **Tier 1** | 67 | 74.4% | 596 | 70.5% |
| **Tier 2** | 23 | 25.6% | 249 | 29.5% |
| **Grand Total** | **90** | **100%** | **845** | **100%** |

### Project Applications by California Climate Zone

In Figure 8 below, the climate zone for all received project applications are shown. Most HP RTU applications came from CA8, CA3, and CA7. The single DOAS project application was in CA6. The CA climate zones which were not represented in the project submissions were CA1, CA5, CA11, and CA14.

| California Climate Zone | DOAS | HP RTU | Grand Total |
|---|---|---|---|
| CA2 | | 3.5% | 3.3% |
| CA3 | | 26.0% | 24.5% |
| CA4 | | 6.6% | 6.2% |
| CA6 | 100.0% | | 5.8% |
| CA7 | | 15.0% | 14.1% |
| CA8 | | 29.5% | 27.8% |
| CA9 | | 3.1% | 2.9% |
| CA10 | | 2.3% | 2.1% |
| CA12 | | 1.0% | 1.0% |
| CA13 | | 2.4% | 2.3% |
| CA15 | | 1.0% | 1.0% |
| CA16 | | 9.4% | 8.9% |
| Grand Total | 100.0% | 100.0% | 100.0% |

% of Tons

1.0% 100.0%

**Figure 8: Project submissions by California climate zone.**

## Pilot Participant Feedback

Equipment eligibility requirements for the ET24SWE0066 Midstream Incentive Pilot have been raised above the efficiency levels established in the existing California eTRM fuel substitution measure.[31] With stricter efficiency criteria comes a distinct set of challenges: incentive amounts and overall experience at the distributor level.

After speaking with the participating distributors, it became clear that for this focused pilot to be successful, increasing incentive amounts would be necessary to help offset higher equipment costs.[32] This allows the payback for the customer to be less than three years—an important benefit, as customers are reluctant to approve or accept significantly higher cost of higher efficiency and/or units with variable speed compressors without a reasonable payback period. Some customers demand a two-year payback, and property managers in particular demand low first-cost equipment but can sometimes be moved with shorter payback timeframes. Sales engineers across all distributors often emphasize short payback periods as a key sales strategy because advanced heat pump rooftop units (HP RTUs) and dedicated outdoor air systems (DOAS HPs) currently have higher upfront costs, are not yet standard in commercial design, and may face limited product availability. Selling these systems requires direct engagement to shift customer preferences away from conventional specifications toward higher-efficiency, program-eligible equipment. By framing projects around shorter payback timelines, distributors can more effectively address customer concerns about cost and return on investment.

While the stocking and availability of the Tier 1 equipment wasn't of major concern to the distributors, the sales of certain equipment—specifically the DOAS units and Tier 2 requirements—was a barrier to strong participation. One distributor noted that their primary manufacturer does not include inverters in their systems and shared that ERV as a feature is exceedingly rare in HVAC systems that use return air instead of a high volume of outside air. These additional components may be specified at the time the unit is specified or retrofitted. Lead times for additional components are custom to order and have a similar lead times to the packaged unit itself (4-6 weeks). The distributor noted that one of their manufacturers is set to come out with equipment that includes inverters in 2027. Some manufacturers currently offer variable speed compressors, and their cost is substantially higher.

Many distributors reported being increasingly busy during this cooling season, making their participation in the incentive pilot more difficult. The team used engagement efforts, including weekly emails and phone calls, to encourage an increase in participation. Direct phone calls were necessary to intercept impending opportunities on distributors' desks, as the team asked about current work and projects in the pipeline. This critical strategy proved to be highly successful, allowing the team to consistently remind distributors to upsell eligible equipment when proposed projects, design drawings, and meetings with mechanical engineers and architects occurred. Without this dedicated engagement, many project opportunities would have been missed.

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[31] CAeTRM SWHC046: https://www.caetrm.com/measure/SWHC046/03/

[32] Through work on both pilots, along with two decades of experience implementing California commercial upstream HVAC programs, the project team learned that to transform the market for mechanical engineers, design build contractors, and distributors' sale engineers, the incentive should cover 80 percent of the incremental measure costs (IMCs).

There were 66 sales captured in the Midstream Incentive Pilot for Tier 1 HP RTUs and 23 sales for Tier 2 HP RTUs; however, the sole AC DOAS sale did not qualify for Tier 2. These sales trends support the point above: The demand for higher efficiency systems is not yet common for commercial applications. Tier 2 HP RTUs and DOAS systems are not especially common, likely due to the increased cost and are not commonly specified unless. In many cases, higher efficiency units are not as readily available as code minimum units.

Distributors expressed that it is easy and simple to submit claims in the program portal, Iris. This is a critically important requirement. As the team knows from decades of experience with upstream HVAC programs, distributors will not participate in an unautomated application process. One distributor created an internal process of gathering eligible models from their sales team into a spreadsheet and uploading those into Iris monthly, which proved to be an effective and efficient approach that maximized their pilot participation.

Distributors unanimously agreed that substantial incentives—approximately 80 percent of incremental measure cost (IMC) coverage—are necessary to drive increased sales and installation of higher-efficiency equipment, including both HP RTUs and HP DOAS. They noted that the current $500 per ton incentive level for HP RTUs is sufficient to meaningfully boost sales activity.

However, when asked about the potential for long-term incentives to influence stocking behavior higher efficiency heat pump RTUs, distributors indicated that sustained stocking of qualified equipment year-round is unlikely given current business models and storage limitations. One distributor explained that, while maintaining inventory on-site could improve availability, it does not align with their existing business plan. Another emphasized that the wide range of design configurations and options makes stocking standardized equipment impractical, even if desired.

Several cities require that packaged single zone units are replaced with HP RTUs. For example, in September of 2025, the City and County of San Francisco amended San Francisco Building Code (City and County of San Francisco, Board of Supervisors 2022) via Ordinance 174-25. requiring projects including a “substantial upgrade to mechanical systems”[33] use all-electric appliances (City and County of San Francisco, Board of Supervisors 2025). Those updates went into effect on October 10, 2025, but enforcement timelines vary. Because of these county level requirements, several distributors observed a shift in overall stocking trends, noting that heat pump units now represent a substantial number of stocked systems—a reversal from previous years. This comment indicates the powerful influence of local codes on inventory and sales patterns.

[33] Definition of a substantial upgrade to mechanical systems in

An alteration or addition to an existing building where the proposed project either:

(1) Replaces space heating and hot water heating system for the entire building; or

(2) Installs space heating and water heating systems that will serve 80% or more of the total conditioned floor area of the building; or

(3) Installs space conditioning or water heating systems serving the area of addition.

## Efficiency Tier Matrix Results

### Proposed Program Tiers

Based on the review of high efficiency equipment features, current OEM product availability, and national program benchmarks, the project team developed a three-tier incentive structure that balances ambition with market feasibility, which is detailed further in Table 20 and Table 21 below. The first step in this process was identifying performance thresholds that are meaningful in California's climate zones while still aligning with commercially available equipment options. This required analysis of which combinations of efficiency, controls, and operational features deliver measurable savings under the state's temperature and load profiles, while considering the baseline requirements already addressed in Title 24, Part 6.

The project team then mapped these technical criteria against national incentive program structures to ensure consistency and competitiveness, but adjusted thresholds where California's climate warranted it. For example, the project team set the elimination of electric resistance heating as a requirement in all but the coldest climate zones, recognizing that most of the state's mild winter conditions support full reliance on high efficiency heat pump operation without backup resistance elements, avoiding unnecessary peak demand impacts.

Features like variable-speed compressors, advanced ventilation control, and ARC-enabled high-turn-down fans, were weighted more heavily because they provide measurable benefits, which is particularly relevant in California's moderate-temperature coastal zones. The project team also considered how these features align with OEM production lines and distribution channels to avoid designing tiers around specifications that the market cannot yet supply at scale.

For the HP RTU recommended IEER levels were set at 10 percent better than Title 24 code minimum requirements for Tiers 1 and 2. For Tier 3 HP RTUs, IEER was scaled to 20 percent better than Title 24 code minimum. For DOAS units, ISMRE2 and ISCOP2 efficiency metrics were recommended. The minimum Title 24 ISMRE2 and ISCOP2 were scaled by 10 percent, 15 percent, and 20 percent; ISCOP2 requirements only apply to HP DOAS.

Table 20: Proposed three-tier incentive structure for HP RTUs.

| Proposed Tier | Size Category | IEER | Additional Required Features | Climate Zone (CZ) Notes |
|---|---|---|---|---|
| Tier 1 | ≥ 65,000 to <135,000 btuh | 15.3 | None beyond Title 24 compliance. | Applies statewide; establishes an above code but easily attainable entry level. |
| | ≥ 135,000 to <240,000 | 14.6 | | |
| | ≥ 240,000 | 13.5 | | |
| Tier 2 | ≥ 65,000 to <135,000 btuh | 15.3 | No electric resistance heat (CZ1-13, CZ15)<br><br>Supply-fan VFD/ECM managed by ARC | Electric resistance heat is allowed only in CZ14 and CZ16 under cold-climate or dual fuel path; ARC dashboard provides verification. |
| | ≥ 135,000 to <240,000 | 14.6 | | |
| | ≥ 240,000 | 13.5 | | |
| Tier 3 | ≥ 65,000 to <135,000 btuh | 16.7 | No electric resistance heat (CZ1-13, CZ15)<br><br>Supply fan VFD/ECM managed by ARC | Highest incentive level; targets deepest kWh reduction and peak-kW relief. |
| | ≥ 135,000 to <240,000 | 16.0 | | |
| | ≥ 240,000 | 14.8 | | |

Table 21: Proposed three-tier incentive structure for DOAS.

| Proposed Tier | Has Energy Recovery? | Core Performance Metric | Additional Required Features | Climate Zone (CZ) Notes |
|---|---|---|---|---|
| Tier 1 | Without energy recovery | 4.2 ISMRE2, 2.3 ISCOP2 | Energy recovery per current Title 24 requirements.<br><br>Supply fan VFD/ECM. | Applies statewide; establishes an above code but easily attainable entry level. |
| | With energy recovery | 5.5 ISMRE2, 3.5 ISCOP2 | | |
| Tier 2 | Without energy recovery | 4.4 ISMRE2, 2.4 ISCOP2 | No electric heat (CZ1-13, CZ15).<br>Energy recovery.<br>Supply fan VFD/ECM.<br>Hot gas reheat. | Electric resistance heat allowed only in CZ 14 and 16. |
| | With energy recovery | 5.8 ISMRE2, 3.7 ISCOP2 | | |
| Tier 3 | Without energy recovery | 4.6 ISMRE2, 2.5 ISCOP2 | No electric heat (CZ1-13, CZ15).<br>Energy recovery.<br>Supply fan VFD/ECM.<br>Demand control ventilation.<br>Hot gas reheat. | Highest incentive level; targets deepest kWh reduction and peak-kW relief. |
| | With energy recovery | 6.0 ISMRE2, 3.8 ISCOP2 | | |

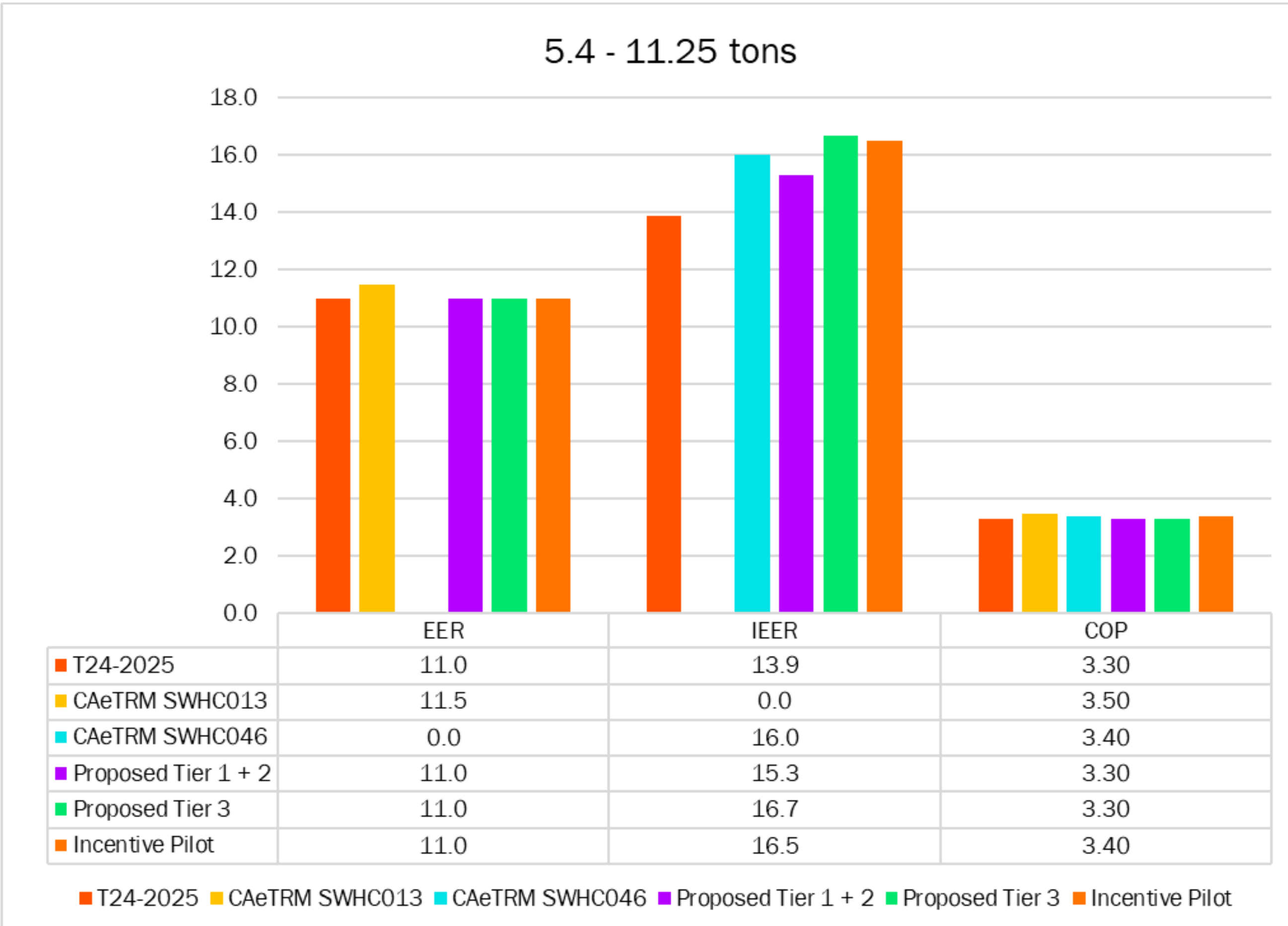
### HP RTU Measure Analysis

The proposed HP RTU tiers compared to the existing measure packages and code efficiency metrics are depicted in Figure 9, Figure 10, and Figure 11 below. For more information on these existing measures and code efficiency requirements, please refer to the Existing California RTU Programs section of the report.

For RTU measures in the 5.4- to 11.25-ton cooling capacity range, the like-for-like RTU measure (SWHC013) was the only one that exceeded code requirements. The EER requirements for this measure reduced the number of eligible HP RTUs significantly, stifling participation and savings impacts. The fuel substitution measure (SWHC046), proposed tiers, and incentive pilot EER requirement all aligned with the code.

