Supply-Chain Engagement for Increasing Packaged Unitary Heat Pump System Adoption

Final Report

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Additionally, we acknowledge the support of Comfortably California, CLEAResult, and CalMTA for their resources and insights that supported our research. Their assistance and commitment to advancing energy-efficient HVAC solutions were instrumental to the success of this project.

This report reflects a collective effort, and we thank everyone involved for their dedication and partnership in promoting sustainable heating and cooling solutions in the state of California.

Executive Summary

The Supply-Chain Engagement for Increasing Packaged Unitary Heat Pump System Adoption Focused Pilot aimed to understand the barriers limiting greater adoption of commercial heat pump rooftop units (HP RTUs) in California and overcome them through a midstream incentive approach. According to the U.S. Energy Information Administration (EIA) commercial building survey results, approximately 64 percent of all commercial buildings in the Pacific region[1] of the United States used packaged air conditioners (AC RTUs) to provide space conditioning (EIA 2022) (EIA 2018) . Compared with conventional packaged RTUs with natural gas heating, HP RTUs are estimated to reduce greenhouse gas (GHG) emissions and energy costs by up to 50 percent (U.S. Department of Energy 2025).[2] However, despite the prevalence of replacement-ready AC RTUs, HP RTUs have not reached widespread adoption in the commercial sector.

This project provides a market characterization of the commercial heat pump market to identify challenges and opportunities to transform the commercial RTU market in favor of HP RTUs. To complete this market characterization, the project team engaged with market actors across the supply chain to gain insights into barriers to sales, design, and installation of HP RTUs, and to explore potential interventions to mitigate these obstacles. The team also researched HP RTU technologies available in the market, their technical specifications, California code requirements, California Technical Resource Manual (TRM) requirements (electronic TRM for deemed measures), and the Comfortably California incentive structure to better understand the current program challenges and develop technical program requirements that will help with program adoption. This market research helped guide the development of the focused midstream pilot offered in support of this project.

The focused midstream pilot component of the project was designed to address program participation barriers including difficulties collecting customer contact information at the midstream level and low incremental measure cost (IMC) coverage for HP RTUs. A midstream HVAC program pays incentives to and collects data from distributors of HVAC equipment. The project team ran a focused midstream pilot offering enhanced incentives and creating a more streamlined program experience to boost HP RTU participation.

[1] The Pacific Region is defined as Washington, Oregon, California, Alaska, and Hawaii, as designated by the U.S. Census Bureau: https://www.eia.gov/consumption/commercial/maps.php#census

[2] Commercial Building Heat Pump Accelerator Fact Sheet: https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/AcceleratorFactSheet.pdf

This report details the activities completed by the project team to achieve its objectives. Due to California Public Utilities Commission (CPUC) regulations, recruitment of participants for the focused midstream pilot and the payment of incentives was prohibited up until the approval of an advice letter on May 3, 2024. The project team has completed the following activities listed below:

- Completed two to four rounds of interviews with five distributor sales teams and one manufacturer.
- Interviewed one program implementer, two contractors, and one end-use customer.
- Researched currently available RTU equipment in the market and their specifications.
- Created a market transformation logic model, defining the relationship between existing HP RTU barriers, activities, outputs, as well as short, intermediate, and long-term outcomes.
- Designed and launched a focused midstream pilot.
- Enrolled six distributors in the focused midstream pilot. Four of the six distributors actively participated in the Focused Pilot.
- Incentivized 468 tons and 44 HP RTUs through the focused midstream pilot. 1,499 tons and 114 RTUs were submitted across all projects.
- Determined IMC for 5.4 to 11.2-ton size category through market actor engagement.

These completed activities directly support the project's objectives to identify market barriers preventing HP RTU adoption in California, test a midstream incentive model to encourage adoption, and provide data-driven recommendations for a full-scale program. The insights gathered also inform necessary updates to California's HP RTU measure package, ensuring alignment with evolving market needs. This work lays a solid foundation for future initiatives aimed at accelerating heat pump technology adoption and improving energy efficiency statewide.

Conclusion and Recommendations

Based on our research findings and in alignment with EIA commercial surveys, AC RTUs with gas packs are the overwhelmingly dominant HVAC equipment specified and installed in commercial applications. We recommend that HVAC programs focus on single zone system replacement with HP RTUs for units in the 6 to 25 tons cooling capacity range. Standalone installations such as in retail and restaurant buildings fall into this application category. Applications received by the focused midstream pilot included the following building types: manufacturing light industrial, large offices, primary schools, and hotels. Among the submissions, manufacturing light industrial buildings were the most prevalent across all size categories, making up forty-five percent of the application submissions. A more comprehensive analysis of building types is provided in the **Building Type Trends** section on page 33.

Currently, installation and operational cost benefits of electrification going from AC RTUs to HP RTUs are not accurately documented. End-use operating costs are misunderstood by market actors and are inhibiting sales of HP RTUs. Given California's high electricity rates, we recommend further research on the financial impacts of the installation of commercial HP RTUs. Specifically, we need to accurately calculate operating costs for an AC/furnace RTU and compare with an HP RTU. To perform a comprehensive cost analysis, a natural gas BTU of output heat should be compared with an electric BTU of output heat. Comparisons of unit efficiencies between the AFUE of a natural gas furnace compared with the COP with a heat pump also need to be made. The final cost analysis should be presented in a marketing piece and custom made for each market actor: distributor, contractor, and customer.

The statewide Comfortably California program incentives cover only about 15 percent of the retail price of HP RTUs. Increased program incentives may help increase HP RTU adoption and scale the program. To be cost competitive with other technologies, we recommend increasing the HP RTU incentive amounts to 75 to 85 percent of the HP RTU incremental measure cost (IMC). This study found that the typical IMC is $465/ton, making the recommended incentive level $350/ton to $400/ton.

To remedy other market barriers, supply-chain awareness can be improved by providing distributors with training and literature highlighting the benefits of HP RTU technology, as well as marketing materials (specifically operating cost calculations described above) to be distributed to local contractors. Additionally, all market actors need to be educated in the advanced performance of HP RTU in cooler weather to eliminate the old perceptions that HP RTU have higher operating costs due to the operation of auxiliary electric resistance heat. Once distributors have gained more familiarity, this increased awareness could lead to stocking larger-sized systems at higher rates.

Abbreviations and Acronyms

Acronym	Meaning
AC	air conditioner
AC RTU	air conditioning rooftop unit
CalMTA	California Market Transformation Administrator
CPUC	California Public Utilities Commission
CEC	California Energy Commission
EIA	U.S. Energy Information Administration
ERTU	efficient rooftop unit
HP RTU	heat pump rooftop unit
HVAC	heating, ventilation, and air conditioning
IOU	investor-owned utility
MTIs	market transformation initiatives
PA	program administrator
PG&E	Pacific Gas and Electric
PY	program year
RTU	rooftop unit
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric

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Introduction

This report presents findings from a focused midstream pilot aimed at increasing the adoption of commercial packaged heat pump rooftop unit (HP RTU) systems (greater than or equal to 5.4 tons) in California.[3] Despite the state's mild climate, which is ideal for heat pump use in most climate zones, HP RTU adoption remains significantly lower than expected. In some cases, these systems can be drop-in replacements for the thousands of existing rooftop air conditioners installed across the commercial sector, offering a substantial opportunity to improve energy efficiency and reduce greenhouse gas (GHG) emissions.

The focused midstream pilot was designed to address critical obstacles identified by Comfortably California, the statewide HVAC program implementer. To overcome the identified statewide program participation barriers, the pilot offered higher incentives at $300/ton and a streamlined application process that did not require customer contact information. This work, in turn, strives to support the improvement of the statewide program at large.

Increased program participation from higher incentives was leveraged to identify intervention strategies, i.e., solutions to market barriers, to improve accessibility and appeal of HP RTUs to distributors, contractors, and end users alike. The project team conducted interviews at as many levels of the supply chain as possible, including with manufacturers, distributors, and design engineers, to understand the barriers limiting commercial HP RTU adoption in California and engage market actors to recommend intervention strategies, i.e., market-driven solutions. The findings from this study will inform future program design and other initiatives aimed at increasing heat pump adoption throughout California. Additionally, the findings from market interviews were used to construct the HP RTU market transformation logic model in support of California electrification initiatives.

The findings of this focused pilot support the California Market Transformation Administrator (CalMTA), as efficient rooftop units (ERTUs) are one of the top three market transformation initiatives [4](MTIs) advancing in 2025. They will be shared with relevant market stakeholders — including (but not limited to) Comfortably California, CalMTA, and CLEAResult — and published on the CalNEXT website (CalNEXT 2024).[5] We have coordinated with these stakeholders throughout the focused pilot [6] and will continue to do so throughout the project timeline.

[3] Specifically, equipment listed or tested to AHRI 340/360.

[4] For more information on Efficient Rooftop Units (ERTUs) and the market transformation initiatives in play, see: https://calmta.org/resources-and-reports/efficient-commercial-rooftop-hvac-ertus-advancement-plan/ and https://calmta.org/efficient-rooftop-units/

[5] https://calnext.com/approved-projects/

[6] We have now held four successful coordination calls, on July 25, September 5, and October 3 of 2024, and March 6 of 2025, where we reviewed and aligned each investor-owned utility (IOU) and California Public Utilities Commission (CPUC)-funded program's goals, tactics, and timelines.

Report Structure

This report is organized into seven comprehensive sections, each addressing essential components of the project aimed at enhancing the adoption of HP RTU technology in California.

1. Background: The report begins with a Background section that sets the context for the project. It outlines the project scope, detailing the known barriers to HP RTU adoption and evaluating the effectiveness of midstream incentives. Additionally, it presents a market overview that analyzes the current heating, ventilation, and air-conditioning (HVAC) landscape in California, including trends, challenges, and the competitive environment surrounding HP RTUs.
2. Objectives: This section outlines the main goals of the project, focusing on implementing a focused midstream pilot to boost the adoption of commercial HP RTUs. The program aims to engage various supply-chain stakeholders to identify barriers to heat pump adoption and evaluate whether addressing these programmatic barriers enhances participation in incentive programs. It also seeks to gather insights on obstacles, design requirements, current practices, educational needs, and the existing market landscape for HP RTU products. The section also includes progress to date for each objective.
3. Methodology and Approach: This section describes the strategies employed to gather data and insights throughout the project. It outlines the outreach efforts directed at market actors, including distributors and contractors, through interviews and data collection. This section also details the launch of incentive programs designed to facilitate HP RTU adoption and summarizes the technology market transformation logic model and roadmap, which guides the project's framework. Furthermore, it discusses the ongoing engagement with market actors to gather feedback and refine project strategies.
4. Findings: The Findings section synthesizes insights gathered from different areas of the project. First, the market transformation logic model, intended to improve uptake of HP RTUs, is presented. Secondly, this section provides an overview of the primary conclusions drawn from stakeholder interactions and market analyses. It identifies current market barriers that hinder HP RTU adoption and opportunities within the HVAC market to facilitate greater heat pump expansion. We also present focused midstream pilot results with project characteristics and volumes. This section also addresses market opportunities.
5. Conclusions: The Conclusions section summarizes the barriers to HP RTU uptake in California and the significance of each.
6. Recommendations: The Recommendations section outlines strategic actions aimed at addressing the barriers to HP RTU adoption. These recommendations are designed to enhance the uptake of heat pump technology in the market, supporting California's energy-efficiency goals.
7. Appendices: The four appendices display the supporting documents developed as part of this project, including references, the focused midstream pilot participation flyer, and supporting research performed by TRC.