The like-for-like measure (SWHC013) also required the highest heating efficiency, measured by COP rating. However, based on product availability, this requirement was much higher than currently available equipment. Most available HP RTUs can only achieve 0.1 to 0.2 above code minimum, but the proposed measures, the incentive pilot, and the existing fuel substitution measure were all set to 0.2 COP above code, at 3.4 COP.

The incentive pilot's IEER requirement was higher than both existing HP RTU measures and the proposed HP RTU Tiers 1 and 2; the proposed HP RTU Tier 3 IEER level exceeded these at 16.7 IEER, almost 3 IEER above code.



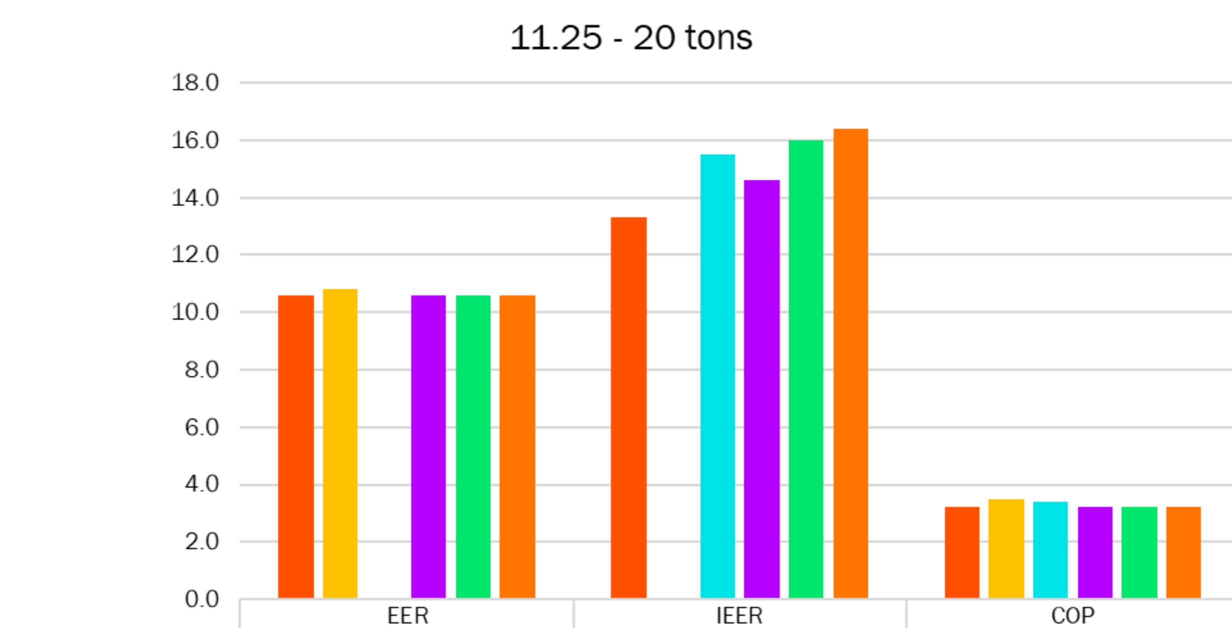

| | EER | IEER | COP |
|---|---|---|---|
| T24-2025 | 11.0 | 13.9 | 3.30 |
| CAeTRM SWHC013 | 11.5 | 0.0 | 3.50 |
| CAeTRM SWHC046 | 0.0 | 16.0 | 3.40 |
| Proposed Tier 1 + 2 | 11.0 | 15.3 | 3.30 |
| Proposed Tier 3 | 11.0 | 16.7 | 3.30 |
| Incentive Pilot | 11.0 | 16.5 | 3.40 |

**Figure 9: HP RTU measure efficiency comparison (5.4–11.25 tons).**

For RTU measures in the 11.25- to 20-ton cooling capacity range, the like-for-like RTU measure (SWHC013) was the only one that exceeded code requirements for full load cooling efficiency, rated in EER. The proposed tiers and incentive pilot EER requirement aligned with the code.

The incentive pilot's IEER requirement was higher than both existing HP RTU measures and the proposed HP RTU tiers, exceeding code by 3.1 IEER. The proposed measures were set at IEER levels above and below the fuel substitution measure (SWHC046).

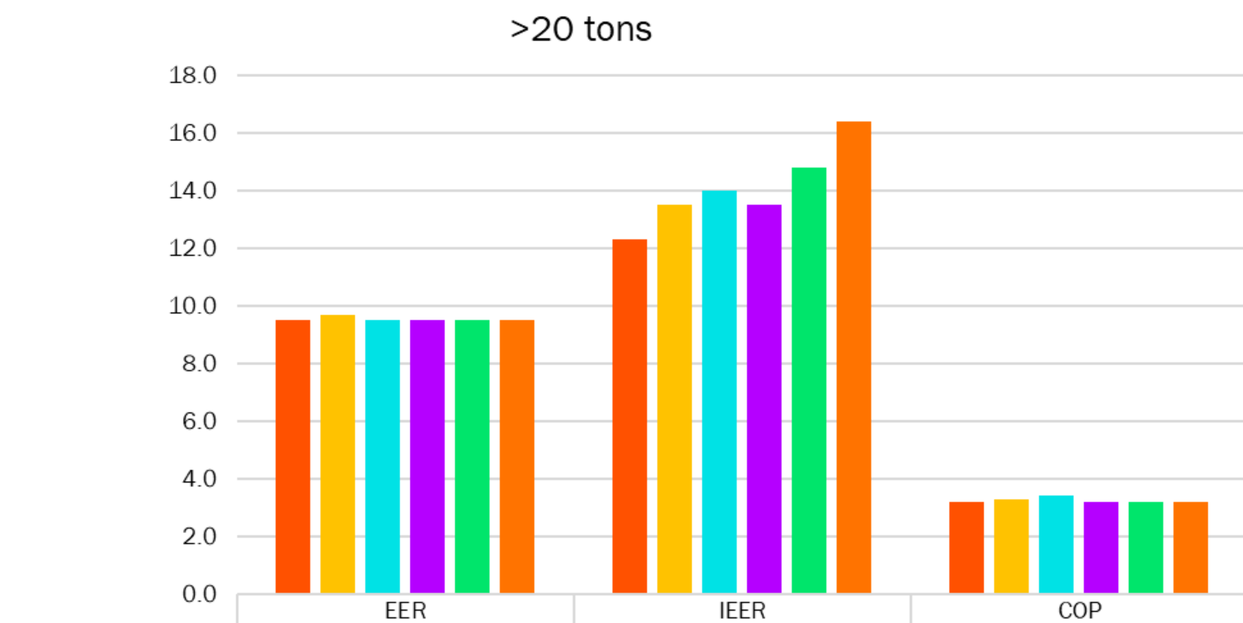
The like-for-like measure required the highest heating efficiency, measured by COP rating, while the fuel substitution measure had the same heating efficiency requirements as code. The proposed tier was set to 3.3, which is code for equipment manufactured after 2023.




| | EER | IEER | COP |
|---|---|---|---|
| T24-2025 | 10.6 | 13.3 | 3.20 |
| CAeTRM SWHC013 | 10.8 | 0.0 | 3.48 |
| CAeTRM SWHC046 | 0.0 | 15.5 | 3.40 |
| Proposed Tier 1 + 2 | 10.6 | 14.6 | 3.20 |
| Proposed Tier 3 | 10.6 | 16.0 | 3.20 |
| Incentive Pilot | 10.6 | 16.4 | 3.20 |

**Figure 10: HP RTU measure efficiency comparison (11.25–20 tons).**

For the >20-ton size category, the Midstream Incentive Pilot IEER requirements exceeded all other measures and standards considered by far. EER requirements were 0.1 EER higher for the like-for-like RTU measure (SWHC013) but were otherwise constant across the board. COP requirements were 0.1 higher than code for the existing like for like measure and 0.2 COP higher for the fuel substitution measure (SWHC046).




| | EER | IEER | COP |
|---|---|---|---|
| T24-2025 | 9.5 | 12.3 | 3.20 |
| CAeTRM SWHC013 | 9.7 | 13.5 | 3.30 |
| CAeTRM SWHC046 | 9.5 | 14.0 | 3.40 |
| Proposed Tier 1 + 2 | 9.5 | 13.5 | 3.20 |
| Proposed Tier 3 | 9.5 | 14.8 | 3.20 |
| Incentive Pilot | 9.5 | 16.4 | 3.20 |

**Figure 11: HP RTU measure efficiency comparison (>20 tons).**

## Savings Impacts Model Results

The modeled energy savings showed significant benefits for Tiers 2 and 3 to reduce building energy use, with most of the savings coming from reducing HVAC supply fan speed. The fans were scheduled to operate on weekdays for 20 hours per day. The variable speed fan modeled for incentive Tiers 2 and 3 operated for the majority of occupied hours at only 30 percent of the power used for the single-speed fan in the baseline and Tier 1 models. This fan was observed to increase above its low-speed setting during only 6 percent of occupied hours, leading to significant fan energy savings.

The improved cooling efficiency of Tiers 1, 2, and 3 resulted in additional HVAC energy savings of 4 percent to 13 percent, compared to the baseline heat pump. The lower fan energy use for models with variable speed fans resulted in higher heating loads and lower cooling loads due to the reduced fan heat added to the building.

For small retail, Figure 12 below shows the energy savings from baseline and Tiers 1, 2, and 3. For the small retail building type, Tier 1 saved 1,333 kWh, Tier 2 saved 22,221kWh, and Tier 3 saved 23,239 kWh. For the small office building type, Tier 1 saved 1,733 kWh, Tier 2 saved 39,015 kWh, and Tier 3 saved 40,324 kWh, as shown in Figure 13. For both building types, there are significant energy savings in Tiers 2 and 3. It appears that the primary driver in energy savings comes from disabling the electric resistance back-up heat. There were minimal energy savings associated with increased IEER, since Tiers 1 and 2 share the same simulated IEER rating.

Across the building types, Tier 1 showed limited HVAC energy savings over the baseline equipment, with only a 2 percent reduction in HVAC energy and 8 percent heating and cooling energy savings. Fan energy accounted for about 71 percent of all HVAC energy, so the lack of a variable speed fan limited the savings potential. Tier 2 showed 49 percent HVAC energy savings, with only 5 percent coming from improved cooling efficiency, while Tier 3 showed 50 percent HVAC energy savings, with 12 percent coming from the improved equipment efficiency. While the fraction of savings can be small for Tier 1, the electricity energy savings are still substantial.

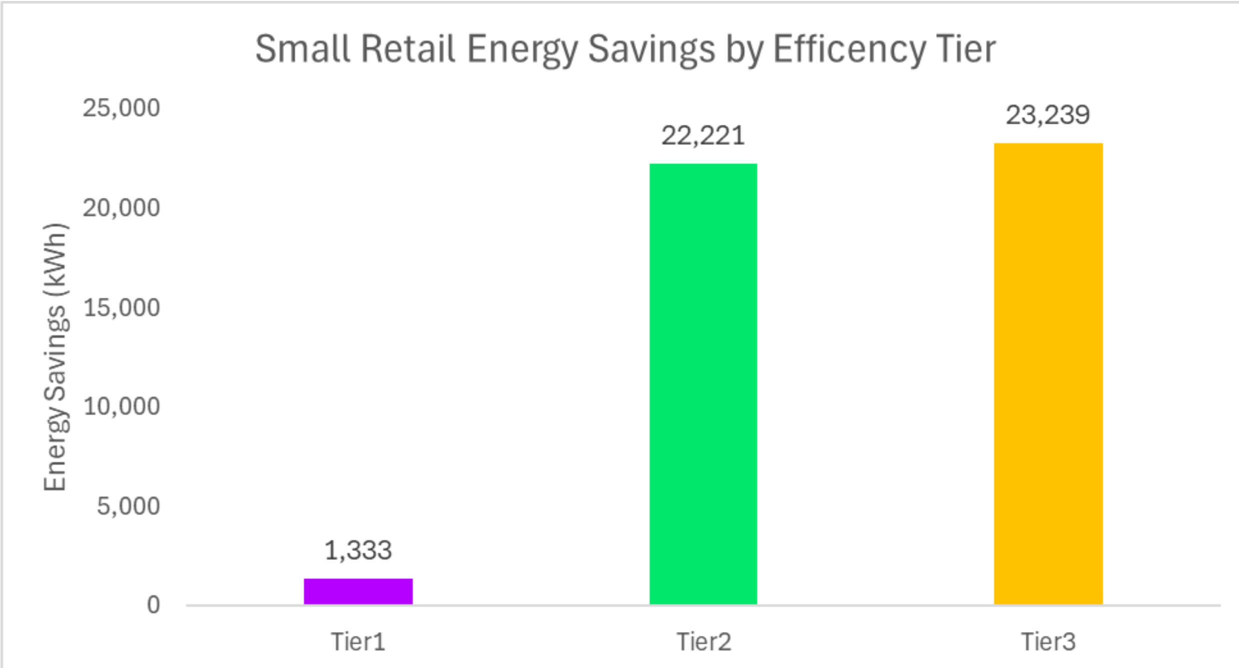



**Figure 12: Small retail energy savings by efficiency tier.**

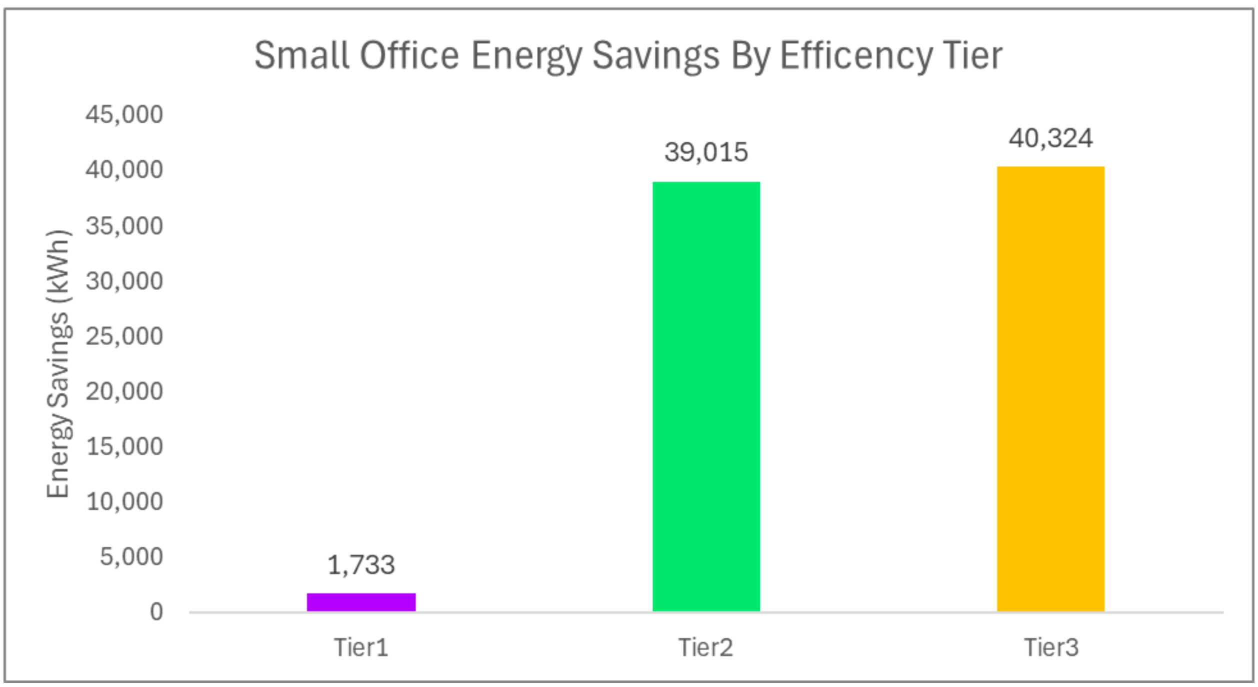



**Figure 13: Small office energy savings by efficiency tier.**

## Product Characterization Study Results

The following subsections detail the findings discovered through the literature review and equipment catalog processes.