Focused Pilot Objectives

The objectives of this study are to:

1. Identify market barriers preventing HP RTU adoption in California.
2. Test a midstream incentive model to encourage adoption.
3. Provide recommendations for a full-scale program.
4. Inform necessary updates to California's HP RTU measure package.

The focused midstream pilot aimed to increase adoption of commercial HP RTUs by engaging market actors and conducting supply-chain interviews with the goal of identifying barriers and potential solutions to result in increased HP RTU adoption. This program assesses whether addressing programmatic barriers can boost HP RTU adoption and inform future program designs.

This study completed a series of interviews with stakeholders across the supply chain — (manufacturers, design engineers, distributors, contractors, and end users) — to provide insights into barriers to HVAC HP RTU adoption including the following:

- Real and perceived adoption barriers.
- Commercial building design requirements.
- Design practices affecting heat pump adoption.
- Educational needs for increased adoption.

Additionally, this report documents our research into existing HP RTU products, the current market landscape, and identifies opportunities for future updates.

Background

Project Scope

This project focuses on air-source heat pump (ASHP) systems rated to the AHRI 340/360 standard (greater than or equal to 5.4 tons cooling capacity) (AHRI 2022), [7] as these systems are expected to serve as like-for-like adjacent replacements for the large stock of air conditioner RTUs (AC RTUs) installed throughout California. Both equipment types are rated under this standard.

Heat pump efficiency and performance is optimum in milder climates, such as in many California climate zones. On that account, and because of product similarities[8] between rooftop air conditioners and heat pumps, many existing commercial rooftop air conditioner installations are well suited for replacement with HP RTUs. However, adoption remains lower than necessary to meet California's goal of installing six million heat pumps by 2030. Incentive programs for HP RTUs have been available in California for many years, but HP RTUs still see low adoption compared to AC RTUs. An analysis of California Energy Data and Reporting System (CEDARS) claim data[9] (CPUC 2024) shows that only 5-to-10 percent of all AHRI 340/360-rated systems submitted through Comfortably California in 2022 and 2023 are HP RTUs. The rate of growth of HP RTUs is lower than planned to meet GHG reduction goals and needs additional support to change trajectory of this market.

This report investigates the factors preventing broader HP RTU adoption in California and evaluates the effectiveness of midstream incentives in addressing these barriers. By engaging supply-chain actors in the transaction and delivery channel — including distributors and contractors — through interviews and data collection, it assesses both market challenges and opportunities to support a broader, scalable adoption of HP RTU technology.

The statewide incentive program for HVAC energy-saving technologies, Comfortably California, has experienced several program barriers, including low incremental measure cost (IMC) coverage and complex data collection requirements. The focused midstream pilot described in this report sought to address these identified issues by offering higher incentives to cover more of the IMCs, providing a more streamlined application process and reducing data reporting requirements for participants where possible.

In addition to programmatic barriers, there are potential obstacles to the specification, purchase, and installation of heat pumps that are independent of any current program interventions, which this project aimed to uncover. Examples include product availability, cost, and heating performance. By identifying and analyzing these challenges, the project sought to create a more favorable environment for HP RTU adoption in California.

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[7] AHRI 340/360: 2022 Standard for Performance Rating of Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment. https://www.ahrinet.org/system/files/2023-06/AHRI%20Standard%20340-360-2022%20%28I-P%29.pdf

[8] Both HP RTUs and AC RTUs are rated under AHRI 340/360 test conditions, as dictated by federal code.

[9] California energy efficiency program data may be accessed via the following URL: https://cedars.cpuc.ca.gov/reports/record-level/all/

Technology Landscape

The project team researched existing equipment offerings for HP RTUs. All major HVAC manufacturers make HP RTU products, some of which are eligible for incentives under the existing measure packages in California. The project team includes analysis of size, efficiency, and refrigerants of available HP RTU equipment in the following subsections.

Size of HP RTUs

As part of the current market analysis, the AHRI product database was examined for unitary systems within scope. The analysis included 2,182 active units with unique model numbers, focusing on capacity and efficiency ratings, with capacities ranging from 5.4 tons to 63.3 tons. 501 duplicate units shared identical specifications and performance metrics across different brand names; these duplicates were excluded for accuracy, retaining only one instance of each model number. In Table 1 below, the number of units for each size is presented. It is worth noting that, due to one manufacturer's selection software and naming conventions, the 20- to 63.3-ton size category shows an exceptionally large number of available units. This stems from one product line from one manufacturer and skews the raw data by showing more available units in the size category that is least used by the market.

Table 1: Size Distribution of HP RTUs in the AHRI Specification Directory

Size Category	Number of AHRI Certified Units
5.4–11.3 tons	74
11.3–20 tons	70
20–63.3 tons	1,537
Total	1,681

Efficiency

Below is a catalog of different HP RTU product families available in the market and their range of efficiency and capacity offered. This catalog, developed in 2024, provides a snapshot of the market during the pilot. Note that manufacturers frequently update product lines and introduce new product families over time.

Table 2: Efficiency and Capacity Ranges of HP RTUs

Product	1	2	3	4	5	6
Refrigerant	R-410A	R-410A	R-410A	R-410A	R-410A	R-410A
Available Capacity Range	3–25 ton	6–60 ton	3–28 ton	6.5–12.5 ton	12.5–25 ton	5–25 ton
IEER [10] Part Load Cooling Efficiency (5.4–11.3 ton units)	15	Up to 22.5	19.3–20.6	13.2–13.5	NA	14.3–16.5
IEER Part Load Cooling Efficiency (11.3–20 ton units)	14	Up to 19.9	18–20	NA	16.1–18.4	14.3–15.5
COP[11] Heating Efficiency	3.3–3.6		3.33–3.69	3.2–3.4	3.3	3.4–3.7

HP RTU Refrigerants

The project team also categorized the refrigerant types used, identifying 120 units using R-410A, 30 units using R-454B, and 1,531 units using R-32. As globally adopted refrigerant protocols are implemented, the mix of refrigerants used in HVAC equipment is changing. This shift has limited impacts on equipment efficiency. Additionally, it may affect Total System Benefit (TSB) scores and

[10] Integrated Energy Efficiency Ratio

[11] Coefficient of Performance

electronic TRM (eTRM) measure design recommendations as R-32 and R-454B become more prevalent across equipment size categories.

The American Innovation and Manufacturing (AIM) Act[12] enacts these changes, supporting the phasedown of hydrofluorocarbons (HFCs) in line with global targets (EPA 2024). This code shift is driven by the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer,[13] which is "an international agreement to phase down the production and consumption of HFCs by 80–85% by 2047" (EPA 2024). Currently, R-454B holds a modest two percent market share, with only about 30 units listed in AHRI, as shown in Table 3. According to our market interview results, the shift to lower global warming potential (GWP) refrigerants is anticipated to affect larger HVAC units — especially those over 20 or 25 tons — most significantly, as these systems will require adaptations to meet the new refrigerant standard and improve performance. This regulatory change will drive innovation in design and installation practices to align with the updated requirements.

Table 3: Refrigerant Distribution of HP RTUs

Refrigerant Type	Number of AHRI Units	Percent of AHRI Units	GWP	GWP Source
R-410A	120	7.1	2,088	(National Refrigerants Ltd 2024)
R-454B	30	1.8	466	(National Refrigerants Ltd 2024)
R-32	1,531	91.1	675	(National Refrigerants Ltd 2024)

12 More information on the AIM Act and how it is enforced by the U.S. Environmental Protection Agency (EPA) is available at https://www.epa.gov/enforcement/enforcement-american-innovation-and-manufacturing-act-2020.

13 Background on HFCs and the AIM Act is available at https://www.epa.gov/climate-hfcs-reduction/background-hfcs-and-aim-act#:~:text=The%20Kigali%20Amendment%20to%20the,the%20end%20of%20the%20century.

Current HP RTU Market Saturation

The project team analyzed CEDARS claim data from the Comfortably California program lifetime and it found that 5 to 18 percent (in terms of tonnage)[14] and 5 to 14 percent (in terms of unit quantity) of AHRI 340/360-rated equipment was heat pumps. Heat pump participation was strongest in the first year of program implementation (2021) and has decreased since. This decrease may be attributed to program changes made after the 2021 program year in response to evaluation concerns.

Table 4: Comfortably California Program Participation for Air Conditioners and Heat Pumps ≥ 5.4 Tons

Program Year	Tons Air Conditioners	Tons Heat Pumps	Percent of Heat Pump Tons[15]	Number of Air Conditioner Projects	Number of Heat Pump Projects	Percent of Heat Pump Projects[16]
2021	22,825	3,620	13.7	1,978	432	17.9
2022	9,368	483	4.9	763	44	5.5
2023	8,361	570	6.4	602	69	10.3

[14] Tonnage is synonymous with the sum of cooling capacity in tons. 1 ton = 12,000 btu/hr.

[15] Percent of heat pump tons indicates the percent of heat pump and air conditioning tons that were heat pumps incentivized by the Comfortably California program for that program year.

[16] Percent of heat pump projects indicates the percent of heat pump and air conditioning projects that were heat pumps incentivized by the Comfortably California program for that program year.

Methodology and Approach

The following subsections describe project activities and associated findings in detail.

Manufacturer Engagement and Specification

TRC completed a thorough literature review detailing the product technical specifications, product capacities, electrical requirements, refrigerants, controls, ventilation requirements, and design considerations for RTU equipment. This study significantly contributed to defining the market barriers outlined in the **Supply-Chain Interview Results** section. The logic model is presented in the **Logic Model Infographic** section, while the latest draft of the Manufacturer Engagement and Specification Documentation memo issued to Energy Solutions on October 18, 2024, can be found in Appendix D: Commercial Heat Pump RTUs Logic Model Highlighting Activities and Outcomes for Higher Technology Adoption.

Market Interviews

Energy Solutions interviewed market actors in the transaction and delivery channels — including manufacturers, distributors, contractors, and end users — to identify barriers preventing greater adoption of commercial HP RTUs and potential intervention solutions. Our sampling strategy prioritized HVAC distributors and manufacturers with significant market share and a long history of stocking, upselling, and specifying commercial HP RTUs. Within each sampled organization, we targeted both senior management and sales engineers who are directly involved with specifying and retrofitting commercial HP RTUs. To initiate contact with contractors and end users, distributors provided several network contacts for surveying.

This engagement focused on gathering insights from both Northern and Southern California markets, reflecting regional variances in climate, policy influences, and customer demand. Specifically, we interviewed three distributors in Northern California and two in Southern California, along with two contractors, two design engineers, and one manufacturer. Through these discussions, we aimed to capture market actors' perspectives on HP RTU sizing practices, market adoption barriers, retrofit costs (e.g., box size, weight, and electric panel upgrades), and other technical considerations essential to shaping program recommendations for HP RTU adoption across the diverse applications and climates in California. Surveys used for supply-chain market actors are provided in the **Initial Market Actor Survey** and **Final** sections below.

The project team also interviewed the implementer of the Comfortably California program to gain insights into current efforts that Comfortably California is taking to promote heat pump adoption. Survey questions used during the interview are included in the **Implementer Survey** section below.

Upon the conclusion of the focused midstream pilot, we collected participant feedback pertaining to their experience participating in the focused midstream pilot. The survey used is provided in the **Midstream Pilot Feedback Survey** section below.

Initial Market Actor Survey

The list of questions used for the completed interviews is below. Summarized responses to the survey can be found in the **Supply-Chain Interview Results** section.

1. How often are commercial packaged HP RTUs sold and installed compared to packaged RTU AC/gas furnaces? Greater than 5.4 to 25 tons.
    a. Assume the two equipment types occupy 100 percent of the market.
    b. Percentage of RTU ACs.
    c. Percentage of HP RTUs.
2. Can an HP RTU physically replace an existing packaged RTU AC/gas furnace?
    a. If not, what additional equipment is required? A larger curb?
3. What are the stocking practices for HP RTU's?
    a. Are they available on demand or ordered (and how long)?
4. Why are technical and market barriers for installing or specifying commercial RTUs HP not specified more often in place of 5-to-20-ton or 25-ton RTUs AC/gas furnaces?
    a. Why not specified in the new construction market?
    b. Why not specified in the replacement market?
    c. Do customers and contractors understand heat pump technology?
    d. Defrost cycle, activation of electric resistance heat?
5. Why do most manufacturers of HP RTUs stop at 20 or 25 tons?
    a. Are HP RTUs limited to single zones applications? Note: If yes, this would limit the largest size.
        i. Is this due to testing standards?
    b. Technical issues?
    c. Market demand?
6. How much more does a 5-to-20-ton or 25-ton HP RTU cost than a 5-to-20-ton or 25-ton AC/furnace RTU?
    a. What are the additional costs associating with replacing an existing AC RTU/furnace with an HP RTU?
        i. Increase sub-panel size, labor, controls.
    b. Document difference in cost (HP RTU vs. RTU AC/furnace) for a 10-ton unit.
        i. Incremental measure cost (IMC) in dollars?
        ii. IMC in percent?
7. How much of an incentive ($/ton) would be needed to substantially cover the IMC (difference in cost from an RTU AC/gas furnace) and substantially increase sales of air-source heat pumps (over alternative technologies) in these two size categories?
    a. 5-to-20-ton category?
    b. Greater than 20-ton category?

8. What are the other electric options in the 5-to-20- or 25-ton range? Note: This question is designed for the purpose to identify electric alternatives to HP RTUs
    a. Variable refrigerant flow (VRF) systems?
        i. If yes, is this a cost-effective option since it's not like for like?
    b. Custom built HPs?
        i. Describe the custom HP system components/design?
    c. Other?
9. What are the other electric options in the greater than 20 or 25-ton range?
    a. VRF systems? Is this a cost-effective option since it's not like for like?
    b. Custom built ASHP?
        i. Describe the custom HP system components/design?
    c. Other?
10. What are the most common building types and geographic regions for existing sales of HP RTUs?
    a. Building types
    b. Geographic regions
11. What are the design considerations for specifying an HP RTU?
    a. Design considerations?
        i. Is it based on load calculations?
        ii. Sizing guidance?
        iii. Other?
    b. What is the negative impact on the unit with short or constantly cycling in the heating mode?
12. What are the design considerations when replacing an existing package RTU AC/furnace?
    a. Installation requirements?
    b. Are HP RTUs used in multiple zone applications?
13. With electrification, are customers and contractors increasing demand for package RTUs HPs?
    a. 5 to 20 tons?
    b. Greater than 20 tons?
14. Are manufacturers responding to electrification and increasing production of HP RTUs?
    a. 5 to 20 tons? When?
    b. Greater than 20 tons? When?

15. Are there questions this study could ask that would help sell more package HP RTU?
16. What incentives would you recommend per HP RTU to move the market?
17. What building types, applications would be most standard for prescriptive incentive approach?
18. Does your basic HP RTU product come with VFD or demand-control ventilation (DCV) controls? Or are these add-ons?
19. Do you have any other thoughts on how California can improve adoption of the HP RTU products?

Final Market Actor Survey

Final interviews were conducted with focused midstream pilot participants to further expand upon HP RTU barriers. Summarized responses to the survey can be found in the **Supply-Chain Interview Results** section.

1. What barriers are preventing widespread adoption of HP RTUs? What are the individual solutions?
2. To what extent do current design practices hinder adoption of HP RTUs?
3. What percentage of your HP RTU sales are greater than 25 tons? Compared to furnace gas/AC unit. estimates are okay.
4. Is additional education regarding heat pumps needed, and who would the target audience be?
5. What market actor develops installer training and design options for retrofit applications?
6. What are common issues you run into when installing commercial HP RTU's in place of RTU AC/gas packaged systems?
7. What is the incremental cost between AC/furnace RTUs and HP RTUs for:
    a. 5.4 to 20 tons
    b. 20 to 63.3 tons
8. Why are customers not requesting HP RTUs?
9. What incentive amount would cover the $/ton difference between HP RTUs and AC/gas RTUs?

Implementer Survey

Feedback was collected from the statewide HVAC program implementer to inform future RTU program recommendations. The questions posed to the pilot participants are provided below. Summarized responses to the survey can be found in the **Implementer Feedback** section.

1. What changes should the statewide HVAC program consider implementing to increase participation?

2. Is additional education regarding heat pumps needed, and who would the target audience be?
3. Are measure package revisions recommended? The measure in question is:
    a. California eTRM Measure SWHC046,[17] Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution
4. What percentage of the program is gas Total System Benefit (TSB)?
5. What percentage of Comfortably California participation is commercial HVAC HP?
    a. How many tons of AC units greater than 5.4 tons were incentivized in 2024?
    b. How many tons of HP fuel substitution greater than 5.4 tons were invented in 2024?
    c. Do you have this data in commercial tonnage and units?
    d. What can be done to increase this percentage of HP projects?
6. Are you aware of the elimination of natural gas incentive measures?
    a. What do you know?
7. We want to hear about data collection requirement impact on participation and compare CEDARS data to their responses:
    a. What is the number of tons and units for commercial HPs?
    b. What is the number of tons and units for commercial ACs?
8. What can be done to increase participation?
9. What do you know about the elimination of commercial gas incentives?

Midstream Pilot Feedback Survey

At the conclusion of the focused midstream pilot, feedback was collected from participants to inform future RTU program recommendations. The questions posed to the pilot participants are provided below. Summarized responses to the survey can be found in the **Error! Reference source not found.** s ection.

1. How can we improve the accessibility of a midstream program for distributors?
2. It can be challenging at best to identify and obtain contractor and end customer information. Document feedback on the following aspects of the focused pilot:
    a. Eligibility criteria:
        i. COP
        ii. IEER

[17] Fuel substitution unitary heat pump measure in the California eTRM, applicable to units greater than 5.4 tons.

b. Iris (Claim Submission Platform)

c. Timeline of program

d. Level of difficulty to participate in the CalNEXT HP RTU Focused Pilot

e. Level of difficulty to participate in the other RTU programs (currently or in the past)

Midstream Pilot Launch

Incentives were offered for new construction and retrofit applications for both fuel substitution and non-fuel substitution, i.e., electric resistance baseline, projects. Program efficiency requirements matched those specified in the eTRM measure SWHC046-03[18] - Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution (California Technical Forum 2024). The efficiency requirements are outlined in Table 5 below.

The incentive offering was $300/ton for any system that met the minimum measure equipment efficiency requirements. The incentive was flexible, meaning that the market actor submitting the claim could choose to pass it through to the contractor or customer or to keep it to offset additional costs. Table 5 below shows the program requirements. Incentives were limited to a maximum of $15,000 across all eligible equipment installed at any unique location. Additionally, each participant was limited to a maximum incentive of $50,000.

Table 5: Midstream Pilot Efficiency Requirements

Size Category (Cooling Btu/h)	Minimum IEER	Minimum COP	Incentive/ton
≥ 65,000 and < 13,5000	15.0	3.4	$300
≥ 135,000 and < 240,000	14.5	3.2	$300
≥ 240,000	13.5	3.2	$300

* 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. Incentives are limited to a maximum of $15,000 across all eligible equipment installed at any unique location and $50,000 per participating distributor.

The project team recruited five participants[19] and offered incentives once they were enrolled and eligible projects had been submitted. The framework for the program uses Energy Solutions' online rebate processing system, which accepts incentive claims as soon as projects are submitted from enrolled participants.

[18] The Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution measure package can be found here: https://www.caetrm.com/measure/SWHC046/03/

[19] The project team identified suitable market actor candidates for the pilot program, specifically looking at those who were not enrolled in or participating in Comfortably California. To prevent overlap, the project team coordinated as needed with Comfortably California.

To minimize the administrative burden on program participants, the project team aimed to require as little data as possible. The online rebate processing system is designed to provide a streamlined user experience to reduce barriers to program participation. Program participants receive access to the system upon enrollment in the focused midstream pilot and can submit claims immediately thereafter. In addition to requesting minimal data from the participant, the system also streamlines the application process by reducing equipment data entry needs and automatically matching equipment to eligible measure offerings when possible. Rather than requiring that dealers assess measure eligibility or enter detailed equipment information, program participants enter enough information to identify the equipment — typically manufacturer and model — and the system identifies and processes related information to determine the appropriate rebate or measure. Participants who have made multiple sales can submit multiple claims at once, streamlining the incentive payment process and addressing critiques made about the Comfortably CA program.

The program team evaluated customers' addresses to verify that projects were within eligible Investor-Owned Utility (IOU) territory, using the open-source Electric Load Serving Entities (IOU & POU)[20] GIS tool[21] developed by the California Energy Commission (CEC 2024). Claims that met territory and efficiency requirements and did not exceed project limits[22] were approved.

Claim Submission Process

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 in the portal:
    a. Installation address, city, zip code, and state
    b. Business name
    c. Building type
    d. Customer phone number (optional)
    e. Customer email (optional)
    f. Project type
    g. Existing equipment type
    h. Estimated install date.
    i. Contractor business name

[20] Investor-owned utilities and publicly owned utilities

[21] California Electric Load Serving Entities GIS tool can be accessed here: https://cecgis-caenergy.opendata.arcgis.com/datasets/CAEnergy::electric-load-serving-entities-iou-pou/explore?location=34.039805%2C-118.181893%2C18.91

[22] Incentives were limited to a maximum of $15,000 across all eligible equipment installed at any unique location.

j. Contractor email (optional)
k. Contractor phone number (optional)
l. Invoice number
m. Sales date
n. AHRI reference number
o. Quantity
p. Product type
q. Model/condenser
r. Evaporator/indoor unit/ducting type
s. Serial number
t. Specification sheet[23]

3. The project team validates the claim via automated and manual processes.
4. Claims that meet all focused midstream pilot requirements, including territory and efficiency requirements, and do not exceed project limits[24] are approved and paid out.

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

[24] Incentives were limited to a maximum of $15,000 across all eligible equipment installed at any unique location.

Findings

The Findings section of this report presents a detailed analysis of the current state of HP RTUs within the commercial HVAC market. Drawing on extensive data collection and stakeholder feedback, this section delves into various aspects of HP RTUs, including market saturation, available products, existing barriers, and potential opportunities for growth. By systematically examining these elements, the findings aim to provide actionable insights that can inform future strategies for promoting the adoption and effectiveness of HP RTUs. This comprehensive overview serves as a foundation for understanding the challenges and possibilities that lie ahead in the transition to more sustainable heating and cooling solutions.