### Common Product Features

RTU and DOAS have similar product features which enable them to be highly efficient. The following features are common between both equipment types, although they may be used differently depending on the system.

#### ADVANCED COMPRESSOR TECHNOLOGY

Standard RTUs and DOAS units often use single-speed compressors, which are either fully on or fully off. High efficiency models typically incorporate two-stage, variable speed, or inverter-driven compressors. Definitions for various compressor types were combined in Table 22 from the previous CalNEXT report, "Light Commercial Variable Speed Heat Pump Performance Map" and the AHRI 210/240 standard.

**Table 22: Compressor types and definitions.**

| Terminology | Definition | Efficiency Rating (IEER) | Definition Source |
|---|---|---|---|
| **Single Stage Compressor** | A compressor with a single, fixed capacity set point. | Standard | (AHRI 2024) |
| **Two-capacity (or Two-stage) Compressor** | A compressor or group of compressors operating with only two stages of capacity. One full capacity setting and one lower capacity setting. | Good | (AHRI 2024) |
| **Multiple Capacity (Multiple Stage) Compressor** | compressor having three or more stages of capacity that has neither an inverter, nor variable frequency drive, or a group of compressors with three or more stages of capacity. | Better | (Bansal, et al. 2024) |
| **Variable Speed Compressor** | A compressor that has capability of varying its rotational speed in non-discrete stages or steps from low to full using an inverter or variable frequency drive. | Best | (Bansal, et al. 2024) |

A scroll compressor is driven by a permanent magnet inverter that modulates smoothly from roughly 20 percent to 100 percent of rated load, reducing the start-stop cycling and crankcase heater losses embedded in multi-stage designs. Multi-stage/Multi capacity compressors (MSC) change their compressor stage for higher or lower pressures and save energy by lowering the amount of work the compressor needs to do to meet the required pressures. Inverter driven compressors (IDCs) or variable speed compressors, use an inverter to control direct current (DC) voltage to the compressor, to lower the work output of the compressor to match the demand, similar to multistage compressors.

#### SOPHISTICATED CONTROLS AND BUILDING INTEGRATION

To fully utilize the RTU and DOAS unit control features and information, the equipment must be integrated into the building control system frontend for building operators' easy access. The benefits are more effective from the advanced controls, such as FDD, ventilation rate verification, and other performance diagnostics, when they can be integrated into the wider building control system.

#### DEMAND CONTROL VENTILATION

Demand control ventilation (DCV) reduces outdoor air (OA) load during partial-occupied hours. DOAS units can accomplish DCV by instead varying the supply fan speed using a VFD or ECM, reducing the OA load while simultaneously reducing fan power. However, savings are sensitive to sensor placement and calibration, so it is important to ensure the fan slows with reduced OA. DCV can adjust the OA flow based on occupancy or $CO_2$ sensing to maintain indoor air quality while reducing energy usage.  A package DOAS unit without any external inputs would typically rely on a $CO_2$ sensor in the return air stream. However, California Title 24, Part 6 requires any $CO_2$ sensors to be in the occupied space for more accurate readings, depending on building specifics, as described in Section 120.1.4.

Common occupancy sensors, such as infrared or ultrasonic sensors, can provide information on the individual space's occupancy. Occupancy sensors would be outside of the units but would enable DCV control. Like $CO_2$ sensors, occupancy sensors must meet Title 24, Part 6 requirements, as described in Section 120.1.5.

#### VARIABLE FREQUENCY DRIVES AND ELECTRONICALLY COMMUTATED MOTORS

Both VFDs and ECMs vary their speed to meet the requirements of the system. A VFD is an external component that varies speed by sending different frequencies to the motor, which changes its rotational speed and lowers the airflow. An ECM internally varies speed based on factory-set programming signals from the DOAS unit.

#### REFRIGERANT

In 2025, the Environmental Protection Agency (EPA) began phasing out refrigerants with a GWP greater than 700 for residential and light commercial AC equipment, as part of the American Innovation and Manufacturing Act (AIM) of 2020. The AIM Act plans for an 85 percent reduction in hydrofluorocarbon use by the year 2036 through eliminating refrigerants with GWP greater than 700 for all AC systems (EPA 2016).34 (EPA, AIM 2025).35 Federal enforcement for residential and light commercial HVAC systems to use refrigerants with less than 700 GWP is set to begin on January 1, 2026. California had defined a less aggressive target prior to federal enforcement, requiring all AC

[34] transitioning_to_low-gwp_alternatives_in_res_and_com_ac_chillers.pdf

[35] Enforcement of the American Innovation and Manufacturing Act of 2020 | US EPA

refrigerants to be less than 750 GWP; enforcement of California GWP regulations began on January 1, 2025 (CARB 2025).36  The timeline of federal enforcement of GWP limits is provided in Table 23.

Of the HP RTUs reviewed in the product characterization process, there were three different types of refrigerant available: R-454B, R-32, and R-410A. R-410A has a GWP of 2,088 which is the highest for the product category. R-32 refrigerant has a GWP of 675 and R-454B has a GWP of 466, both of which qualify as low GWP options for air source heat pumps in the United States. It is expected that soon, all manufacturers will offer R-454B, R-32, or other low-GWP refrigerants to meet state and federal mandates. Manufacturers generally only used one refrigerant type in their equipment.

The Refrigerant Data and Safety Classification for R-32 is rated A2L, which means that the refrigerant is less flammable and toxic than some competing low GWP refrigerants. These toxicity and flammability ratings are also a requirement of AIM (ASHRAE 2024).37.R-32 and R-454B may become more expensive, and refrigerant prices could increase the price of HP RTUs during the transition period, although the price is expected to decrease over time. R-454B is a newer refrigerant, designed to replace R-410A. R-454B will initially cost more before its price decreases over time. Transitioning from R-410A to R-454B requires minor equipment modifications around valves and seals. While R-410A production is being ramped down, its prices are expected to increase over time.

**Table 23: AIM Act federal refrigerant GWP limits (EPA Office of Air and Radiation 2023)[38].**

| | GWP Limit | Manufacturing & Import Deadline for Products | Sale and Export Deadline for Products | Installation Deadline for Systems |
|---|---|---|---|---|
| **Residential & Light Commercial Air Conditioners and Heat Pumps** | **700** | **January 1, 2025** | **January 1, 2028** | **January 1, 2025** |

36 Air-conditioning Equipment | California Air Resources Board

37 ASHRAE 34 - Designation and Safety Classification of Refrigerants - Engineering Workbench

38 Final Rule - Phasedown of Hydrofluorocarbons: Restrictions on the Use of Certain Hydrofluorocarbons under Subsection (i) of the American Innovation and Manufacturing Act of 2020

### DEFROST STRATEGY

Frost accumulation on commercial heat pump rooftop units (HP RTUs) typically occurs when the system operates in heating mode and the outdoor coil surface temperature drops below the air's dew point, allowing moisture to condense and freeze on the coil. Frosting tends to occur more readily within the 35°F to 40°F range than at lower ambient temperatures, making an effective defrost strategy essential for maintaining system performance and efficiency. To mitigate frost buildup, many systems periodically reverse the refrigerant cycle—forcing hot gas through the outdoor coil in cooling mode—to melt accumulated ice. Because this temporarily shifts the unit into cooling mode, supplemental electric resistance heating may be used to prevent unintentional cooling of the conditioned space during the defrost cycle. While this approach introduces an additional energy load and reduces overall efficiency, it is necessary to sustain heating capacity and prevent coil blockage.

Manufacturers employ various defrost control methods, including time-based cycles, performance-sensing triggers, and surface temperature monitoring to determine when to initiate and terminate defrost. Variable refrigerant flow (VRF) and air-to-water heat pump systems also incorporate distinct defrost mechanisms, making defrost strategy design a continuing area of technical refinement and industry debate.

## HP RTU High Efficiency Product Features

The following features are common in HP RTU equipment.

### COOLING AND HEATING PERFORMANCE EFFICIENCY (IEER)

Several original equipment manufacturers (OEMs) have released top-tier HP RTU models, which list IEER values from the high 19s into the low 22s for the 10- to 20-ton range. The team collected and reviewed factory literature for the following products:

- **Product Line 1**: 19.8 IEER (10-ton HP) is stocked with a permanent-magnet inverter compressor, VFD condenser fans, and a two-inch double-wall R-10 cabinet.
- **Product Line 2**: 21.5 IEER (15-ton HP) uses a variable speed scroll, electronically commutated indoor supply fan, and a factory energy-recovery wheel option.
- **Product Line 3**: IEER 20.6 (12.5-ton) includes a staged inverter tandem compressor and direct-drive VFD indoor fan.
- **Product Line 4**: IEER 20.1 (17.5-ton) contains dual inverter compression circuits, plus adaptive-frequency supply-fan control.
- **Product Line 5**: IEER 22.3 (18-ton), when specified with the eMotors™ IPM scroll, includes a VFD supply fan and R-13 double-wall construction.

Table 24 provides Title 24 code IEER ratings compared to the highest IEER ratings (AESC, Inc. & ASK Energy, Inc. 2021) in the HP RTU market.

**Table 24: AC and HP RTU cooling efficiencies (IEER).**

| | 5.4-ton to 11-ton (IEER) | 11-ton to 20-ton (IEER) | 20-ton to 63.3-ton (IEER) |
|---|---|---|---|
| T24 Code Baseline | 14.1 | 13.5 | 12.5 |
| Highest Efficiency | 22 | 21 | 18 |
| Δ IEER | 7.9 | 7.5 | 5.5 |

Title 24 code COP ratings compared to the highest COP ratings in AHRI are provided in Table 25 below.

Table 25: AC and HP RTU heating efficiency (COP).

| | 5.4-ton to 11-ton (COP) | 11-ton to 20-ton (COP) | 20-ton to 63.3-ton (COP) |
|---|---|---|---|
| T24 Code Baseline | 3.4 | 3.4 | 3.3 |
| Highest Efficiency | 4.0 | 3.9 | 3.7 |
| Δ COP | 0.6 | 0.5 | 0.4 |

Based on the product catalog in Appendix G, auxiliary heat is commonly included in HP RTU systems. There were multiple options auxiliary heat options available, including natural gas, electric resistance, and for one manufacturer, hot water.

### ENHANCED FAN SYSTEMS

Because fan power varies with the cube of fan speed, slowing the blower from the design airflow criteria of 100 percent to 70 percent saves roughly half the wattage; however, the IEER calculation only credits a fraction of that. Whether the motor-controller package is an integral ECM on small frames or a standalone VFD on larger units, effective fan speed control requires two additions: a mixed-air economizer sequence that demands just enough outdoor air for load or ventilation, and a supervisory logic that links fan speed to ventilation demand. Crucially, IEER underweights that advantage because the test protocol fixes fan airflow at each compressor-load bin. IVEC corrects this oversight by measuring fan power at ASHRAE 62.1 OA flow.

In the advanced rooftop controller (ARC) CATALYST portfolio, VFD fan turndown represented 15 percent to 22 percent of the 42 percent average kilowatt-hour (kWh) savings and critically, half of the measured peak kilowatt (kW) reduction on hot afternoons, when the coil was lightly loaded (Kisch, et al. 2019).

### ADVANCED ROOFTOP CONTROLLERS

Traditional RTUs are controlled by receiving signals from zone thermostats calling for heating or cooling. ARCs, whether factory-integrated or retrofitted, provide supervisory control that integrates operations from variable speed fans, DCVs, economizer sequencing, compressor staging, fault detection and diagnostics, and building automation system integration, and also potentially provides cloud-based analytics. Pacific Northwest National Lab's (PNNL) six-state ARC demonstration logged three benefits (PNNL 2012):[39]

- Lower fan energy by ensuring the supply VFD runs at the minimum airflow that satisfies either zone sensible load or the $CO_2$ driven OA rate, delivering 15 percent to 22 percent kWh reduction.
- Better economizer reliability by detecting stuck OA dampers via a mixed-air credibility test, restoring 1 to 2 megawatt-hour (MWh) per year$^{-1}$ in mild coastal blocks, where economizing inefficiencies are rife.
- Strip heat lockouts by automatically disabling electric resistance below a user-set OA threshold, or after a fixed warm-up window, cutting up to 3 MWh yr$^{-1}$ in California's Central Valley sites.

The New York State Energy Research and Development Authority (NYSERDA) CATALYST program scaled these results to 191 installations and verified a mean 42 percent whole-unit electricity saving and 7 percent gas saving (NREL 2024).[40] Because the ARC aggregates multiple high-value functions into a single commissioning object, it can serve as the verification portal for DCV rates, damper operation, and strip heat lockouts—drastically lowering program EM&V cost.

### AIR-SIDE ECONOMIZERS

High efficiency units often include integrated economizers with advanced controls, such as controlling dampers, to enable economizer operations. Economizers bring in cool outside air when outdoor conditions are favorable, and when outside air has less energy than the return air, it provides free cooling and significant energy saving. Economizers are a prescriptive measure in Title 24, Part 6 for most new rooftop units. Coastal California climates total 2,500 to 3,500 hours per year of favorable dry bulb or enthalpy conditions, where every percentage point of economizer uptime is considered high value.

### WHOLE BOX THERMAL INTEGRITY (HIGH R PANELS AND LOW LEAK DAMPERS)

Increasing insulation in the storage cabinet reduces heat transfer and minimizes heat loss. Additionally, tighter cabinet construction and better seals are needed to reduce air leakage, ensuring that the conditioned air goes where it is intended. The project team learned from NEEA program engineers that insulation and leakage improvements often add the last 5 percent to 10 percent of energy savings once the mechanical efficiencies are maxed out according to their ongoing modeling focused study. NEEA's team mentioned that bumping cabinet insulation from single skin R-4 to double-wall R-12 shaved 5 percent HVAC energy use intensity (EUI) in Climate Zone 3C and offered a reduction of 9 percent to 10 percent in Climate Zone 9.

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[39] PNNL-21944.pdf

[40] End-Use Savings Shapes Measure Documentation: Advanced Rooftop Unit Control

## DOAS High Efficiency Product Features

Standard DOAS units are essentially comprised of an air intake, filters, a mechanism to heat and/or cool the air, a supply fan, and any accompanying optional components based on energy efficiency and control needs. The following features are common in DOAS equipment.

### ENERGY RECOVERY VENTILATOR AND HEAT RECOVERY VENTILATOR

Both energy recovery ventilators (ERVs) and heat recovery ventilators (HRVs) use the exhaust air (EA) to either heat or cool outdoor air, depending on indoor and outdoor air conditions. ERVs can exchange both sensible and latent heat, and HRVs only exchange sensible heat. This can be done with either a rotating wheel or a “fixed core” heat exchanger.

ASHRAE 90.1 specifies requirements to incorporate some exhaust air energy recovery, depending on OA airflow and ASHRAE zone. This requires exhaust air for the building to be routed through the ERV or HRV, which can present a challenge for existing buildings with distributed exhaust systems. Another item of concern when using the wheel is the unintended exchange of air between OA and EA. The wheel rotating between the two airstreams creates an inherent air transfer within the wheel or through the housing. However, this can be tested during commissioning, and ERVs have a way to minimize the impact of the infiltration to ensure EA does not go into the OA.

### ECONOMIZER DAMPER CONTROL

Economizing is the process by which a cooling demand in the building can be satisfied by delivering cool OA rather than using the DX process. This occurs under specific conditions, typically in the morning hours when outdoor temperatures are mild. Economizers in DOAS units with integrated ERV or HRVs operate differently than in an RTU, allowing OA to bypass around the ERV or HRV to avoid exchanging heat with the warmer exhaust air.

### HOT GAS REHEAT

To remove moisture from the incoming OA, the DOAS system generally cools the air below the dewpoint, forcing condensation. Depending on the amount of necessary moisture, this can lead to overcooling of the indoor space. Reheating the air before it goes into space controls dehumidification and sensible cooling independently, leading to more acceptable RH and comfort. Hot gas reheat (HGR) uses the already generated heat from the refrigeration cycle to reheat the OA, rather than rejecting it into ambient conditions through the condenser.

## Current Market Barriers and Gaps

Participants provided feedback that highlighted the multiple barriers high efficiency RTU and DOAS markets must overcome before transformation can occur. The following factors played a vital role in lower participation for HP RTU and DOAS equipment in the Midstream Incentive Pilot.

### Upfront Cost

The enrolled distributors provided cost estimates for the various equipment types included in the Midstream Incentive Pilot. Based on their responses, the team estimated IMC per cooling capacity ton and then calculated the percentage IMC covered by each offering to demonstrate the level of market influence each incentive was expected to have. Table 26 provides the IMC (measured in dollars per ton) and percent of IMC coverage for each Midstream Incentive Pilot measure.

Each distributor promotes and sells one or more specific manufacturers' equipment, so price varies among the distributors. However, HP RTUs have similar cost trends as both AC/gas and HP DOAS. To influence stocking practices and garner interest, it will be critical to correctly assess the incentive amounts. Successful IMC coverage typically ranges from 70 to 85 percent and as Table 26 illustrates, the Tier 1 HP RTU unit incentives fall within this recommended range. However, there is a significant gap in IMC coverage for all other product offerings.

**Table 26: Incremental measure cost estimates and incentive coverage.**[41]

| Product Type | Efficiency Tier | Incentive ($/ton) | Estimated IMC ($/ton) | Percent (%) IMC Coverage |
|---|---|---|---|---|
| HP RTU | Tier 1 | 375 | 465 | 81% |
| | Tier 2 | 500 | 875 | 57% |
| AC/Gas DOAS | Tier 1 | 500 | 1,134 | 44% |
| | Tier 2 | 600 | 2,059 | 29% |
| HP DOAS | Tier 1 | 500 | 2,467 | 20% |
| | Tier 2 | 600 | 4,231 | 14% |

### Operating Cost

Installation costs could potentially increase, depending on the local utility rates at the installation site. If the price of gas is much cheaper than electricity, swapping from a gas RTU or DOAS system will likely increase the bill. An in-depth rate analysis would help narrow down what efficiency level is necessary for fuel switching efforts.

[41] Incremental measure cost (IMC) estimates are subject to change during the duration of the Focused Pilot. Market interviews are ongoing, and if newly collected cost data impacts the estimated averages, the IMC table will be updated accordingly.

### Strip Heat

When asked whether electric resistance (ER) strip heat is necessary to meet design heating loads for HP RTU installations, distributors explained that the need depends on building type, climate zone, internal heat gains, and operating schedules. Compressor performance during colder conditions remains a concern, as frost accumulation on the outdoor coil can trigger defrost cycles lasting 5 to 20 minutes, during which the system reverses refrigerant flow and can deliver cold supply air to the space. In systems equipped with ER heat, this auxiliary source activates to temper the air during the defrost period and maintain occupant comfort; one distributor noted that their company includes ER heat on all HP RTU installations in colder climates for this reason.

However, previous studies have demonstrated that strip heat is unnecessary for many California installations, as mild winter conditions and internal heat gains often allow design loads to be met without supplemental resistance heat. Avoiding ER heat in these cases reduces installation costs by allowing the use of existing electrical infrastructure, minimizes peak electricity demand, and improves operating efficiency by preventing low-COP operation modes. As such, while ER heat remains valuable for colder climate zones or extended runtime schedules, its inclusion should be climate- and application-specific rather than standard practice statewide.

### Electrical Service Panel Upgrade

Increased costs associated with increased electrical service requirements are not uncommon for retrofit applications. If the load increases associated with switching from an AC/gas RTU or AC/gas DOAS to their HP counterpart trigger a panel upgrade, the project cost increases significantly. Similarly, installing electric strip heat can necessitate electrical service upgrades.

## Compressor Terminology

Compressor operation represents one of the largest contributors to overall efficiency in heat pump rooftop units (HP RTUs) and dedicated outdoor air systems (DOAS). Compressor performance is reflected in established efficiency metrics—Integrated Energy Efficiency Ratio (IEER) for HP RTUs and Integrated Seasonal Moisture Removal Efficiency (ISMRE) for DOAS units. Because energy savings calculations are directly tied to these ratings, compressor type and performance significantly influence the measurable energy impact of a heat pump system.

Compressor efficiency is particularly impactful in mild climates where part-load operation is common, and the IEER metric effectively captures performance across these varying load conditions. The upcoming Integrated Variable HVAC Efficiency (IVHE) metric will further refine this assessment by distinguishing the additional impacts associated with fan operation. While IEER primarily accounts for compressor-related savings, IVHE is expected to provide a more holistic view of equipment efficiency under realistic operating conditions.

During the design phase of the Midstream Incentive Pilot's measures, compressor type was a topic of uncertainty. The difference between "variable capacity" and "variable speed" in different manufacturer's marketing materials was not immediately clear. Upon interviewing distributors and manufacturers, the team landed on definitive answers. Both compressor types adjust the compressor's speed from lower part load to full load performance, with the objective of reducing energy consumption when the indoor room temperature has reached the set point. However, variable speed compressors are more flexible than variable capacity compressors since they do not need pre-calibrated stages to reach a lower run speed.

## Prevalence of HP RTUs with Variable Speed Compressors

Distributors reported that all major heat pump manufacturers are developing or have begun offering VSC HP RTUs in some capacity. However, they emphasized that these models currently carry a significant cost premium—approximately $500 to $750 per ton—which often steers retrofit projects toward lower-cost alternatives such as fixed-speed or digital scroll compressors. Consistent with broader market trends, 85 percent to 90 percent of current HP RTU sales remain at Title 24 minimum efficiency levels, indicating that substantial incentives are required to stimulate demand for higher-efficiency, VSC-equipped units.

Larger mainstream manufacturers have started introducing tiered product lines that allow customers to choose among varying efficiency levels, signaling gradual progress toward broader VSC adoption. Distributors identified five manufacturers that currently offer inverter-driven compressor models, suggesting the technology is gaining foothold in the market but remains cost-limited without program support or manufacturer incentives.

## Distributor Stocking Practices

Discussions with participating distributors revealed clear differences in stocking practices and market readiness across product types. Heat pump RTUs are the most commonly available of the three technologies, particularly in the light commercial (<15 ton) range, though higher-tonnage and higher-efficiency models remain limited in stock due to space and demand constraints. In contrast, both heat pump DOAS and AC/furnace DOAS systems are custom engineered and built-to-order, with no distributors maintaining inventory of these products. Their sales cycles are driven by project-specific design and specification, rather than by warehouse availability.

Stocking limitations appear to be driven more by market structure and HVAC system design practices than by distributor willingness. One participating distributor reported that HP RTUs qualifying for Tier 2 are rarely sold and that variable-speed compressors are not yet included in their primary manufacturer's product line. HP RTUs equipped with energy recovery ventilators (ERVs) were also noted as uncommon. However, several distributors expect the availability of variable-speed HP RTUs to increase around 2027, once a major OEM introduces new models into the product mix.

Distributors reported that HP RTUs are generally available for light commercial applications, with most maintaining limited inventory of units below 15 tons. Larger units are typically special order only, constrained by both warehouse space and market demand, as roughly 80 percent of HP RTU sales fall within the <15-ton range. The majority of current sales—85 percent to 90 percent—are Title 24 minimum efficiency models, highlighting the opportunity for incentives to drive higher-efficiency adoption. Distributors noted that design adjustments, such as replacing VAV with terminal reheat configurations, could expand HP applicability if paired with strong midstream incentives and design community engagement.

All distributors indicated that HP and AC/furnace DOAS units are not stocked due to its highly customized nature and limited market demand—often 12 to 14 weeks for one well-known manufacturer. These systems are typically made-to-order for large commercial projects requiring 100 percent outdoor air ventilation, such as schools or healthcare facilities. The units are larger, heavier, and costlier than conventional RTUs, making stocking impractical. As a result, sales rely on specification-stage influence by sales engineers and design-build contractors, underscoring the need for design assistance and early-stage incentives over traditional stocking programs.

Distributor feedback reinforced that stocking barriers are not due to reluctance but rather to inherent limitations in HVAC market design and product availability. For HP RTUs, short-term strategies should focus on increasing stocking of <15T Tier 1 and Tier 2 models, while preparing for Tier 3 adoption in the next product cycle (≈2027) as variable-speed and ERV-equipped units become more prevalent. For both HP DOAS and AC/Furnace DOAS, midstream stocking mechanisms are not appropriate; instead, upstream manufacturer collaboration, design-community training, and specification-based incentives will be key to driving adoption of high-efficiency ventilation solutions.

### Long Lead Time for Larger Equipment

During the manufacturer interviews in the ET23SWE0073 Focused Pilot, the project team learned that HP RTUs and DOAS systems over 25 tons are custom built and have an extended lead time. Both systems also have a large degree of configurability when desired by the customer, which comes at a higher cost in addition to the longer lead times.

To implement a successful energy efficiency program, future programs must allow for the gap of time between when equipment is ordered and installed. The Midstream Incentive Pilot has too short of a time span to accommodate larger projects outside the “chance” of coinciding with install days for pre-scheduled projects.

### DOAS Ratings Availability

The lack of AHRI-listed DOAS equipment impacted the incentive pilot negatively. Participants who were highly engaged and submitted multiple claims a month did not submit any DOAS equipment and only submitted HP RTUs with active AHRI certifications. The requirement for participants to submit equipment specification documents hindered their ability to be more active in the program.

Because AHRI does not yet support DOAS equipment in their equipment directory, collecting efficient product features and associated efficiency differences for DOAS equipment would not be possible without the guidance of our interviewed supply chain actors.

The project team interviewed several manufacturers, who reported that many DOAS manufacturers are pursuing AHRI directory listings for the certified performance of their equipment, which would align with AHRI 920-2022 test conditions. This finding accelerated our progress to establishing incentive pilot minimum efficiency requirements. The DOAS measure requirements were intended to match Title 24, Part 6 Building Efficiency Standard minimums.

### AHRI Efficiency Ratings

During the interview process, the project team requested specification sheets from the participating distributors for both HP RTU and DOAS equipment, which participating distributors were generous in providing. Upon further examination, it became clear that many of the smaller manufacturers did not test with respect to AHRI standards when the team noted missing seasonal efficiencies—such as IEER, ISMRE2, and ISCOP2—on the first submitted specification sheets. After discussions with the distributors concerning the discrepancies, participants discovered that the AHRI test conditions were not configured correctly in the performance simulation software and reached out to the manufacturers. Manufacturers subsequently told participants they would change the simulation software in the coming months to accommodate the calculation of AHRI ratings for their RTU and DOAS equipment.

## Market Opportunities

Although there are a multitude of opportunities to prioritize in the RTU and DOAS markets, the following suggestions are focused on energy efficiency and building electrification program success.

### Optimize Fuel Substitution Opportunities

SCE estimates that RTUs provide space conditioning for 75 percent of commercial building space in California (SCE, 2015). California has a relatively mild climate in much of the state, allowing heat pump technology to perform efficiently year-round—and often without the need for electric resistance strip heat. To reduce installation costs for heat pump RTUs, the program team recommends avoiding supplemental heating systems as an intervention strategy. We encourage the market to identify heat pump RTU solutions without relying on electric resistance strip heaters, which will address this barrier and provide further data supporting the practice moving forward.

### High Efficiency Measure for HP RTUs

There is a good opportunity to add a higher efficiency tier to California's measure portfolio. The Midstream Incentive Pilot received strong participation for HP RTU equipment with higher IEER efficiency ratings than the current California HP RTU measure offerings. With an appropriately sized incentive level and appropriate midstream program design, higher efficiency HP RTU sales can be increased effectively.

Adding a higher efficiency tier for HP RTUs to the measure portfolio provides an opportunity for increased claimable savings. Additionally, a higher efficiency tier offers the potential for more impactful programs and lower energy bills for customers.

### Variable Capacity HP RTUs Measure

Based on the TSB impacts from past California RTU programs, the variable capacity compressor measure for AC RTUs is trending to perform better in TSB than the fuel substitution and like-for-like measures, despite being lower volume. The same trend could be applied to HP RTUs if variable capacity HP RTUs were included in the SWHC043 measure package or a similar measure package was created for HP RTUs.

### Investigate Regional Code Impacts

Based on participant feedback from the Midstream Incentive Pilot, HP RTU stocking practices and product availability have been largely driven by regional code updates. Investigating regional and county level code requirements may be a good next step for further characterization of the commercial heat pump market.

### Establish the First DOAS Measure or Program

DOASs consume a large amount of energy due to the high amount of moisture they must remove from up to 100 percent OA. If the market prioritizes high efficiency, these systems' large consumption of energy presents an opportunity for big impacts.

Although the DOAS market is still ramping up to getting listed on AHRI, that market opportunity is likely to be here soon. DOAS equipment is actively being certified by AHRI, and when the database is available, program implementation barriers will be less daunting. Measure package efforts should begin ahead of schedule to establish baseline assessments and prepare for when efficiency ratings become readily available to the public.

## Stakeholder Feedback

The following sections describe the project team's coordinating efforts with external stakeholders.

### MNCEE

The project team interviewed a Minnesota Center for Energy and Environment representative familiar with RTUs in April 2025 in support of this research. MNCEE has a next generation, Minnesota-based RTU program which also operates in Illinois, New York, and California. The program's primary focus is on dual-fuel heat pump solutions,[42] but they also prioritize cold-climate HPs and energy recovery.

### CEE

In May 2025, the project team met with the CEE staff person who manages the CEE Commercial Air Conditioning and Heat Pumps Initiative. The goal of the Initiative is to increase the availability of high efficiency commercial unitary air conditioners and heat pumps across the United States and Canadian market and to encourage efficient upgrades to commercial AC and HP systems. The CEE Commercial Air Conditioning and Heat Pumps Committee's HP RTU project is currently investigating low-ambient HP performance, ERVs, grid connectivity, and opportunities for RTU cabinet improvements (such as insulation).

Some of the CEE Commercial ACHP Committee's primary focuses are next generation HP RTUs and partnering with the DOE commercial building HP accelerator initiative[43]. The CEE staff person mentioned that it would not be practical for a program to require all RTUs to have integrated ERVs, particularly for RTU replacement scenarios. One reason for that is that commercial buildings often have exhaust air vents in a different location than the RTU. CEE publishes annual Commercial AC and HP program summaries that identify members offering program support for AC and HP equipment, ERVs, DCVs, and other related efficiency measures[44].

### NEEA

The project team met with NEEA in June of 2025 to discuss efficient RTU program design. NEEA has investigated many topics in this area, including development for market uptake, whole-box metrics, nuances surrounding the ECD and VSD baseline, and more. NEEA is particularly focused on "whole box" efficiency rather than mechanical components alone during the interview period. The key features NEEA emphasized were higher insulation values, e.g., increasing to R-8 or R-12 insulation, low-leakage dampers, and low-box air leakage.