Overview

The Findings section of the report is organized into several key areas:

1. **Market Transformation Logic Model and Roadmap** identifies the challenges hindering the widespread adoption of HP RTUs, including economic, technical, and regulatory obstacles that stakeholders face.
    a. **Logic Model**
2. **Supply-Chain Interview Results** presents insights gathered from key market actors, providing valuable perspectives on the experiences and challenges faced in the specifying, stocking, upselling (moving specifications from Title 24 code-minimum efficiency units to high-efficiency HP RTUs, installing, and selling of HP RTUs.
    a. **Market Barriers**
    b. **Technology Barriers**
    c. **Policy Barriers**
3. **Midstream Pilot Results** presents participation data through several lenses, impact estimates of the pilot, and feedback received from the statewide program implementer and pilot participants.
    a. **Distributor Participation Results**
    b. **Implementer Feedback**
    c. **Pilot Feedback**
4. **Market Opportunities** explores potential avenues for growth and innovation within the HP RTU sector, outlining strategies that could enhance market penetration and customer acceptance.

This structured approach ensures that stakeholders can easily navigate through the critical findings and gain a holistic view of the current state of HP RTUs in the market.

Market Transformation Logic Model and Roadmap

TRC constructed a program logic model to describe the range of barriers necessary to overcome in the short, intermediate, and long term, which we classify into the following three types:

- Market barriers — Economic factors such as product availability, cost, awareness, acceptance, and the availability of market information necessary for market actors to make informed decisions.
- Technology barriers — Physical constraints of the buildings in which the units will be installed, as well as necessary advancements in the technical features of HP RTUs to make them viable alternatives for capturing increasing market share.
- Policy barriers — Challenges and limitations of existing programs, incentive structures, and application processes.

We use the model to document all necessary activities, i.e., steps, required to surmount these barriers within three time frames:

1. Short term represents the current state, where HP RTUs are used in like-for-like replacement of smaller electric units with limited added features.
2. Intermediate term represents the near future state, where program-supported activities foster manufacturer R&D to develop newer units that overcome many of the technical barriers, and other programmatic activities help surmount many market and policy barriers.
3. Long term represents full market transformation, where HP RTUs become a viable alternative to all relevant alternative products.

The logic model infographic is included as **Figure 1** on the following page. The final draft of the Manufacturer Engagement and Specification Documentation memo can be found in **Appendix D: Commercial Heat Pump RTUs Logic Model Highlighting Activities and Outcomes for Higher Technology Adoption.**

Logic Model Infographic

Figure 1 below separates barriers into technology, market, and program/policy categories, which are represented in the teal portion at the top of the figure. We then split up the activities, outputs, and outcomes and listed them as short, intermediate, and long-term activities, outputs, and outcomes. This infographic captures the feedback of the five distributors, two implementers, and one manufacturer interviewed, while also offering solutions of how to remedy these barriers.

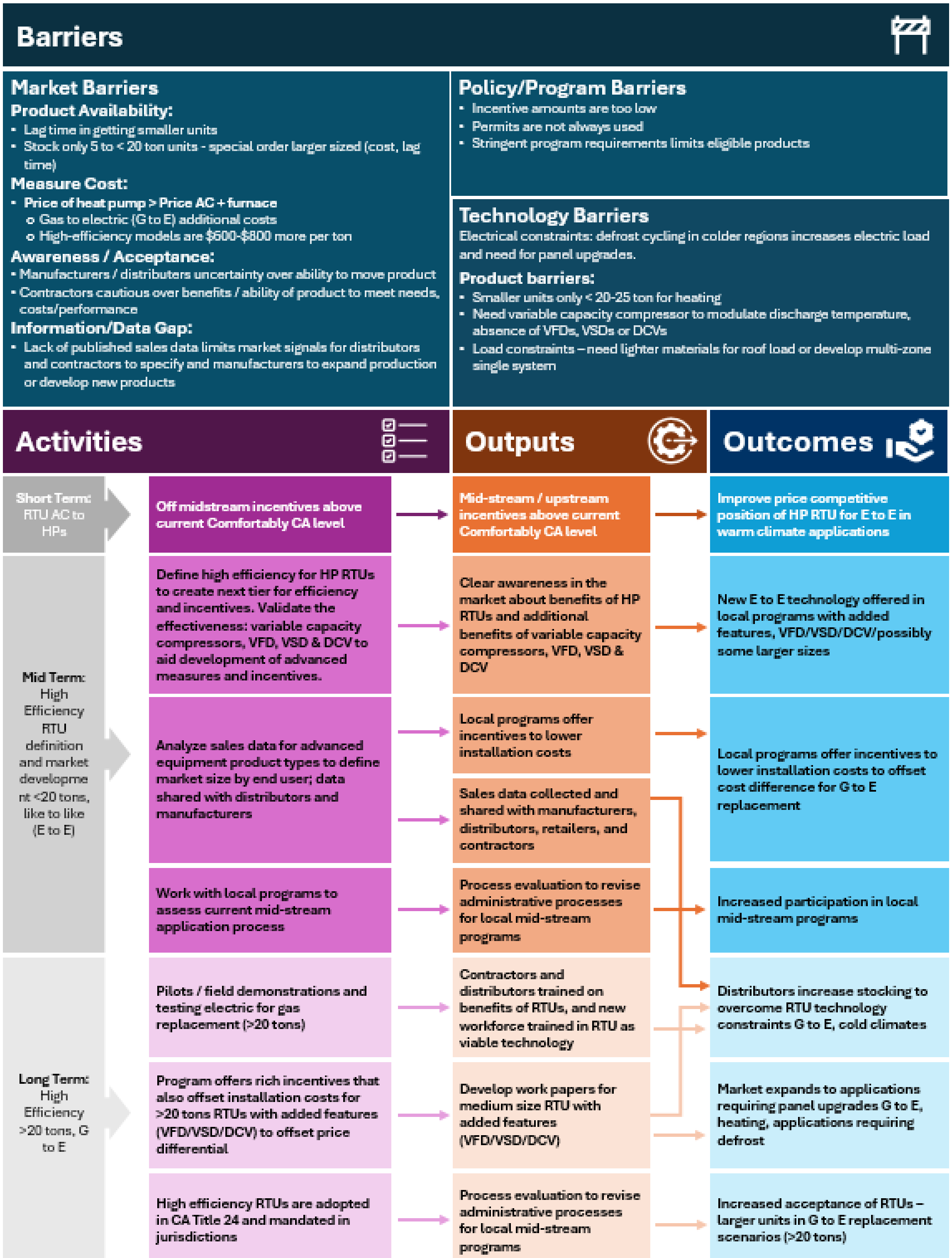

Figure 1: Logic model infographic.

Supply-Chain Interview Results

This section summarizes feedback received from market actors across the upstream, midstream, and downstream sectors in addition to implementer feedback about what problems arise during the implementation of a midstream HP RTU incentive program. These survey responses support the logic model's findings and further show the need for both measure package and California program updates to increase HP RTU uptake.

Based on supply-chain interviews, these barriers can be categorized into three primary constraints: market barriers, technology barriers, and policy barriers. These constraints collectively create obstacles to expanding the market for HP RTUs, particularly in the face of well-established competing technologies. Addressing these challenges will pave the way for these units to emerge as attractive alternatives within the HVAC market.

Market Barriers

From the supply-chain interviews, we identified that the market barriers represent physical, financial, perceptional (awareness and acceptance), and information constraints limiting expanded market adoption of HP RTUs. The project team identified market barriers that impact the economics of specifying HP RTUs; awareness and acceptance of the technology among contractors, specifiers, engineers; and workforce readiness to adapt to installing HP RTUs as they become more attractive alternatives. The following section describes the first cost, installed cost, acceptance and awareness, and market intelligence barriers.

EQUIPMENT COST

Cost is the predominant market barrier impacting adoption of HP RTUs. The replacement market for heating and cooling is constrained to like-for-like replacements due to the high equipment costs discussed below. When interviewed, market actors reported that the acquisition costs of HP RTUs are still greater than furnace plus air conditioning, leaving them at a competitive disadvantage from a first cost price perspective.

Depending on HP RTU efficiency and size, equipment cost can vary. **Table 6** and **Figure 2**Figure 2 below compare the average equipment costs for code-minimum, typical-efficiency, and highest-efficiency models at different capacities. According to an industry standard practice study of air conditioner and heat pump systems (SDG&E 2021), typical-efficiency[25] and highest-efficiency HP RTUs relative to code-minimum requirements are provided in the following table. The price differential between code-minimum models and high-efficiency heat pumps is $600 to $800 per ton. This price difference is also noticeable between typical-efficiency and high-efficiency heat pumps, ranging from $400 to $700 per ton. The highest efficiency results align with the average IMC cost of $465 per ton which was reported from interviewed distributors.

[25] Typical efficiency heat pump rooftop units were average in performance.

Table 6: Typical Costs of HP RTUs by Efficiency

HP RTUs, Fuel Substitution 5.4 Tons to 11.2 Tons			
	Retail Price ($/ton)	Comfortably California Incentives	Calculated IMC
Title 24 Code Minimum	$1,050–$1,055	No incentive	$0
Typical Efficiency	$1,206–$1,243	$165/ton	$156–$193
Highest Efficiency	$1,700–$1,780	$165/ton	$650–$730

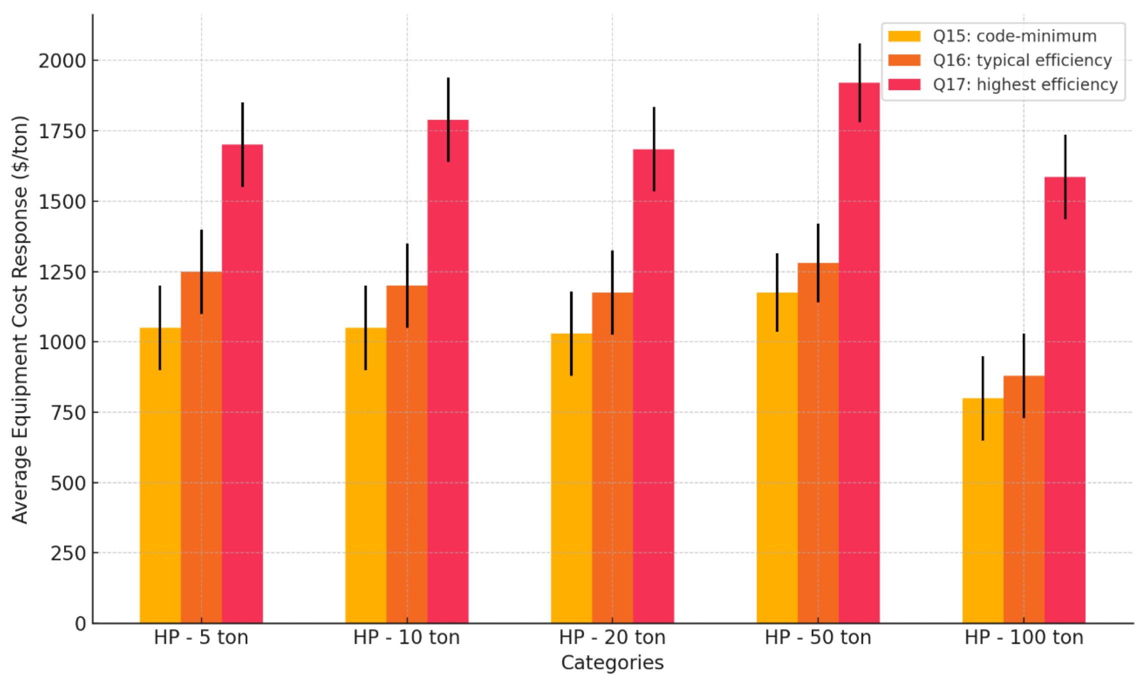

Figure 2: Average equipment costs for code-minimum, typical-efficiency, and highest-efficiency heat pumps.