In June 2025, NEEA published "National Efficient Rooftop Unit Energy Modeling," a model study[45] considering seven building types across eleven locations which span eight climate zones, demonstrating the energy savings potential from increasing package insulation values and addition

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[42] Final Performance Report: Dual Fuel RTU Monitoring Accessible at: https://www.mncee.org/final-performance-report-dual-fuel-rtu-monitoring

[43] DOE Announces Better Buildings Initiative to Accelerate Heat Pump Manufacturing and Adoption, Reducing Energy Waste and Lowering Energy Bills. Accessible at: https://www.energy.gov/articles/doe-announces-better-buildings-initiative-accelerate-heat-pump-manufacturing-and-adoption

[44] CEE published Annual Commercial AC and HP program summaries. Accessible at: https://cee1.org/program-resources/

[45] National Efficient Rooftop Unit Energy Modeling. Accessed at: https://neea.org/resource/national-efficient-rooftop-unit-energy-modeling/

of ERV on RTU energy savings potential. The report states upgrading box insulation to R-8 or R-12 can deliver up to 15 percent site EUI savings, on average (NEEA 2025). Although insulation is not currently considered in existing efficiency tier metrics, NEEA advocates for a whole box efficiency metric, with the purpose of standardizing credits for enclosure-based improvements.

### CALMTA

The project team met with CalMTA in May of 2025 to discuss the High Efficiency RTU Focused Pilot and potential coordination opportunities. However, we were unable to share much data since CalNEXT, at the time, required current studies to be published before we could discuss findings. We were able to share report questionnaires with CalMTA, but further coordination was unable to occur beyond reference to publicly available information.

On November 6, 2025, CalMTA published the *Commercial Rooftop Units MTI Plan*[46] (CalMTA 2025). That document's Appendix C: Product Assessment Report shared modeling results for many efficiency-enhancing product features in HP RTUs, which recognized variable speed heat pumps for their ability to reduce the need for electric resistance in all-electric applications. These findings align closely with our project team's recommendations. indicating a consistent theme in commercial heat pump RTU market transformation research.

[46] Commercial Rooftop Units MTI Plan. Accessed at: https://calmta.org/resourcereport/commercial-rooftops-unit-mti-plan/

# Recommendations

The recommendations below focus on the addition of measure packages for HP RTUs and DOAS, as well as program design best practices.

The measure package recommendations involve the implementation of the Proposed Program Tiers described in Table 20 and Table 21 of the Efficiency Tier Matrix Results section. By implementing higher efficiency measure requirements that are appropriately calibrated to the current market conditions, we can optimize claimable savings and promote market transformation more effectively than current measures.

The program design recommendations provide guidance to improve energy efficiency and building electrification program efficacy. These recommendations are supported by first-hand accounts from participants in the Midstream Incentive Pilot.

## Measure Package Recommendations

Across nearly all commercial HVAC incentive programs the project team reviewed, cooling and heating performance metrics—such as IEER and COP—remain the primary benchmarks for defining RTU efficiency. These metrics capture standardized part-load and full-load behavior and form the basis of federal code compliance and OEM product differentiation. Considering this industry consensus, the project team's tiered incentive framework anchors each level to progressively higher IEER thresholds. However, given California's unique climate zones and energy priorities, the team also identifies a series of state-specific high efficiency features that address performance gaps IEER does not capture alone, and offers additional savings in California conditions.

The efficiency tiers outlined in this report are intended to accelerate the adoption of high-performance HP RTUs and encourage installations without electric resistance (ER) heat, addressing peak energy use and adoption barriers. When replacing a traditional RTU with an HP RTU that includes ER heating can double the power requirements of the new system. This would often require upgrading the RTU's electrical service to support the added load and could potentially trigger a full panel upgrade, which can be time-consuming, costly, and complex—all critical HP RTU barriers. Furthermore, since HP and ER heating can operate simultaneously, removing electric heaters can also reduce the peak power use of the HP RTU by a factor of two. ER heaters can also add significant energy use by overuse of electric heating, but this can be avoided in many cases by proper commissioning.

### No Strip Heat

ER “strip heat” is factory or field installed in many HP RTUs as a safety net for the coldest hours of the day or for fast morning warm up, intended to decrease the time required to heat up. On average, strip heat adds 5 kW of electric elements and controllers to a heat pump unit less than 5.4 tons (Higa, et al. 2024). By scaling this rate up to a typical 10-ton unit, a commercial unit would have an average of 10 kW of added load associated with ER strip heat. Considering relative error and deviation from the average, a typical 10-ton commercial ER kit adds 8 kW to 12 kW.

California’s Title 24, Part 6 climate zone map shows that 14 of the state’s 16 nonresidential climate zones have 99 percent design dry bulb temperatures above 25°F, where only mountain regions Climate Zone 14 and Climate Zone 16 drop reliably below 20°F (DOE n.d.)[47] during the winter months. In other words, modern cold climate HP compressors can satisfy design heating loads almost everywhere in the state without resistance backup, yet ER kits are still in use either because factory defaults are left unchanged or due to contractors’ oversized setback schedules. Hourly weather data supports this point, with typical meteorological year data showing fewer than 10 hours below 35°F per year in the coastal San Francisco (Climate Zone 3) and roughly 90 hours in inland Fresno (Climate Zone 6).

For Climate Zone 14 and Climate Zone 16, where design temperatures fall below 20°F, an ER kit or gas backup is still practical. An incentive design can exempt these two zones while driving an ER-free specification everywhere else.

### VFD and ECM Supply Fans Integrated with Advanced Rooftop Controller

High turn-down supply fans driven by VFDs or ECMs address one of the most persistent mismatches in packaged HVAC units where the fan continues to blow design airflow long after the cooling or heating coil has throttled back. One key enabling technology is the ARC, which dynamically adjusts fan speed based on the most critical constraint—whether that is the zone’s sensible load, economizer setpoint, or outdoor air requirements driven by $CO_2$ levels—while actively managing economizer damper position. In PNNL’s multi-site ARC field trial on 66 RTUs, advanced controls of VFD fan turndown, integrated economizer logic, and DCV cut normalized annual RTU electricity use by 22 to 90 percent (DOE n.d.).[48]

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[47] EnergyPlus

[48] PNNL-21944.pdf

## Program Design Recommendations

The following program design recommendations are based on barriers identified during market interviews and the implementation of the Midstream Incentive Pilot.

### Prioritize Efficiency Data Accessibility

Data accessibility is key to energy efficiency and electrification initiatives pertaining to HP RTUs and DOAS equipment. Efficiency ratings at AHRI conditions were more accessible for HP RTUs than DOAS units, which made implementing a midstream incentive program more realistic for the participating distributors. The custom equipment evaluation and submission process is often too cumbersome for a distributor to dedicate much time to.

### Minimize Data Collection Requirements

As identified in the ET23SWE0073 Focused Pilot, participants prioritize a smooth application process. Minimizing required data on applications reduced barriers for those participating in the incentive pilot, who enjoyed being able to access equipment without needing to submit specification sheets. Current data requirements used in the Focused Pilot include end-use customer contact information such as name, title, phone number, and address details (city and ZIP code). To address certain data requirements such as if a gas unit was replaced, establishing baselines for the region accounts for variation in projects and allows for more flexibility and increased program participation.

### Offer Adequate Incentives

Incentive levels for market transformation efforts are critical to strong participation and influencing customer purchase trends. Due to lower demand, HE equipment was often not stocked by manufacturers, or was rare to find. Because HE HP RTUs and HE DOASs are significantly more costly, larger, and heavier than their code-minimum counterparts, the incentive must be large enough to motivate distributors to change their stocking plans.

The incentive levels offered for Tier-1-qualifying HP RTUs received many more applications than the other equipment categories in the Midstream Incentive Pilot. The incentive covered 81 percent of the IMC, falling within the recommended 70 percent to 85 percent IMC coverage range. As previously explained, the main objective for this market-transforming incentive was to set it high enough that the distributors' sales engineer can offer the high-efficiency equipment with a two-to-three-year payback—a strategy supported in design conversations with customers, design build contractors, mechanical engineers, and architects. In contrast, many participating distributors stocked low quantities of Tier 2 equipment but did not take it off the shelf; this was likely due to the lower coverage of IMC, which ranged from 14 percent to 57 percent.

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# Appendix A: Glossary[49]

The following definitions are quoted from section 100.1 of the 2022 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (California Energy Commission 2022).

**Coefficient Of Performance (COP), Heat Pump**: The ratio of the rate of useful heat output delivered by the complete heat pump unit (exclusive of supplementary heating) to the corresponding rate of energy input, in consistent units and as determined using the applicable test method in Appliance Efficiency Regulations or Section 110.2.

**Condenser:** A refrigeration component that condenses refrigerant vapor by rejecting heat to air mechanically circulated over its heat transfer surface.

**Dedicated Outdoor Air System (DOAS)**: A ventilation system that delivers 100 percent outdoor air and delivers ventilation supply air to each space, either directly or in conjunction with local or central space-conditioning systems serving those same spaces such as a DX-DOAS, HRV, ERV, or custom ventilation only unit.

**Dx-Dedicated Outdoor Air System (DX-DOAS)**: A type of air-cooled, water-cooled, or water-source DOAS unit that dehumidifies 100 percent outdoor air and includes reheat that is capable of controlling the supply dry-bulb temperature of the dehumidified air to the designed supply air temperature. This conditioned outdoor air is then delivered directly or indirectly to the conditioned spaces. It may precondition outdoor air by containing an enthalpy wheel, sensible wheel, desiccant wheel, plate heat exchanger, heat pipes, or other heat or mass transfer apparatus.

**Desiccant Dehumidification System**: A mechanical dehumidification technology that uses a solid or liquid desiccant to remove moisture from the air.

**Dew Point Temperature:** The vapor saturation temperature at a specified pressure for a substance undergoing phase change from vapor to liquid.

**Dual-Fuel Heat Pump**: An electric heat pump with gas furnace supplemental heat that alternates between the two fuel sources.

**Fan System, Multi-Zone Variable Air Volume (VAV)**: A fan system that serves three or more space-conditioning zones where airflow to each zone is individually controlled based on heating, cooling and/or ventilation requirements, indoor fan airflow varies as a function of load, and the sum of the minimum zone airflows is 40% or less of the fan system design conditions.

**Fluid Cooler**: A fan-powered heat rejection device that includes a water or glycol circuit connected by a closed circulation loop to a liquid-cooled refrigerant condenser, and may be either evaporative-cooled, air-cooled, or a combination of the two.

[49] Definition sourced from pages CA 2022 Building Efficiency Standards. For more information, see: https://www.energy.ca.gov/sites/default/files/2022-12/CEC-400-2022-010_CMF.pdf

**Heat Pump**: An appliance that consists of one or more assemblies; that uses an indoor conditioning coil, a compressor, and a refrigerant-to-outdoor air heat exchanger to provide air heating; and that may also provide air cooling, dehumidifying, humidifying, circulating, or air cleaning.

**Integrated Energy Efficiency Ratio (IEER):** A single-number cooling part load efficiency figure of merit calculated as specified by the method described in ANSI/AHRI Standard 340/360/1230. This metric replaces the IPLV for ducted and non-ducted units.

**Integrated Seasonal Coefficient Of Performance (ISCOP)**: A seasonal efficiency number that is a combined value based on the formula listed in AHRI Standard 920 of the two COP values for the heating season of a DX-DOAS unit water or air source heat pump, expressed in W/W.

**Integrated Seasonal Moisture Removal Efficiency (ISMRE)**: A seasonal efficiency number that is a combined value based on the formula listed in AHRI Standard 920 of the four-dehumidification moisture removal efficiency (MRE) ratings required for DX-DOAS units, expressed in lb. of moisture/kWh.

**Multiple Zone System**: An air distribution system that supplies air to more than one space conditioning zone, each of which has one or more devices (such as dampers, cooling coils, and heating coils) that regulate airflow, cooling, or heating capacity to the zone.

**Outdoor Air:** Air taken from outdoors and not previously circulated in the building.

**Recovered Energy**: Energy used in a building that (1) is recovered from space conditioning, service water heating, lighting, or process equipment after the energy has performed its original function; (2) provides space conditioning, service water heating, or lighting; and (3) would otherwise be wasted.

**Sensible Energy Recovery Ratio**: A ratio of the change in the dry-bulb temperature of the outdoor air supply to the difference in dry-bulb temperature between the outdoor air and entering exhaust airflow, with no adjustment to account for that portion of the dry-bulb temperature change in the leaving supply airflow that is the result of leakage of entering exhaust airflow rather than heat exchange between the airstreams.

**Variable Air Volume (VAV) System**: A space-conditioning system that maintains comfort levels by varying the volume of supply air to the zones served.

**Ventilation System, Balanced**: A mechanical device intended to remove air from buildings and simultaneously replace it with outdoor air.

**Ventilation System, Central Fan Integrated (CFI)**: A ventilation system configuration in which the ventilation ductwork is connected to the duct system of a dwelling unit space conditioning system to enable distribution of ventilation air to the dwelling unit while the space conditioning system air handling unit is operating.

**Ventilation System, Energy Recovery (ERV)**: A mechanical device intended to remove air from buildings, simultaneously replace it with outdoor air, and in the process transfer heat from the warmer to the colder of the simultaneous airflows and transfer moisture from the most humid to least humid of the simultaneous airflows.

**Ventilation System, Exhaust**: A mechanical device intended to remove air from buildings, causing outdoor air to enter by ventilation inlets or normal leakage paths through the building envelope.

**Ventilation System, Heat Recovery (HRV)**: A mechanical device intended to remove air from buildings, simultaneously replace it with outdoor air, and in the process transfer heat from the warmer to the colder of the simultaneous airflows.

**Ventilation System, Supply**: A mechanical device intended to bring outdoor air into buildings, causing indoor air to flow out of the building through ventilation relief outlets or normal leakage paths through the building envelope.

# Appendix B: 2022 Building Efficiency Standards

Applicable minimum efficiency requirements for applicable air conditioning and heat pump equipment are provided in the following tables. All efficiency requirements are quoted from the 2022 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (California Energy Commission 2022).

**Table 27: 2022 Building Energy Efficiency Standards minimum efficiency requirements for air conditioners and condensing units.**[50]

| Equipment Type | Size Category | Efficiency | Test Procedure |
|---|---|---|---|
| Air conditioners, air cooled both split system and single package | ≥ 65,000 Btu/h and < 135,000 Btu/h | 11.2 EER<br>14.8 IEER | AHRI 340/360 |
| Air conditioners, air cooled both split system and single package | ≥ 135,000 Btu/h and < 240,000 Btu/h | 11.0 EER<br>14.2 IEER | AHRI 340/360 |
| Air conditioners, air cooled both split system and single package | ≥ 240,000 Btu/h and < 760,000 Btu/h | 10.0 EER<br>13.2 IEER | AHRI 340/360 |
| Air conditioners, air cooled both split system and single package | ≥ 760,000 Btu/h | 9.7 EER<br>12.5 IEER | AHRI 340/360 |

[50] Values sourced from Table 110.2-A (pages 105-106) in California's 2022 Building Energy Efficiency Standards https://www.energy.ca.gov/sites/default/files/2022-12/CEC-400-2022-010_CMF.pdf

Table 28: 2022 Building Energy Efficiency Standards minimum efficiency requirements for heat pumps.[51]

| Equipment Type | Size Category | Rating Condition | Efficiency | Test Procedure |
|---|---|---|---|---|
| Air Cooled (Cooling Mode), both split system and single package | ≥ 65,000 Btu/h and < 135,000 Btu/h | | 11.0 EER<br>14.1 IEER | AHRI 340/360 |
| Air Cooled (Cooling Mode), both split system and single package | ≥ 135,000 Btu/h and < 240,000 Btu/h | | 10.6 EER<br>13.5 IEER | AHRI 340/360 |
| Air Cooled (Cooling Mode), both split system and single package | ≥ 240,000 Btu/h | | 9.5 EER<br>12.5 IEER | AHRI 340/360 |
| Air Cooled (Heating Mode) Split system and single package | ≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity) | 47° F db/43° F wb outdoor air | 3.4 COP | AHRI 340/360 |
| Air Cooled (Heating Mode) Split system and single package | ≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity) | 17° F db/15° F wb outdoor air | 2.25 COP | AHRI 340/360 |
| Air Cooled (Heating Mode) Split system and single package | ≥ 135,000 Btu/h and < 240,000 Btu/h (cooling capacity) | 47° F db/43° F wb outdoor air | 3.3 COP | AHRI 340/360 |

[51] Values sourced from Table 110.2-B (pages 107-108) in California's 2022 Building Energy Efficiency Standards https://www.energy.ca.gov/sites/default/files/2022-12/CEC-400-2022-010_CMF.pdf

| Equipment Type | Size Category | Rating Condition | Efficiency | Test Procedure |
|---|---|---|---|---|
| **Air Cooled (Heating Mode) Split system and single package** | ≥ 240,000 Btu/h and < 760,000 Btu/h | 47° F db/43° F wb outdoor air | 3.2 COP | AHRI 340/360 |
| **Air Cooled (Heating Mode) Split system and single package** | ≥ 135,000 Btu/h (cooling capacity) | 17° F db/15° F wb outdoor air | 2.05 COP | AHRI 340/360 |

**Table 29: Air-source DX-DOAS units, single-package, and remote condenser minimum efficiency requirements.**[52]

| Equipment Type | Energy Recovery | Efficiency | Test Procedure |
|---|---|---|---|
| **Air cooled (Dehumidification mode)** | Without energy recovery | 4.0 ISMRE | AHRI 920 |
| **Air source heat pumps (Dehumidification mode)** | Without energy recovery | 4.0 ISMRE | AHRI 920 |
| **Air source heat pumps (heating mode)** | Without energy recovery | 2.7 ISCOP | AHRI 920 |
| **Air cooled (Dehumidification mode)** | With energy recovery | 5.2 ISMRE | AHRI 920 |
| **Air source heat pumps (Dehumidification mode)** | With energy recovery | 5.2 ISMRE | AHRI 920 |
| **Air source heat pumps (heating mode)** | With energy recovery | 3.3 ISCOP | AHRI 920 |

[52] Values sourced from Table 110.2-K (pages 120-121) in California's 2022 Building Energy Efficiency Standards https://www.energy.ca.gov/sites/default/files/2022-12/CEC-400-2022-010_CMF.pdf

# Appendix C: Existing RTU Measure Packages

This appendix details the current prescriptive RTU measure packages that have been approved by the California Public Utility Commission (CPUC) (CalTF 2025). More information on each measure package can be found on the California eTRM website: https://www.caetrm.com/.

## SWHC013-07:[53] Unitary Air-Cooled Air Conditioner, over 65 kBtu/h, Commercial

The current SWHC013 measure package allows all unitary direct expansion (DX) equipment meeting the minimum EER, IEER, and COP specifications. For normal replacement projects, the existing equipment must be replaced with the same type of equipment (e.g., a heat pump for a heat pump). For new construction projects, the baseline is assumed to be electric. This measure excludes scenarios where an AC RTU is substituted by a HP RTU. Unitary HPs and ACs equipped with electric resistance heating are not eligible. Equipment must meet the efficiency specifications shown in Table 30 and Table 31 to qualify for this measure.

[53] Unitary Air-Cooled Air Conditioner, Over 65 kBtu/hr, Commercial. April 2025. https://www.caetrm.com/measure/SWHC013/07/

Table 30: Measure SWHC013-07 AC RTU efficiency criteria.

| Capacity Range (kBtu/h) | Tier | EER | IEER |
|---|---|---|---|
| 65 - 134 | 1 | 11.5 | 14.6 |
| | 2 | 12.0 | 14.6 |
| | 3 | 12.5 | 14.6 |
| | 4 | 13.0 | 15.0 |
| 135 - 239 | 1 | 11.5 | 14.0 |
| | 2 | 12.0 | 14.0 |
| | 3 | 12.5 | 14.0 |
| 240 - 760 | 1 | 10.8 | 13.0 |
| | 2 | 11.5 | 13.0 |
| | 3 | 12.5 | 15.5 |
| >760 | 1 | 10.2 | 12.3 |
| | 2 | 11.0 | 12.3 |
| | 3 | 12.0 | 13.8 |

Table 31: Measure SWHC013-06 HP RTU efficiency criteria.

| Capacity Range (kBtu/h) | Tier | EER | COP |
|---|---|---|---|
| 65 - 134 | 1 | 11.5 | 3.5 |
| | 2 | 12.0 | 3.55 |
| 135 - 239 | 1 | 10.8 | 3.48 |
| | 2 | 11.2 | 3.51 |
| 240 - 760 | 1 | 9.7 | 3.3 |
| | 2 | 10 | 3.3 |

## SWHC043-07:[54] Multiple Capacity Unitary Air-Cooled Commercial Air Conditioners Between 65 and 240 kBtu/h

This measure applies to AC RTUs ranging from 65 kbtuh (5.4 tons) to 240 kbtuh (20 tons) equipped with either a variable speed compressor, a compressor with multiple steps (>1 speed), or multiple compressors operating within a single refrigeration circuit. The AC equipment must also include an indoor fan with three steps or greater. In addition to the required equipment features, the equipment must meet the minimum efficiency requirements provided in Table 32 below.

**Table 32: Measure SWHC043-07 efficiency criteria.**

| Capacity Range (kBtu/h) | Tier | IEER | EER |
|---|---|---|---|
| 65 - 134 | 1 | 19.0 | 12.0 |
| | 2 | 19.0 | 13.0 |
| 135 - 239 | 1 | 17.5 | 12.0 |
| | 2 | 17.5 | 12.5 |

[54] Multiple Capacity Unitary Air-Cooled Commercial Air Conditioners Between 65 and 240 kBtu/hr. April; 2025. https://www.caetrm.com/measure/SWHC043/07/

## SWHC046-05:[55] Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution

This measure requires the replacement of existing less efficient AC and natural gas furnace equipment, which must be removed and decommissioned upon installation of the measure equipment. Additionally, existing gas lines must be capped off, and/or removed refrigerant must be handled and disposed of in accordance with all state and local regulations. All the packaged or split HP must exceed the minimum efficiency requirements indicated in Table 33. Accelerated replacement (AR) scenarios have a lower efficiency requirement than if the project is new construction (NC) or normal replacement (NR).

**Table 33: Measure SWHC046-05 efficiency criteria.**

| Capacity Range (kBtu/h) | Measure Application Type | IEER | COP |
|---|---|---|---|
| 65 - 134 | AR | 15.0 | 3.4 |
| | AR | 16.0 | 3.4 |
| | NC, NR | 16.0 | 3.4 |
| 135 - 239 | AR | 14.5 | 3.4 |
| | AR | 15.5 | 3.4 |
| | NC, NR | 15.5 | 3.4 |
| 240 - 760 | AR | 13.5 | 3.4 |
| | AR | 14.0 | 3.4 |
| | NC, NR | 14.0 | 3.4 |

[55] Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution. July 2025. https://www.caetrm.com/measure/SWHC046/05/

## SWHC048-04:[56] Packaged Air Conditioner Heat Recovery, Commercial

This measure applies to AC RTUs equipped with a heat recovery system. Heat recovery systems may vary in configuration across manufacturers but are defined by the measure as “a packaged air conditioner…that is equipped with an air-to-water heat exchanger to preheat service hot water.” This measure currently only applies to new and existing fast food restaurants with gas water heating systems. No minimum efficiency criteria is defined by this measure package.

[56] Packaged Air Conditioner Heat Recovery, Commercial. December 2023. https://www.caetrm.com/measure/SWHC048/04/

# Appendix D: Initial Market Actor Survey

1. What are the specifications/rating you use to define efficiency for DOAS?
2. When configured as DOAS, with 100% outside air, then do cut sheets rate units in accordance with AHRI - 920?
3. DOE Title 10-May 1, 2024, has standards for ISMRE2 and ISCOP2.
    a. Are they reported on your cut sheets with AHRI-920?
4. What design components and control strategies are included in your highest efficiency HP RTUs? What about for DOAS?
5. Do you report other DOAS performance standards?
6. Are there other design features we should note that significantly increase efficiency (IEER/COP/etc.) for HP RTUs/DOASs?
7. What advanced temperature control features do your products include?
8. Do DOAS units have more efficiency features than HP RTUs?
9. What percent of DOAS units are sold in California including heat recovery?
    a. Estimated increase in cost of a HR unit? Percent increase?
10. What percentage (%) of DOAS units sold are heated by natural gas and with AC?
11. What percentage of DOAS units are sold with are heated with HPs?
12. Do you sell VCHP >5.4 tons?
13. What size DOAS products do you sell?