In comparison to conventional air conditioner and furnace systems, the initial investment for HP RTUs is often significantly higher, which can deter decision-makers from considering these options. While design codes and mandates for publicly owned properties are moving the needle, budget constraints are the main reason like-for-like retrofits, e.g., air conditioner or furnace are replaced with a new air conditioner or furnace, occur most often. Considering the retail price of HP RTUs is currently only covered by approximately 15 percent under the statewide Comfortably California incentives, increasing the incentive amounts could enhance the financial appeal of HP RTUs.

INSTALLATION COST

While the cost differential between HP RTUs and competing technologies is substantial, the high acquisition cost of HP RTUs is only one source of cost differences. Higher costs from installing HP RTUs come from: panel upgrades, fuel conversion costs, structural engineering costs, and construction costs from structural engineering review.

In gas to electric replacements, the higher installation cost due to electrical upgrades further limits the market. This is due to installation cost pressure resulting from the need for electrical panel upgrades that may be required to handle increased electrical loads. For example, in northern regions, the need for defrost cycling can increase electrical load requirements, thereby making panel upgrades necessary either at the sub-panel or main panel. In such cases, the customer and installer are more likely to elect for like-for-like replacements with new gas units.

The process of capping gas lines when taking the gas equipment out of service also contributes to cost increases. Customers are faced with a higher upfront installation cost to increase the electrical capacity and the liability concern of what to do with the gas piping that once supplied natural gas throughout the building. While most owners and operators take on the added expense to remove gas piping, tenants are less inclined to do so and typically just cap the gas line(s).

Additionally, heavier equipment could require structural analysis, which market actors currently avoid. A larger HP RTU could be heavier, requiring an expensive structural engineering analysis of the roof and possible structural modification to the building. Over the years since the existing unit was installed, there have been numerous codes and standards changes that now require the new HP RTU to be much more efficient with a larger condenser, resulting in a heavier and larger box. HP RTUs were reported to be 5 to 25 percent heavier than existing installed air conditioner or furnace RTUs. It is worth noting that some new AC RTUs may also trigger structural analysis, although the market avoids triggering structural review when possible. The weight increase may trigger structural calculations and plans ranging from $15,000 to 20,000 per project, plus the costs of any needed structural updates.

Economic considerations play a pivotal role in the specification and adoption of HP RTUs. Installation costs remain critical factors for distributors, contractors, and end users when evaluating HP RTUs against traditional HVAC options. The higher upfront costs associated with HP RTUs, coupled with the financial implications of retrofitting existing systems, contribute to customer hesitancy in adopting them. Market actors indicated that understanding the long-term financial benefits of HP RTUs, such as energy savings and potential incentives, is essential for overcoming these economic barriers.

DISTRIBUTOR PRODUCT AVAILABILITY AND STOCKING PRACTICES

Distributor stocking practices have a significant impact on the equipment available to contractors for installation. Distributors stock by demand and are driven by their customers’ preferences within the bounds of state and federal code. One distributor reported that stocking and ordering HP RTUs have lead times of 20 to 36 weeks, with about 10 percent of sales pre-stocked. Distributors highlighted significant challenges related to stocking HP RTUs greater than 20 to 25 tons due to prohibitive costs and limited availability.

Stocking concerns were further compounded by the current refrigerant code change,[26] which mandates the phaseout of R-410A in favor of R-454B and other low-GWP refrigerants beginning on January 1, 2025. Although R-454B will be the new industry standard, it currently represents only about two percent of AHRI-rated units. This limited availability raised concerns about stocking R-454B-compliant units early in the pilot.

Delays due to lack of distributor product availability hinder electrification efforts since contractors cannot install what is not available. To encourage increased stocking of HP RTU equipment by distributors, increased incentives from current statewide program levels are advised to increase product demand.

ACCEPTANCE AND AWARENESS

Increasing awareness and acceptance of HP RTU technology among industry professionals — including contractors, engineers, and the broader workforce — presents significant hurdles. Interviews revealed a lack of familiarity with HP RTUs and their advantages, which affects the willingness of stakeholders to recommend or specify these units.

While distributors all agreed that more educational opportunities were needed, the target audience answers ranged from the design engineer and architects overseeing the project design, to the boots-on-the-ground contractor performing the installations, and others in between the supply chain. Facility directors, property managers, and maintenance supervisors were consistently brought up by three distributors interviewed, since these are the personnel in charge of overseeing the project implementation at the ground level.

Many design-build contractors and mechanical engineers will want to replace the air conditioner or furnace with another air conditioner or furnace, i.e., like-for-like, due to lower installation and equipment costs and familiarity with design and installation of these systems. To increase uptake of HP RTU retrofits in place of AC and gas RTUs, the financial and energy benefits of the technology must be documented and socialized with this group. Additionally, education materials focused on the installation of HP RTUs is highly recommended.

Contractor education is needed to explain heating capacities at different cooler and colder temperatures, i.e., 47°F, 17°F, 5°F, and how new HP RTU performance, i.e., heating capacity and COP, has improved from units manufactured 20 years ago. A bin analysis could help educate contractors that there are a minimal number of operating hours when the HP RTU is operating at less than 100 percent of rated heating capacity. Contractors risk losing profits and future sales when customer call in complaints, so they avoid the potential risks associated with unknown and unfamiliar equipment performance. Contractors prefer to specify and install HVAC systems that ensure customer satisfaction, particularly during cold weather, to minimize the likelihood of complaints.

Many end-use customers either lack understanding about heat pump technology or have heard or experienced (from decades ago) that these units have higher operating costs, supply cooler air on cold days compared to gas systems, and take a longer time to warm the space. One distributor

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[26] More information on the AIM Act and how it is enforced by the EPA is available at https://www.epa.gov/enforcement/enforcement-american-innovation-and-manufacturing-act-2020

reported that there is a current misperception around heat pump technology that there won't be enough heat for the space. Time-of-use (TOU) rates and differing HVAC use cases by customer, such as climate zone, building type, and load profile, complicate the cost benefits of switching from AC RTUs to HP RTUs.

One interesting finding from our customer surveys was that public institutions (e.g., schools, colleges, universities, and governmental buildings) are committed to replacing existing AC/furnace RTUs with HP RTUs even with higher: equipment costs, cost for panel upgrades, gas line removal costs, etc. They are motivated by California's policy to electrify and reduce GHGs. Contrary to this support for California's policy to electrify, private companies are still committed to making financial decisions based on lowest first cost and a one-to-three-year payback. This is a strong driver for Utility incentives that are high enough to close sales on HP RTU conversions.

Tailored education and outreach initiatives are needed to improve understanding and acceptance of HP RTUs in commercial settings, thereby facilitating their integration into existing market practices. As market transformation occurs, highlighting the financial aspects and trends, such as energy bill impacts and eligibility for incentives, could help shift perceptions and encourage wider adoption of HP RTUs in commercial applications. By addressing these economic considerations and emphasizing the long-term savings potential, stakeholders can foster a more conducive environment for the transition to heat pump technology.

Technology Barriers

This section summarizes the technology barriers identified by supply-chain market actors, reflecting the technical limitations of replacing existing RTU equipment with HP RTUs.

TECHNOLOGICAL CONSTRAINTS

Market actors highlighted the demand for various technological advancements to enhance the functionality and adaptability of HP RTUs. Essential features such as variable capacity compressors, variable refrigerant flow (VRF), variable frequency drives (VFDs), and demand control ventilation (DCV) are crucial for meeting diverse operational requirements. Furthermore, there is a clear market need for larger, i.e., greater than 25 ton, and multizone HP RTUs to effectively address commercial segments currently underserved by existing systems. Fixed-capacity HP RTUs are unsuitable for multizone applications, as they lack the flexibility needed to meet varying heating and cooling demands within a single building. While larger systems or systems with additional features may be custom built, the cost and lead time necessary for securing these custom-built systems creates a market barrier, as timeliness is a key consideration for the technology to remain competitive.

ELECTRICAL CONSTRAINTS FOR RETROFIT APPLICATIONS

One barrier of transitioning from an AC RTU with gas heating to an all-electric HP RTU is potential need for electrical panel upgrades may to accommodate the increased electrical load. Market actor interviews revealed that one of the most dominant technological constraints HP RTUs faces is the substantial increase in electrical panel load requirements. This includes increased load due to defrost cycling, particularly in colder climates like those found in Northern California.

In colder areas like Northern and Eastern California, where temperatures drop below 30°F, electric resistance heat strips for defrost cycles are essential for HP RTUs, as exposure to ambient cold and ice formation can impact performance. Electric resistance heat is also needed for HP RTUs in buildings with zones requiring high ventilation rates, like classrooms.

The inclusion of auxiliary heating mechanisms, such as electric strip heat, may trigger higher electrical service requirements. One manufacturer reported that, in almost all cases where a panel upgrade is required, customers often decide to install a new AC/furnace RTU instead of an HP RTU. Looking at how this applies to the market, distributors reported on average that 25 percent of retrofit projects require auxiliary heating, meaning 75 percent of projects do not require auxiliary heat. These projects avoid the need for panel upgrades. Projects avoiding panel upgrades have reduced IMC and should be targeted for program offerings to increase HP RTU uptake.

DESIGN PRACTICES

Current building design practices hindering HP RTU adoption include the use of auxiliary heat to support the defrost cycle and the widespread use of variable air volume (VAV) systems with limited heat pump options in larger buildings.

One distributor reported that auxiliary heat is included in 25 percent of their HP RTU projects. All school, university, assembly, and public buildings with high ventilation requirements will require auxiliary heat. If auxiliary heat is required, some market actors prefer to avoid the associated costs, additional work, permitting, and expenses. This is especially a concern when bidding a job, knowing that the customer will decide based on the lowest cost. Auxiliary heat is activated during the defrost cycle and when a thermostat cannot achieve the room temperature setting. The supply air temperature from an HP RTU during cool weather is significantly lower than supply air temperature from an AC or furnace RTU, causing occupants to notice the cool supply air and raise the room temperature setting, which can activate the electric resistance heat. Customers in this situation may call their HVAC contractor and register a complaint. These previous experiences motivate many market actors to specific AC and furnace RTUs over HP RTUs.

One distributor reported that most design engineers don’t install HP RTUs into multizone systems. VAV HVAC systems with terminal reheat are today’s common HVAC system design for multizone applications. These design practices prohibit widespread installation of larger HP RTUs and negatively impact distributor sales. Above 25 tons, the replacement becomes a more “custom” VAV design, which includes supplemental heat and increased amperage, making it significantly more expensive. System designs are being revised, and distributors expect to install HP RTUs greater than 25 tons in the future. However, without an incentive, growth will be slow due to much higher installed costs.

To overcome these barriers to the increased adoption of multizone and higher-efficiency HP RTUs, incorporating features such as variable capacity compressors is essential. Current electric heat pump applications compatible with multizone buildings include VRF and DOAS. These systems lack formal incentive processes in California and should be encouraged through official channels to improve the efficiency of larger building designs. Additionally, program designs involving HP RTUs should include multizone compatibility and increased efficiency as requirements for certain tiers to accommodate these applications.

PRODUCT AVAILABILITY

Due to the limited number of manufacturers producing units larger than 25 tons, a smaller percentage of HP RTU sales align with this size. One distributor reported that an estimated 20 percent of HP RTU sales were greater than 25 tons, while other distributors stated that sales of such units were minimal. Another distributor indicated that their manufacturer produces units up to 70 tons, but few are being specified. Most manufacturers limit single-system offerings to less than 25 tons, with larger systems available up to 70 tons at a much higher cost.

To increase installations of larger HP RTUs in California, incentives should be designed to accommodate the cost of this measure more appropriately. Substantial incentives covering 100 percent of incremental measure costs — inclusive of higher installation costs associated with panel upgrades, decommissioning of gas lines, structural engineering, and construction costs — are needed. Currently, only governmental organizations or others driven by net zero mandates are paying the higher costs to convert from AC or furnace RTUs to HP RTUs.

Policy Barriers

This section summarizes the policy barriers impacting HP RTU uptake, as identified by market actors.

INCENTIVES

There is a fine balance between an incentive being too low and egregiously high. When an incentive is too low, the market remains unimpacted. If the incentive is too high, that can cause a wave of free ridership[27] (TecMarket Works 2004). To consider the range of responses received, multiple perspectives on recommended incentives are provided below.

To better understand what an appropriate incentive amount would be to move the needle on HP RTU adoption, the project team asked distributors what the cost difference is between a 10-ton AC/Furnace RTU and a 10-ton HP RTU. 10-ton units were used for this exercise since we were informed this is the most common sized unit sold. We heard from these market actors that on average, the incremental cost for a program efficiency HP RTU is 15 to 20 percent more when compared with an AC/furnace RTU. While the dollar per tonnage varied across distributors and the HVAC brands they sell, the upfront cost difference, or IMC, averaged $465/ton. These IMCs do not include the additional cost of panel upgrades, which can range from $2,000 to 5,000 per project. If you factor the cost of panel upgrades IMC would be $665 to 1,000/ton.

While program cost effectiveness was not evaluated for these proposed incentive levels, comparison of their reported IMC levels to the current program incentive, $100/ton, indicates that the current incentive level is not substantial enough to drive commercial heat pump sales. A successful program will need to significantly cover the cost difference between installing an HP RTU over an AC or furnace RTU to make significant changes in the market.

CALIFORNIA BUILDING PERMITS AND TITLE 24-2022

California Title 24-2022 requires building permits in both retrofit and new construction projects. California Title 24 offers two compliance options: the prescriptive path, which requires meeting every prescriptive requirement, and the performance path, which allows a comprehensive whole building approach. Additionally, Title 24-2023 went into effect on January 1, 2023; this version requires HP RTUs to be specified under the prescriptive path.

Distributors anecdotally estimate — though this response changes frequently due to many variables — that, in today's economy, 70 percent of their HVAC RTU projects comply with Title 24 under the performance path, while 30 percent comply under the prescriptive path. Projects under the

[27] Free riders are project participants who would have installed the same energy efficiency measures if there had been no program. https://www.calmac.org/publications/California_Evaluation_Framework_June_2004.pdf

performance path are open to AC and furnace RTUs. Also, 30 percent of the projects that are required to install HP RTUs will, without a utility incentive, lead distributors to stock and upsell, i.e., promote, Title 24 code-minimum efficiency projects. One distributor commented: “We may get a request for an AC/furnace RTU for a new job, but they’ll change to a heat pump easily if we recommend it.”

Under the CalNEXT HP RTU focused midstream pilot, program-eligible efficiency tiers are set much higher than in Title 24. As demonstrated by the success of this focused midstream pilot, utility incentives can influence the adoption of HP RTUs with much higher efficiencies than Title 24 standards.

Additionally, we expect the Title 24 prescriptive path, which requires installation of HP RTUs, to aid in distributor stocking and upselling, and enhance end user and contractor experience with HP RTUs.

PROGRAM REQUIREMENTS

Informal interviews conducted during the claim submission process of the focused midstream pilot provide valuable insights for program requirements and design. We identified the collection of end-user data as a significant barrier to program participation. Distributors noted difficulties in obtaining information, such as existing equipment type, which is often needed to allocate accurate savings for each project. However, distributors rarely engage with the end-user sector of the market and often do not have access to this information. These difficult data collection fields are required by either the CPUC or eTRM measure package and pose a barrier to HP RTU measure adoption.

Midstream Pilot Results

The following section includes results from the focused midstream pilot, broken down by efficiency, building type, project type, and climate zone. Additionally, project impacts were estimated by matching up project applications with the California eTRM permutations based on building type, project type, existing equipment type, and climate zone.

Because of incentive capping rules[28] for the pilot, not all eligible applications were incentivized. Because more projects were submitted than could be incentivized, we include all eligible submitted applications in the following analytical sections. This more closely resembles the potential impacts to full-scale adoption by a midstream program.

Distributor Enrollment

Four of the seven distributors initially engaged to participate submitted claims to the focused midstream pilot. Distributors 1 and 3 did not identify any qualifying projects during the short timeline of the incentive offering. Distributor 7 did not end up enrolling since their product line did not align with the program requirements. Detailed dates of enrollment and project submissions for participants are provided in Table 7 below.

[28] Incentives were limited to a maximum of $15,000 across all eligible equipment installed at any unique location and to a maximum of $50,000 per participating distributor.

Table 7: Distributor Enrollment Timeline

Distributors (Anonymized)	Date of Kickoff Meeting	Date of Enrollment	Date of First Project Submission
Distributor 1	10/22/2024	11/20/2024	N/A
Distributor 2	10/15/2024	10/21/2024	1/3/2025
Distributor 3	09/26/2024	10/8/2024	N/A
Distributor 4	10/2/2024	10/10/2024	10/28/2024
Distributor 5	10/2/2024	10/10/2024	10/28/2024
Distributor 6	10/1/2024	10/8/2024	1/17/2025
Distributor 7	09/26/2024	N/A	N/A

Summary Statistics

We received strong participation rates for the focused midstream pilot. From the four distributors who submitted claims, we received the reported number of claims, units, tons, and incentive valued projects, shown in **Table 8** and **Table 9**. Receiving above 2,000 tons of HP RTUs submitted to the focused midstream pilot surprised us, given the lower participation rates indicated by the California reporting database, CEDARS.

Some distributors submitted more claims than were payable due to program limits. Statistics in the *Submitted to Pilot* column are higher than the *Approved for Payment* column because of incentive capping limitations outlined in the program rules. Additional analyses found later in the report are based on eligible submissions, not projects approved for payment.

Based on feedback received from participants, we believe the focused midstream pilot's success may be largely attributed to a streamlined incentive application process with reduced data collection. For more detail on the responses from participants, please refer to the Pilot Feedback section.

Table 8: Project Submission Volume by Payment Status

	Submitted to Pilot[29]	Approved for Payment[30]
Number of Claims	82	35
Number of Units	161	44
Number of Tons	2,007	507
Total Incentive Value of Submitted Projects (Uncapped)	$602,001	$152,229

Table 9: Project Submission Volume by Size Category

	≥65 kbtuh and <135 kbtuh	≥ 135 kbtuh and <240 kbtuh	≥240 kbtuh
Number of Claims	61	3	18
Number of Units	110	4	47
Number of Tons	887	48	1,072
Total Incentive Value of Submitted Projects (Uncapped)	$265,971	$14,400	$321,630

[29] Only projects that were eligible for the incentive are included in Table 8 and 9. Other projects were submitted but did not meet pilot efficiency requirements.

[30] Due to program incentive capping at the project and participant level, not all qualified projects received incentives. For the purposes of analysis, all efficiency qualified projects are included in the results.

Efficiency Trends

Based on the projects submitted, we can assess the efficiency requirements used for the m focused midstream pilot. Efficiency requirements were based on the fuel substitution measure for commercially sized heat pumps[31] and are provided in the **Midstream Pilot Launch** section.

In Figure 3, see IEER and COP ratings of HP RTUs between 65 and 135 kBtuh cooling capacity. Most submissions only met the absolute minimum efficiency requirements for that size category. 100 of the 110 submitted units were rated as 15 IEER and 3.4 COP. The maximum efficiency of submitted units within this size category were 21 IEER and 3.7 COP. However, benefits from these submissions would not be captured by the current measure package savings. A tiered savings approach to cooling efficiency, i.e., IEER, may improve cost-effectiveness and claimable benefits associated with higher-efficiency units.

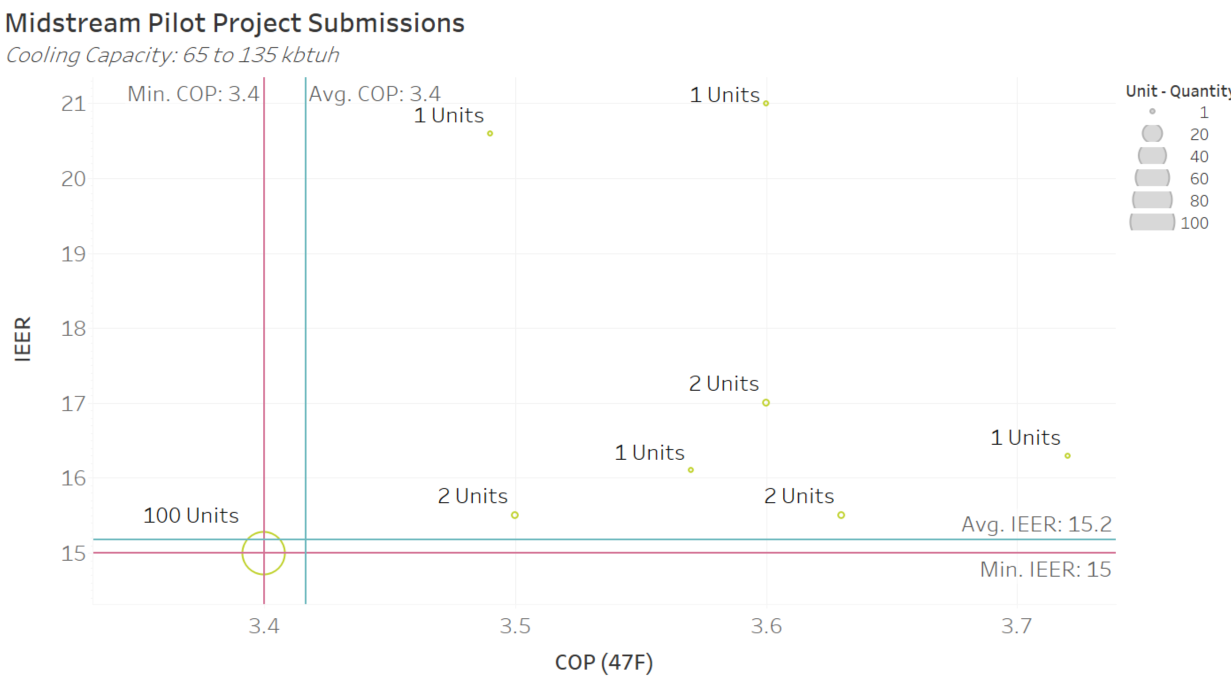


Figure 3: Efficiency of submitted eligible midstream pilot projects (65 to 135 kbtuh).