# Appendix E: Detailed Efficiency Plots of ET23SWE0073 Focused Pilot and AHRI HP RTUs

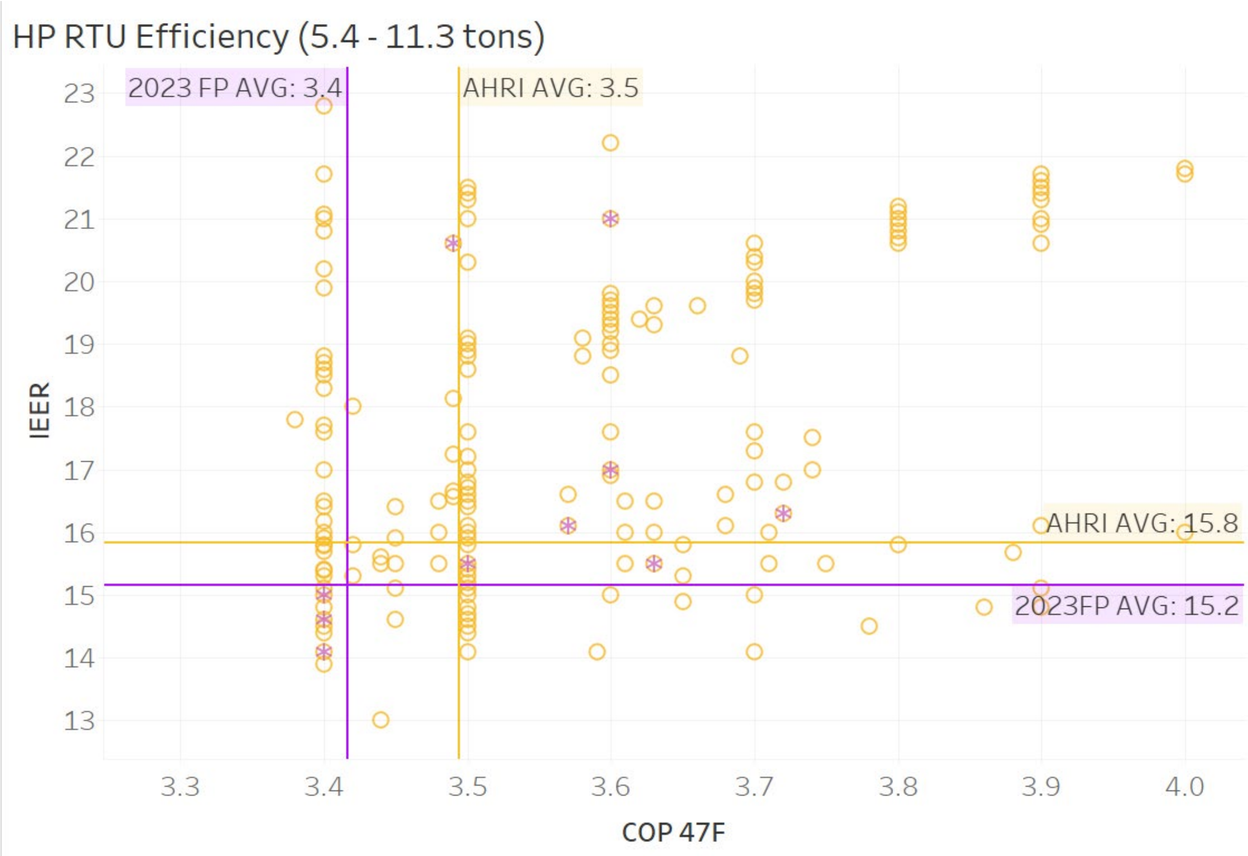



**Figure 14: ET23SWE0073 Focused Pilot HP RTU IEER vs. COP (5.4 to 11.3 tons).**

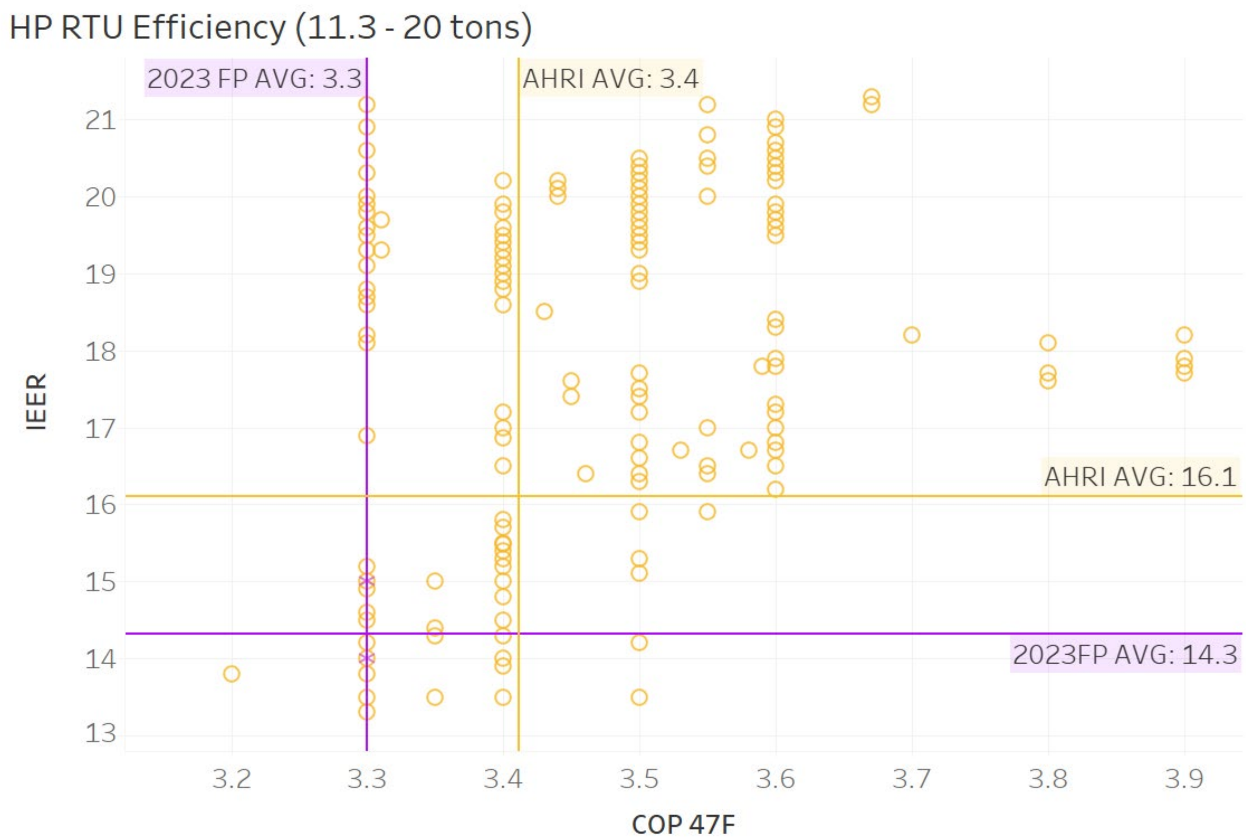



**Figure 15: ET23SWE0073 Focused Pilot HP RTU IEER vs. COP (11.3 to 20 tons).**

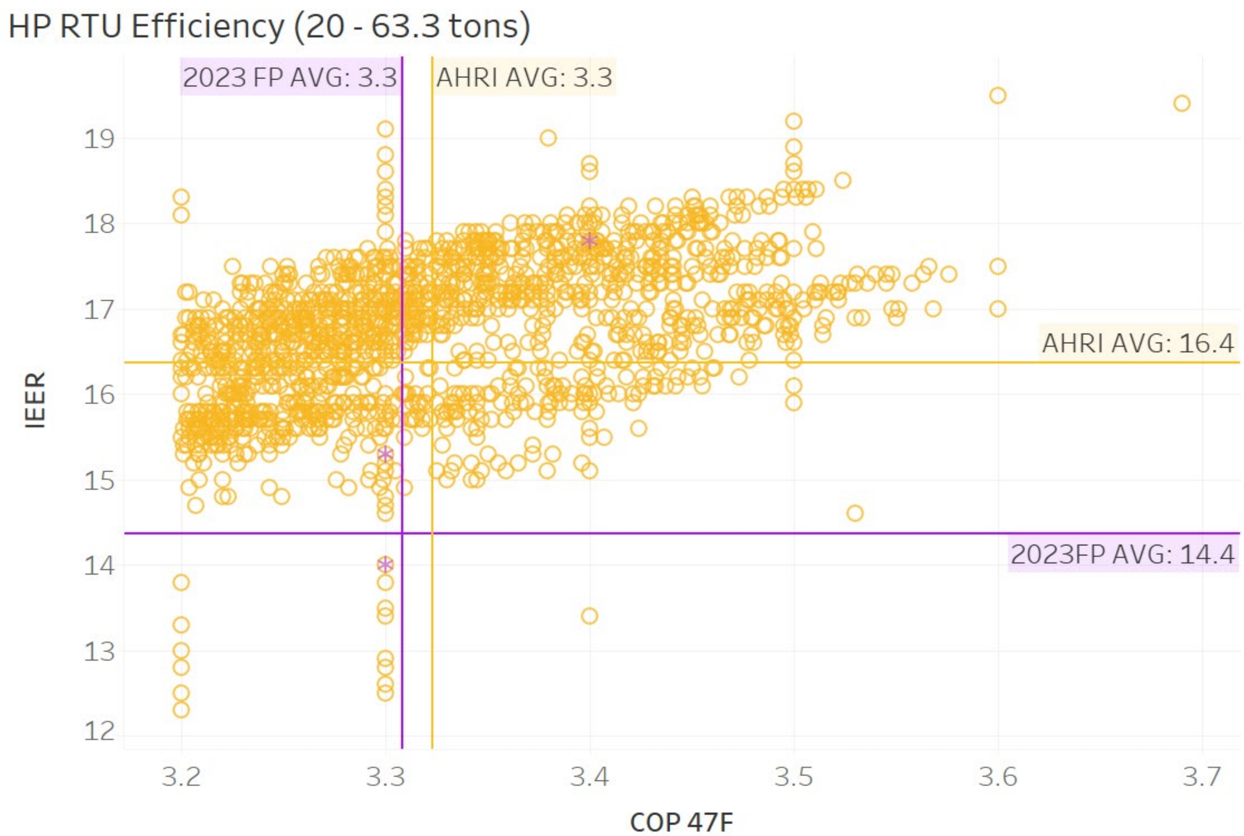
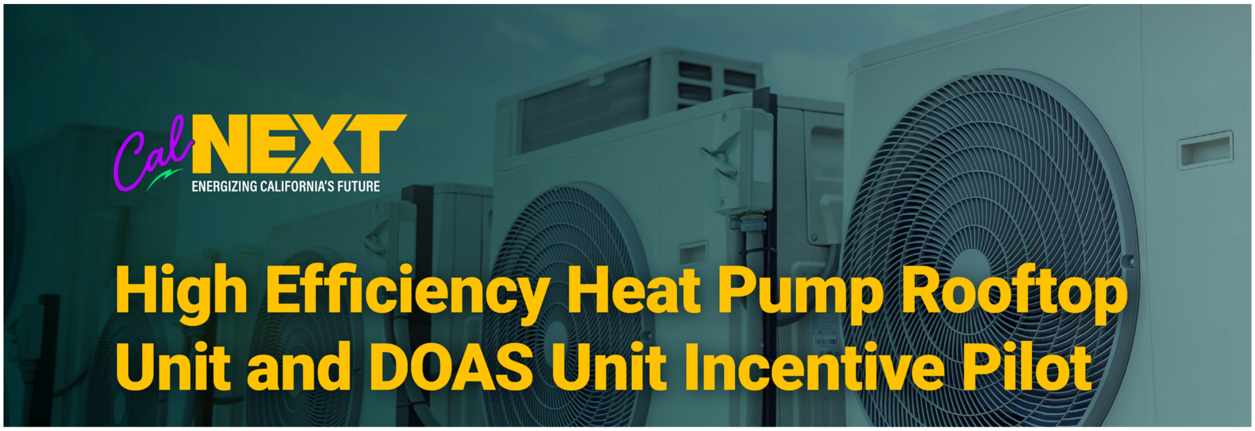



**Figure 16: ET23SWE0073 Focused Pilot HP RTU IEER vs. COP (20 to 63.3 tons).**

## Appendix F: Midstream Incentive Pilot Flyer




Calling distributors: Incentives available for heat pump rooftop units (HP RTU) and dedicated outdoor air systems (DOAS)

### How It Works

1. **Enroll as a distributor** in this pilot program by contacting Grace Bennett at gbennett@energy-solution.com.
2. **Verify equipment eligibility.** Equipment must meet all requirements as indicated in the eligibility tables on the next page.
3. **Contact Energy Solutions to verify customer eligibility.** Incentivized equipment shall be installed in a non-residential location that receives electricity service from PG&E, SCE, or SDG&E.
4. **Complete the sale and installation.** Sales invoiced from June 1, 2025 through October 31, 2025 will be considered for incentives. For further clarification on the program term, please reach out to Energy Solutions.
5. **Submit the application for incentive.** We will provide instructions on how to submit incentive applications through the easy-to-use online portal. Your application will be reviewed, and you will usually receive an incentive reimbursement within two weeks of application submission.

### Participation Benefits

Offer incentives that motivate the purchase of efficient, high-margin equipment that helps reduce your customer's energy costs.

Get reimbursed within two weeks of application submission.

Boost your market advantage by offering competitive pricing on high quality equipment.

Lead the competition to increase market share of HP RTU and DOAS equipment throughout the state.

*This pilot is part of the CalNEXT emerging technologies program. For more information on CalNEXT visit calnext.com.*

ET24SWE0066: High Efficiency Rooftop Unit (HE RTU) Focused Pilot v250702

## Equipment Eligibility - HP RTU

Equipment eligibility requirements are listed below. Equipment capacity is AHRI rated capacity or design capacity at AHRI rating conditions for units without an AHRI rating. Equipment must be listed or tested to AHRI 340/360-2022.

| System Type | Cooling Capacity Range (BTUH) | EER | IEER | COP 47 | Feature Requirements | Incentive Tier | Incentive |
|---|---|---|---|---|---|---|---|
| HP RTU | 65,000 to <135,000 | 11 | 16.5 | 3.4 | N/A | Tier 1 | $375 per ton |
| | 135,000 to <240,000 | 10.6 | 16.4 | 3.2 | | | |
| | ≥240,000 | 9.5 | 16.4 | 3.2 | | | |
| | 65,000 to <135,000 | 11 | 16.5 | 3.4 | Energy Recovery (HRV or ERV) or Variable Speed Compressor | Tier 2 | $500 per ton |
| | 135,000 to <240,000 | 10.6 | 16.4 | 3.2 | | | |
| | ≥240,000 | 9.5 | 16.4 | 3.2 | | | |

EER is CA code minimum (T-24-2022)

## Equipment Eligibility - AC DOAS & HP DOAS

AC DOAS and HP DOAS eligibility requirements are listed below. Equipment must be tested to AHRI 920-2020.

| System Type | Energy Recovery | ISMRE2 | ISCOP2 | Feature Requirements | Incentive Tier | Incentive |
|---|---|---|---|---|---|---|
| AC DOAS | Without energy recovery | 3.8 | N/A | N/A | Tier 1 | $500 per ton |
| | Without energy recovery | 3.8 | N/A | Variable Speed Compressor | Tier 2 | $600 per ton |
| | With energy recovery | 5 | N/A | N/A | | |
| HP DOAS | Without energy recovery | 3.8 | 2.05 | N/A | Tier 1 | $500 per ton |
| | Without energy recovery | 3.8 | 2.05 | Variable Speed Compressor | Tier 2 | $600 per ton |
| | With energy recovery | 5 | 3.2 | N/A | | |

AC DOAS equipment which meets the efficiency and feature requirements and has gas equipment is included in the scope of this program.

If you have questions or would like to enroll in the pilot, contact us at (510) 482-4420 x1049 or email Grace Bennett at gbennett@energy-solution.com.

# High Efficiency HP RTU and DOAS Unit Incentive Pilot

## Incentives

Tier 1 equipment (HP RTUs and DOAS units) are limited to a maximum of $15,000 per project site and $20,000 across all applications. Total incentive budget is $50,000 per participant.

## Enrollment

Invited distributors who sell qualifying equipment to commercial facilities in the California investor-owned utilities (PG&E, SCE, or SDG&E) electric service territory are eligible to participate.

## Pilot Duration

This is a short-term pilot scheduled to operate from June 1, 2025 through October 31, 2025. The purpose of the pilot is to test program features and identify the best way to promote the sale and stocking of this equipment to increase its use in California.

The CalNEXT program is designed and implemented by Energy Solutions and funded by California investor-owned utility (IOU) ratepayers. CalNEXT is available in the service territories of Southern California Edison Company, Pacific Gas and Electric Company, and San Diego Gas and Electric Company, collectively known as the Electric IOUs. Customers who participate in CalNEXT are under individual agreements between the customer and Energy Solutions or Energy Solutions' subcontractors (Terms of Use). The Electric IOUs are not parties to, nor guarantors of, any Terms of Use with Energy Solutions. The Electric IOUs have no contractual obligation, directly or indirectly, to the customer. The Electric IOUs are not liable for any actions or inactions of Energy Solutions, or any distributor, vendor, installer, or manufacturer of product(s) offered through CalNEXT. The Electric IOUs do not recommend, endorse, qualify, guarantee, or make any representations or warranties (express or implied) regarding the findings, services, work, quality, financial stability, or performance of Energy Solutions or any of Energy Solutions' distributors, contractors, subcontractors, installers of products, or any product brand listed on Energy Solutions' website or provided, directly or indirectly, by Energy Solutions. If applicable, prior to entering into any Terms of Use, customers should thoroughly review the terms and conditions of such Terms of Use so they are fully informed of their rights and obligations under the Terms of Use, and should perform their own research and due diligence, and obtain multiple bids or quotes when seeking a contractor to perform work of any type.

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# Appendix G: HP RTU Product Characterization Catalog

**Table 34: HP RTU features across manufacturers.**

| Features | Manufacturers | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Economizer | X | X | X | X | X | X |
| DCV | X | X | | | | |
| ECM | X | | X | | | X |
| VFD | | X | X | | X | X |
| MSC | | X | | | | |
| IDC | | | | X | | X |
| Defrost | X | X | X | X | X | X |

## Manufacturer 1

**Table 35: Manufacturer 1 HP RTU unit features.**

| Economizer | DCV | ECM | VFD | MSC | IDC | Defrost |
|---|---|---|---|---|---|---|
| X | X | X | | | | X |

- Minimum Cooling Capacity – 3 ton (36 kBtu)
- Maximum Cooling Capacity – 25 tons (300 kBtu)
- IEER – 15.0 to 21.2
- EER – 10.5 to 16.0
- Refrigerant – R-454B
- Cooling/Heating
    - Cooling: Standard air source HP
    - Available auxiliary heat: Natural gas, electric, hot water
- Additional notes: Seven available RTU models with a heat pump

## Manufacturer 2

**Table 36: Manufacturer 2 HP RTU unit features.**

| Economizer | DCV | ECM | VFD | MSC | IDC | Defrost |
|---|---|---|---|---|---|---|
| X | X | | X | X | | X |

- Minimum Cooling Capacity – 3 ton (36 kBtu)
- Maximum Cooling Capacity – 25 tons (300 kBtu)
- IEER – 12.5 to 16.8
- EER – 9.5 to 13.6
- Refrigerant – R-454B
- Cooling/Heating
    - Cooling: Standard air source HP
    - Available auxiliary heat: Natural gas, electric
- Additional notes: Only one model with a heat pump

## Manufacturer 3

**Table 37: Manufacturer 3 HP RTU unit features.**

| Economizer | DCV | ECM | VFD | MSC | IDC | Defrost |
|---|---|---|---|---|---|---|
| X | | X | X | | | X |

- Minimum Cooling Capacity – 6 ton (72 kBtu)
- Maximum Cooling Capacity – 30 tons (360 kBtu)
- IEER – 12.5 to 13.9
- EER – 19.9 to 22.5
- Refrigerant – R-454B
- Cooling/Heating
    - Cooling: air-source, water-source, and geothermal heat pump
    - Available auxiliary heat: Natural gas, electric
- Additional notes: N/A

## Manufacturer 4

**Table 38: Manufacturer 4 HP RTU unit features.**

| Economizer | DCV | ECM | VFD | MSC | IDC | Defrost |
|---|---|---|---|---|---|---|
| X | | | | | X | X |

- Minimum Cooling Capacity – 3 ton (36 kBtu)
- Maximum Cooling Capacity – 30 tons (360 kBtu)
- IEER – 14.6 to 17.3
- EER – 10.3 to 13.5
- Refrigerant – R-454B
- Cooling/Heating
    - Cooling: standard air-source heat pump
    - Available auxiliary heat: Natural gas, electric
- Additional notes: Four available RTU models with a heat pump

## Manufacturer 5

**Table 39: Manufacturer 5 HP RTU unit features.**

| Economizer | DCV | ECM | VFD | MSC | IDC | Defrost |
|---|---|---|---|---|---|---|
| X | | | X | | | X |

- Minimum Cooling Capacity – 6.5 ton (78 kBtu)
- Maximum Cooling Capacity – 25 tons (300 kBtu)
- IEER – 13.4 to 16.3
- EER – 10.4 to 12.4
- Refrigerant – R-410A
- Cooling/Heating
    - Cooling: standard air-source heat pump
    - Available auxiliary heat: electric
- Additional notes: N/A

## Manufacturer 6

**Table 40: Manufacturer 6 HP RTU unit features.**

| Economizer | DCV | ECM | VFD | MSC | IDC | Defrost |
|---|---|---|---|---|---|---|
| X | | X | X | | X | X |

- Minimum Cooling Capacity – 3 ton (36 kBtu)
- Maximum Cooling Capacity – 31 tons (372 kBtu)
- IEER – 17.5 to 22.7
- EER – 10.5 to 13.0
- Refrigerant – R-32
- Cooling/Heating
  - Cooling: standard air-source heat pump
  - Available auxiliary heat: natural gas, electric
- Additional notes: N/A

# Appendix H: DOAS Product Characterization Catalog

Table 41 shows select manufacturers providing the above features based on their product marketing and literature. All manufacturer section titles have a link to their website where the information was gathered.