[31] The Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution measure package can be found here: https://www.caetrm.com/measure/SWHC046/03/.

In Figure 4, see IEER and COP ratings of HP RTUs between 135 and 240 kBtuh cooling capacity. The four units within this size category were identical, rated at 15 IEER and 3.3 COP — only 0.5 IEER and 0.1 COP above efficiency minimums. The sample size for this size category is too small to represent typical participation efficiencies.

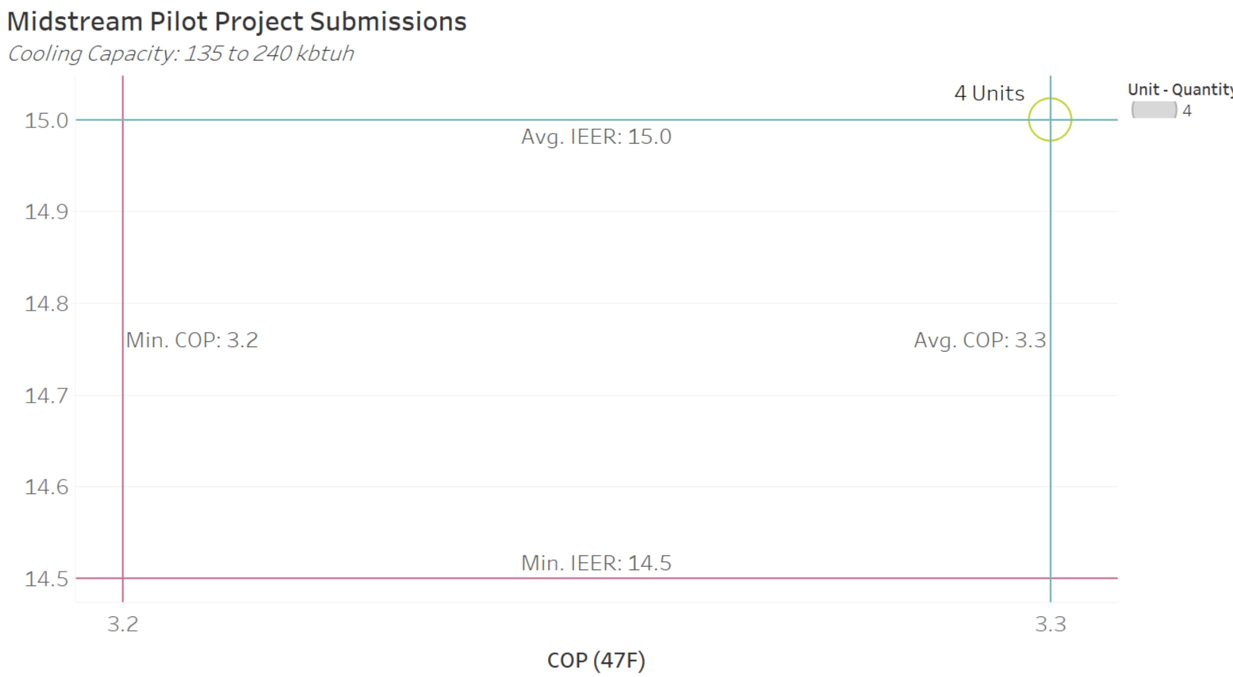


Figure 4: Efficiency of submitted eligible midstream pilot projects (135 to 240 kbtuh)

In Figure 5, see IEER and COP ratings of HP RTUs greater than or equal to 240 kBtuh cooling capacity. We received 47 submissions for this size unit. The average efficiency was 0.9 IEER and 0.1 COP higher than program minimum efficiency. However, efficiencies of submissions reached a maximum of 18 IEER and 3.4 COP. Additional savings could be captured for higher-efficiency projects by implementing efficiency tiers as a part of the commercial heat pump measure package.

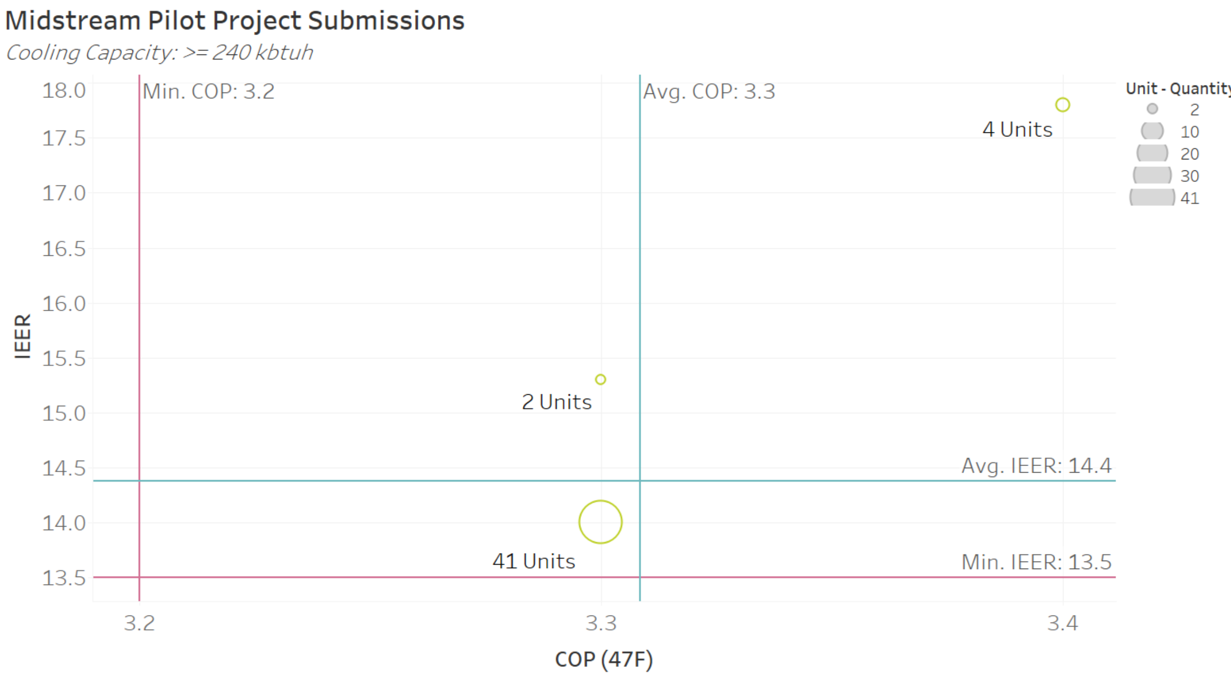


Figure 5: Efficiency of submitted eligible midstream pilot projects (>240 kbtuh).

Building Type Trends

Figure 6 presents a heat map of building types for eligible project submissions. As shown in the heat map, manufacturing light industrial was the most prevalent building type for HP RTU projects across all sizes, accounting for 45 percent of the HP RTUs installed. Thirty-five percent of smaller HP RTUs, ranging from 65 to 135 kBtuh, were installed in large offices, primary schools, and hotels. Primary schools were also a notable building type for HP RTUs greater than 240 kBtuh. Overall, these results align with distributor interviews, which indicated that HP RTUs are popular in K-12 schools, strip malls, and small offices.

Building Types of Submitted Eligible Midstream Pilot Projects

	Cooling Capacity Range (btuh)			
	>= 65,000 BTUH and < 135,000 BTUH	>= 135,000 BTUH and < 240,000 BTUH	>= 240,000 BTUH	Grand Total
Assembly	1% 1 Units		2% 1 Units	1% 2 Units
Hotel	8% 9 Units		2% 1 Units	6% 10 Units
Manufacturing Light Industrial	34% 37 Units	75% 3 Units	68% 32 Units	45% 72 Units
Nursing Home	2% 2 Units			1% 2 Units
Office - Large	18% 20 Units		6% 3 Units	14% 23 Units
Office - Small	6% 7 Units	25% 1 Units	4% 2 Units	6% 10 Units
Primary School	9% 10 Units		13% 6 Units	10% 16 Units
Restaurant - Fast-Food	1% 1 Units			1% 1 Units
Restaurant - Sit-Down	4% 4 Units			2% 4 Units
Retail - Multistory Large	2% 2 Units		2% 1 Units	2% 3 Units
Retail - Single-Story Large	6% 7 Units		2% 1 Units	5% 8 Units
Retail - Small	5% 6 Units			4% 6 Units
Secondary School	4% 4 Units			2% 4 Units
Grand Total	100% 110 Units	100% 4 Units	100% 47 Units	100% 161 Units

Unit - Quantity

1 37

Figure 6: Building types of submitted eligible midstream pilot projects.

Project Type Trends

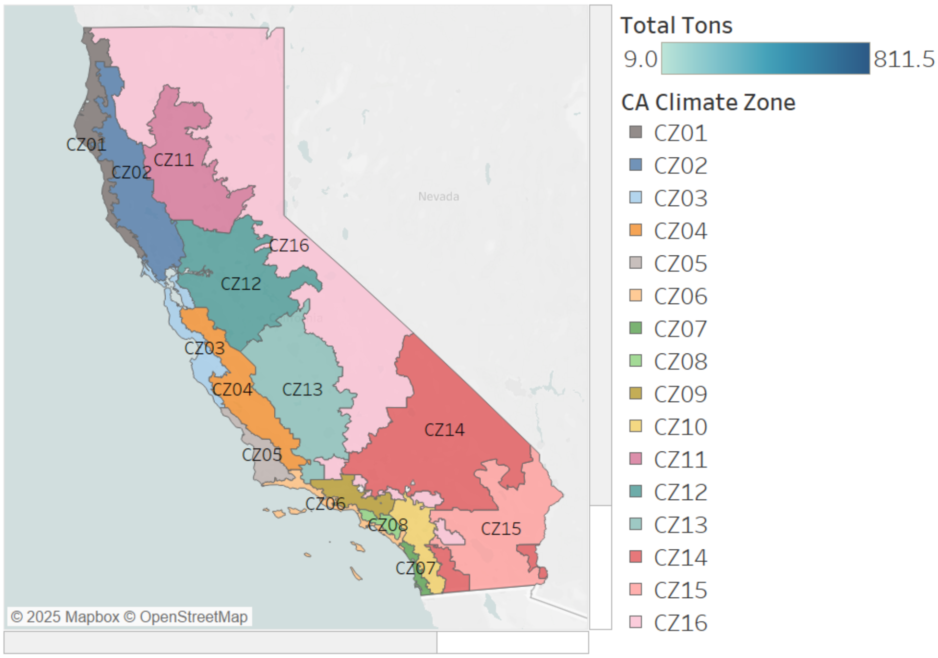
Although retrofit projects were preferred, the focused midstream pilot also accepted new construction projects. Table 10 shows the project types of all eligible submissions. Projects with substantial renovations were classified as new construction. The number of tons is equivalent across project types, but more claims and systems were submitted for the retrofit project type. This trend shows larger units were more often included in new construction projects than in retrofit projects.