A few items of note of the available features:

- ISCOP and ISMRE was not provided on manufacturer data sheets because it varies depending on the configuration of the unit.
- Manufacturers advertise ERVs but not HRVs, potentially using the terms interchangeably.
- No manufacturers directly advertise DCV but do advertise the use of VFDs and some provide an option of an ECM. The flow or static pressure setpoint could be changed based on occupancy to meet the same goals of DCV.
- All manufacturers have options for DX air conditioning and natural gas or electric heating, or HP heating and cooling.
- All manufacturers have an option for HGR.
- In general, if a manufacturer did not offer a DOAS unit-specific standard product they were not reviewed.

**Table 41: DOAS unit features across manufacturers.**

| Features | Manufacturers | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| HRV | | X | | | | | |
| ERV | X | X | X | X | X | X | |
| Economizer | X | X | X | X | X | X | X |
| DCV | | | | | | | |
| ECM | X | | X | | | X | |
| VFD | X | X | X | X | X | X | X |
| MSC | | | | | X | | |
| IDC | | | | X | | | X |
| HGR | X | X | X | X | X | X | X |
| Defrost | X | X | X | X | X | X | |

## Manufacturer 1

**Table 42: Manufacturer 1 DOAS unit features.**

| HRV | ERV | Economizer | DCV | ECM | VFD | MSC | IDC | HGR | Defrost |
|---|---|---|---|---|---|---|---|---|---|
| | X | X | | X | X | | | X | X |

- Minimum Cooling Capacity – 1 ton (12 kBtu)
- Maximum Cooling Capacity – 140 tons (1680 kBtu)
- ISCOP – Unknown
- ISMRE – Unknown
- Refrigerant – R-454B
- Cooling/Heating (not including ERV)
  - Air source HP is standard with some units have water source as an option.
  - Available auxiliary heat: Natural gas, propane, electric, hot water.
  - Reheat options: hot gas reheat and liquid subcooling.
- Additional notes: some of the units are advertised as RTU that can perform as DOAS.

## Manufacturer 2

**Table 43: Manufacturer 2 DOAS unit features.**

| HRV | ERV | Economizer | DCV | ECM | VFD | MSC | IDC | HGR | Defrost |
|---|---|---|---|---|---|---|---|---|---|
| X | X | X | | | X | | | X | X |

- Minimum Cooling Capacity – 3 tons (36 kBtu)
- Maximum Cooling Capacity – 80tons (960 kBtu)
- ISCOP - Unknown
- ISMRE – Unknown
- Refrigerant – R-454B
- Cooling/Heating (not including ERV)
  - Air or water source HPs are available as the standard.
  - Heating: electric, natural gas, propane, hot water.
  - Reheat options: Hot gas reheat.
- Additional notes: none.

## Manufacturer 3

**Table 44: Manufacturer 3 DOAS unit features.**

| HRV | ERV | | Economizer | DCV | ECM | VFD | MSC | IDC | HGR | Defrost |
|---|---|---|---|---|---|---|---|---|---|---|
| | X | | X | | X | X | | | X | X |

- Minimum Cooling Capacity – 2 tons (24 kBtu)
- Maximum Cooling Capacity – 5 tons (60 kBtu)
- ISCOP - Unknown
- ISMRE – Unknown
- Refrigerant – R-454B
- Cooling/Heating (not including ERV)
    - Heat pumps: air or water source (including geothermal), heat pump available as standard.
    - Cooling: chilled water-cooling coil also available as a standard feature.
    - Heating: electric, steam, natural gas, and hot water available as a standard feature.
    - Reheat options: Hot gas reheat.
- Additional notes: The Manufacturer 3 unit is advertised as an RTU but claims it can also operate as a small tonnage DOAS unit.

## Manufacturer 4

**Table 45: Manufacturer 4 DOAS unit features.**

| HRV | ERV | Economizer | DCV | ECM | VFD | MSC | IDC | HGR | Defrost |
|---|---|---|---|---|---|---|---|---|---|
| | X | X | | | X | | X | X | X |

- Minimum Cooling Capacity – 5 tons (60 kBtu)
- Maximum Cooling Capacity – 12 tons (360 kBtu)
- ISCOP - Unknown
- ISMRE – Unknown
- Refrigerant – R-454B
- Cooling/Heating (not including ERV)
    - Heat pumps: Air-source heat pump available as a standard feature.
    - Cooling: chilled water-cooling coil also available as a standard feature.
    - Heating: electric, natural gas, and hot water available as a standard feature.
    - Reheat options: Hot gas reheat.
    - Non-ERV: Total enthalpy core available (non-moving heat exchanger)

## Manufacturer 5

**Table 46: Manufacturer 5 DOAS unit features.**

| HRV | ERV | Economizer | DCV | ECM | VFD | MSC | IDC | HGR | Defrost |
|---|---|---|---|---|---|---|---|---|---|
| | X | X | | | X | X | | X | X |

- Minimum Cooling Capacity – 1 ton (12 kBtu)
- Maximum Cooling Capacity – 70 tons (840 kBtu)
- ISCOP - Unknown
- ISMRE – Unknown
- Refrigerant – R-410A
- Cooling/Heating (not including ERV)
  - Heat pumps: Air and water source heat pump available as a standard feature.
  - Heating: electric, natural gas, and hot water available as a standard feature.
  - Reheat options: Hot gas reheat.
- Additional notes: Manufacturer 5 and Manufacturer 6 are owned by the same parent company.

## Manufacturer 6

**Table 47: Manufacturer 6 DOAS unit features.**

| HRV | ERV | Economizer | DCV | ECM | VFD | MSC | IDC | HGR | Defrost |
|---|---|---|---|---|---|---|---|---|---|
| | X | X | | X | X | | | X | X |

- Minimum Cooling Capacity – 3 tons (36 kBtu)
- Maximum Cooling Capacity – 70 tons (840 kBtu)
- ISCOP - Unknown
- ISMRE – Unknown
- Refrigerant – R-410A
- Cooling/Heating (not including ERV)
  - Heat pumps: Air and water source heat pump available as a standard feature.
  - Heating: electric and natural gas available as a standard feature.
  - Reheat options: Hot gas reheat.
- Additional notes: Manufacturer 5 and Manufacturer 6 are owned by the same parent company.

## Manufacturer 7

**Table 48: Manufacturer 7 DOAS unit features.**

| HRV | ERV | Economizer | DCV | ECM | VFD | MSC | IDC | HGR | Defrost |
|---|---|---|---|---|---|---|---|---|---|
| | | X | | | X | | X | X | |

- Minimum Cooling Capacity – 5 tons (60 kBtu)
- Maximum Cooling Capacity – 12 tons (360 kBtu)
- ISCOP - Unknown
- ISMRE – Unknown
- Refrigerant – R-410A
- Cooling/Heating (not including ERV)
  - Heat pumps: Air source heat pump available as a standard feature.
  - Heating: electric, natural gas, and propane available as an optional feature.
  - Reheat options: Hot gas reheat.
- Additional notes: Only units that do not have heat recovery as an option. They also do not advertise a defrost strategy, but because it is an equipment-safety feature it seems like unlikely to not have standard to their units.

# Appendix I: Final Market Actor Survey

1) Are you stocking **qualified HP RTUs** in these categories? How many units?
    a) 5-11 tons
    b) 11-20 tons
    c) >20 tons
2) Are you stocking **qualified AC/Furnace DOASs** in these categories? How many units?
    a) 5-11 tons
    b) 11-20 tons
    c) 20-63.3 tons
    d) >63.3 tons
3) Are you stocking **qualified HP DOASs** in these categories? How many units?
    a) 5-11 tons
    b) 11-20 tons
    c) 20-63.3 tons
    d) >63.3 tons
4) What is the **root cause for lower participation with both equipment types**?
    a) Is the demand for higher efficiency units lower?
    b) What are some direct reasons why?
5) Are there **specific building types** that are common for HP RTUs or HP DOASs? What are they?
    a) HP RTUs?
    b) HP DOAS?
6) Would your customers purchase **eligible equipment** in a **long-term midstream** (distributor) incentive program?
    a) How would stocking change if the pilot were available longer term?
    b) Are incentive levels high enough to engage you long term?
7) Is **strip heat** necessary to meet design heating loads for HP RTU installations?
8) What is the **percentage of sales** of
    a) RTUs that are HP units?
    b) DOASs that are HP units?

9) When do you expect more manufacturers to begin manufacturing HP RTUs with **variable speed compressors**? *Currently we believe only 2 manufacturers are producing these units.*

10) What is the cost difference (IMC) incurred per ton for the equipment types listed? Please provide the cost difference compared to a minimum efficiency unit (lowest eff./cheapest available).

| | HP RTUs | | |
|---|---|---|---|
| Qualification Tier<br><br>*See Attached Measure table* | Tier 1<br><br>(Meets IEER/COP/EER only) | Tier 2<br><br>(ERV/HRV) | Tier 2<br><br>(VS compressor) |
| 5.4 to 11.3 tons | | | |
| 11.3 tons to 20 tons | | | |
| > 20 tons | | | |

| | HP DOASs | | |
|---|---|---|---|
| Qualification Tier<br><br>*See Attached Measure table* | Tier 1<br><br>(Meets ISMRE2/ISCOP2 only) | Tier 2<br><br>(ERV/HRV) | Tier 2<br><br>(VS compressor) |
| 5.4 to 11.3 tons | | | |
| 11.3 tons to 20 tons | | | |
| > 20 tons | | | |

# Appendix J: Product Characteristics of High Efficiency Commercial Heat Pumps


## Existing HVAC Systems: A Key Pathway to 2030 Heat Pump Targets

Space heating and cooling account for 41 percent of total commercial energy consumption[1] nationwide. In California, 64.5 percent of heated commercial buildings utilize packaged unitary HVAC systems[2]. While heat pump systems are now required for new construction of commercial buildings, the existing building stock of packaged air conditioning systems presents a high potential for market transformation and meeting California's goal to install 6 million heat pumps by 2030.

## Defining High-Efficiency Heat Pump Features with CalNEXT

To maximize the benefits of commercial heat pump installations, CalNEXT piloted a program **to identify the most efficient packaged unitary heat pump systems available in the market**. The pilot's objective was centered around defining advanced efficiency product features and specifications associated with this equipment to improve cost effectiveness and assess market readiness for high efficiency commercial heat pumps.

## Barriers

The pilot identified several barriers to high efficiency commercial heat pump adoption:

1. Increased costs associated with high efficiency packaged heat pumps over minimally compliant units.
2. Low market availability and stocking of high efficiency packaged heat pumps.
3. Lack of characterization of high efficiency product feature benefits.
4. Lack of consistent language surrounding various high efficiency packaged heat pump product features across manufacturers.

[1] U.S. Energy Information Administration. Commercial Buildings Energy Consumption Survey (CBECS). 2018 CBECS Survey Data. Table E1. Major fuels consumption by end use. Access here: https://www.eia.gov/consumption/commercial/data/2018/

[2] California Energy Commission. 2018-2022 California Commercial End-Use Survey (CEUS) Data. Heating Data table. Access here: https://www.energy.ca.gov/data-reports/surveys/california-commercial-end-use-survey/2018-2022-california-commercial-end-use

ET24SWE0066: High Efficiency Rooftop Unit (HE RTU) Focused Pilot v251113

## Key Efficiency Drivers

The metrics which define packaged unitary heat pump efficiency are EER for full load cooling performance, IEER for part load cooling performance, and $COP_H$ (47°F)/$COP_H$ (17°F) for heating performance. IEER and COP ratings are primarily driven by compressor type.

Standard packaged heat pump units often use single-speed compressors, which are either fully on or fully off. Higher efficiency models incorporate two-stage, multiple stage (3+), or inverter-driven compressors, which can adjust to the power they consume based on the cooling or heating load.

## How Do Compressor Types Compare?

| Compressor Type | Definition | Efficiency Rating (IEER/COP) |
|---|---|---|
| Single Stage | A compressor with a single, fixed capacity set point. | Standard |
| Two-capacity (Two-stage) | A compressor or group of compressors operating with only two stages of capacity. One full capacity setting and one lower capacity setting. | Good |
| Multiple Capacity (Multiple Stage) | A compressor having three or more stages of capacity that has neither an inverter, nor variable frequency drive, or a group of compressors with three or more stages of capacity. | Better |
| Variable Speed (Inverter Driven) | A compressor that has the capability of varying its rotational speed in non-discrete stages or steps from low to full using an inverter or variable frequency drive. | Best |

Although current efficiency metrics for light commercial heat pump systems are driven by compressor type, **the DOE plans to replace IEER and COP efficiency ratings with more comprehensive ratings**[3], IVEC and IVHE, which account for ventilation energy expenditure in addition to heating and cooling.

[3] United States Department of Energy. Title 10 Chapter II Subchapter D Part 431 Subpart F. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-F

The amended DOE efficiency ratings account for energy savings benefits attributed to many high efficiency product features below. Some features, like Energy Recovery Ventilators, may only be favorable in certain conditions. **It is important to discuss the specific HVAC application with your distributor or engineer to ensure reduced energy consumption for a particular project.**

## Efficient Product Features to Discuss with Your Distributor

| Product Features | Brief Description |
|---|---|
| Demand Controlled Ventilation (DCV) | DCV reduces outdoor air in partially occupied hours by leveraging occupancy sensors to reduce outside air intake and save energy during lower occupancy periods. |
| Electronically Commutated Motor (ECM) | An ECM varies the ventilation fan's motor speed based on internal set points and signals from the unit it is serving, to lower fan speed when less ventilation is needed. ECMs are an internal component of the HVAC system. |
| Variable Frequency Drive (VFD) | A VFD varies the motor speed based on internal set points and signals from the unit it is serving, to lower fan speed when less ventilation is needed. VFDs are an external component of the HVAC system. |
| Economizer | Economizers increase uptake of outdoor air when outdoor conditions are favorable, lowering cooling energy consumption. |
| Lack of Electric Resistance Heat | Most of California's climate zones (CZ1 – CZ13, CZ15) experience mild winter conditions which may fully rely on high efficiency heat pump operation without backup resistance elements, avoiding unnecessary peak demand impacts and costly electrical upgrades. |
| Energy Recovery Ventilator (ERV)/ Heat Recovery Ventilator (HRV) | Both ERVs and HRVs use the exhaust air to either heat or cool outdoor air, depending on indoor and outdoor air conditions. ERVs can exchange both sensible and latent heat, and HRVs only exchange sensible heat. |

***Help your customers upgrade to a higher efficiency heat pump.***

### About CalNEXT

CalNEXT's vision is to find emerging technology trends and bring commercially available technologies to the energy efficiency program portfolio. The CalNEXT team brings decades of market development and technical ability to provide support and resources for evaluating innovative technologies. We are dedicated to removing barriers to commercial heat pump water heater energy efficient technology adoption so all Californians can benefit from a cleaner and healthier environment. Through our initiative, we are seeking sites in environmentally impacted communities to show this technology and engage community members to gain insight into how to support equity and inclusion in delivering technologies to the market.

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