Table 10. Eligible Project Submissions by Project Type

	New Construction and Substantial Renovations	Retrofit	Grand Total
Number of Claims	24	58	82
Number of Units	53	108	161
Number of Tons	955	1,051	2,007
Total Incentive Value of Submitted Projects (Uncapped)	$286,626	$315,375	$602,001

Climate Zone Distribution

We received applications in 12 of the 16 California designated climate zones (CZs). CZs that were not included in claim submissions were: CZ1, CZ5, and CZ11, and CZ12. A summary of CZs submitted to the focused midstream pilot are provided in Figure 7.



CZ02	12 Tons
CZ03	71 Tons
CZ04	109 Tons
CZ06	54 Tons
CZ07	159 Tons
CZ08	239 Tons
CZ09	217 Tons
CZ10	811 Tons
CZ12	114 Tons
CZ13	149 Tons
CZ14	9 Tons
CZ15	65 Tons
Grand Total	**2,007 Tons**

Figure 7: Climate zones of eligible midstream pilot projects

Estimated Impacts

As part of the midstream pilot's efforts, estimated impacts were allocated based on equipment cooling capacity bin, project type,[32] building vintage, building type, and building location. Measure package SWHC046-03 was used for fuel substitution projects and measure package SWHC013-05 was used for non-fuel substitution projects. Table 11 includes the estimated impacts of the midstream pilot's projects.

Only three units qualified for the deemed fuel substitution measure, as defined in the California eTRM. 103 units were disqualified from the fuel substitution measure package because the existing equipment type was listed as "Other." Because these claims did not specify gas equipment as the existing equipment, these would not qualify for SWHC046-03 in a traditional program offering. Despite existing equipment type not being provided for these claim applications, we assumed the installations replaced gas equipment, due to the prevalence of this equipment in California. 12 units were disqualified from the fuel substitution measure package because of their project type being new construction. However, 11 of these units qualified for the like-for-like measure package, SWHC013-05. One unit did not qualify for this measure since the energy efficiency rating (EER) rating was too low.

The applications collected during the midstream incentive pilot demonstrate the challenges distributors face in determining end-use customer data to comply with program requirements, and how this affects claimable impacts. Without accounting for the projects that failed to list existing equipment type, the total system benefits amount to $8,000. However, the typically unaccounted-for projects potentially saved $300,000 in total system benefits. The Comfortably California program may have received higher rates of participation if the "existing equipment type" data point could have been determined from other sources or was able to use a weighted baseline.

[32] Normal replacement was assumed for retrofit projects. New construction was assumed for new construction projects.

Table 11: Midstream Incentive Pilot Estimated Impacts

Midstream Incentive Pilot Estimated Impacts

Derived from SWHC046-03 and SWHC013-05 CAeTRM Measure Package Permutations

Claim Type	Measure Version ID	Assumption Reasoning	Total Cooling Capacity (Tons)	Unit - Quantity	Total Electric Savings	Total Gas Savings	Total Electric TSB	Total Gas TSB	Total TSB
Existing Equipment Type listed as "Gas Equipment"	SWHC046-03	Meets all SWHC046 requirements	80	6	-6,045 kWh	864 Therms	$0	$17,559	$7,441
Existing Equipment Type listed as "Other"	SWHC046-03	Likely Fuel Substitution but data point is missing	1,922	206	-198,504 kWh	29,710 Therms	$6,517	$610,229	$302,625
New Construction Projects	SWHC013-05	Disqualified from SWHC046 due to project type	327	23	13,897 kWh	0 Therms	$8,348	$0	$8,348
Disqualified New Construction Projects	Null	Disqualified from SWHC046 due to project type and SWHC013 due to EER Requirements	848	44					
Grand Total			2,007	161	-190,652 kWh	30,573 Therms	$14,864	$627,788	$318,414

Implementer Feedback

We met with CLEAResult on a regular basis throughout the span of the pilot to collaborate and share successes with both Comfortably California and the CalNEXT HP RTU pilot incentive program, as well as proactively eliminate any confusion from distributors and the Comfortably California team. Prior to the midstream pilot launch, we reviewed the program flyer[33], which covered the five steps describing how distributors can participate, including customer eligibility, pilot duration, equipment eligibility, incentives, and distributor and project budgets.

The project team interviewed the Senior Account Manager at CLEAResult, the implementer for the Comfortably California program. The objectives of meetings with the implementer were to collaborate on documenting barriers and to discuss intervention strategies for how to make HP RTU rebate programs more favorable to entice market transformation. The barriers identified included the requirement for distributors to submit end-use customer data and the incentive amounts being too low to drive market transformation.

Comfortably California encounters participation hurdles like what we have heard from other market actors, including difficulty collecting end user customer data and lower participation rates than expected. To increase participation in a commercial heat pump incentive program, it boils down to the incentive amount itself. The incentive, or rebate amount, must be enough to move the needle on HP RTU adoption and provide value. These incentive amounts need to factor in the customers' total upfront cost, including installation, to help bridge the price gap of the market replacing existing air conditioner and furnace equipment with HP RTUs.

While Comfortably California grapples with increasing participation with low measure cost coverage, they note that they do see strong participation from one distributor in particular who has the

[33] The midstream incentive pilot flyer may be found in Appendix B.

administrative staffing and software capabilities to submit a high volume of applications. It was stated that a lot of rebate submittals are lost due to the end-user data requirement, often an obstacle for distributors engaged in a midstream program.

CLEAResult also shared that approximately 92.5 percent of TSB from commercial Comfortably California project submissions include air conditioners, furnaces, and boilers, whereas only 7.5 percent of TSB represents heat pump-to-heat pump replacements. Of that 7.5 percent, a mere 1 percent is estimated to cover heat pump fuel substitution, which targets retrofit projects and is the focus of this CalNEXT HP RTU pilot. This data is indicative of how the market is much more interested in the amount of the incentive and the value it provides, rather than what the California Technical Forum (CalTF) eTRM measure package outlines. An interesting perspective gathered from our Program Implementer interview was that the measure package can have minimal effect on the market. Rather, it's common for our industry and the CalTF eTRM to be lagging when compared to projects and installs the market is actively completing for customers out in the field.

Pilot Feedback

We collected participant feedback to assess the effectiveness of the focused midstream pilot. This feedback provides valuable insights that will aid the development of successful incentive programs and inform a strategic approach to participation in electrification efforts, aimed at meeting statewide decarbonization goals.

A critical factor in driving strong participation in a pilot or incentive program is accessibility. Multiple facets of the pilots' accessibility were examined, including overall program accessibility, project submission platform accessibility, and equipment accessibility. We received feedback from the field indicating that the level of difficulty in participating in the CalNEXT HP RTU Focused Pilot was low, with participants describing the experience as "seamless," referencing both the streamlined process and the rebate claim processers. Compared to other RTU incentive programs, this Focused Pilot required a minimal amount of information about the project from the distributor, and participants appreciated not having to upload invoices when submitting projects. However, a few market actors indicated that it's challenging at best to identify, obtain, and document contractor and end-use customer information. Considering these comments, there is some room for improvement around the data collection aspect.

Distributors cited burdensome data collection requirements as a key reason for not participating in the statewide program. They felt the effort required to gather end-user data was not justified by the low incentive offered. Air conditioning and furnace RTUs account for a sizable portion of their sales, and a $10 per ton incentive was insufficient to encourage a shift in inventory. To motivate distributors to stock more heat pump RTUs instead of the commonly sold AC RTUs for retrofit projects, an incentive covering 75%–85% of IMC is required.

Regarding accessibility of the project submission platform, feedback was positive. Participants relayed to us that the process and required fields for incentive submissions were straightforward, with one minor exception: limited visibility into the previous equipment being replaced with an HP RTU. This perspective came from an administrative position who may not be privy to that information, unlike sales and technical engineers who are more likely to have this knowledge for each job.

Distributors also shared that the portal itself is user-friendly, and they appreciated the amount of information it provides, such as rebate amount, number of units, check number, job paid details, and more. Because of the low level of difficulty to participate in this focused midstream pilot, distributors expressed interest in expansion of the pilot into a robust rebate program with a larger annual budget, since many of their equipment units are eligible for a commercial heat pump RTU rebate program.

Market Opportunities

The project team identified the following opportunities for improvement in HP RTU programs: streamline the incentive process, increase program incentives, expand technology offerings, and prioritize high-efficiency features. The following section provides the rationale for how these strategies can enhance market participation in the statewide program.

Streamline the Incentive Process

To enhance participation in the statewide incentive program, it is essential to streamline the incentive process. Historically, there has been low participation due to challenges faced by distributors in data collection and program navigation.

One opportunity for improvement is to lower data collection requirements. Distributors reported difficulties in gathering essential information, such as existing equipment types and other end-user details, during the midstream incentive pilot. Streamlining this process could alleviate the burden on distributors and encourage more project submissions. Downstream market actors have better access to information such as existing equipment types. To improve program effectiveness, alternative methods for collecting this information should be further investigated or estimates for blended baselines could be built into measure packages to remove the need for difficult midstream data collection.

Moreover, addressing database issues related to units manufactured in the same plant but sold by different manufacturers could significantly expedite the claim submission process. If programs could recognize that these systems are effectively the same, despite different branding, it would reduce the complexity of claims and allow for faster processing. However, achieving this would require transparency and cooperation from manufacturers to share necessary information. Implementing these changes could foster greater participation in the incentive program and support the transition to HP RTUs.

Increase Program Incentives

HP RTUs often come with higher costs than traditional RTUs, primarily due to the electrical upgrades and capping of gas lines needed when switching from gas to electric heating. The defrost cycle required for HP RTUs to operate efficiently also contributes to increased project expenses. Additionally, HP RTUs face market constraints, as their reverse cycle valves — an unnecessary component in traditional RTUs — require substantial research and development and thus increase product costs. Distributors estimate incremental installed costs for HP RTUs at around $625 to $1,000 per ton. Increasing program incentives, such as the focused midstream pilot's$300/ton incentive or higher, could help boost HP RTU adoption by alleviating some of the manufacturing and distribution challenges associated with this technology.

Expand Technology Offerings

Results from supply-chain interviews demonstrate that are best suited for single-zone applications. It will take years, if not decades, for HP RTU manufacturers to update their systems to be manufactured for these use cases. However, other commercial heat pump technologies such as DOAS and VRF show potential for significant impacts on the multizone commercial HVAC market. To increase building efficiency for applications that often exclude HP RTUs, the project team recommends developing a measure package for both VRF and for DOAS RTUs.

Prioritize High-Efficiency Features

As mentioned in the Technology Barriers section, many market actors highlighted the need for more efficient HP RTUs. Features such as variable capacity compressors, VFDs, and DCV are desired by the market, but are currently only available through custom orders. An increased emphasis on these features could improve HP RTU performance in the market and accelerate GHG emission reduction goals.

Conclusions

The supply-chain interviews revealed significant barriers to the widespread adoption of HP RTUs in California. These barriers span across market, technology, and policy domains, each presenting unique challenges that must be addressed to promote electrification and meet GHG emissions reduction goals.

HP RTUs face substantial cost disadvantages compared to conventional air conditioning and gas furnace systems. Equipment, installation, and operational costs remain prohibitively high when compared to air conditioner and furnace RTUs. Additional expenses arise from electrical panel upgrades, structural analysis due to heavier HP RTUs than were installed 20 years prior, abandoned gas infrastructure, and fuel conversion.

Incentives under the Comfortably California program currently only offset a small fraction of these costs, limiting financial feasibility for most projects. At $165 per ton for less than 135,000 Btuh, the incentive covers only 36 percent of the IMC. At $50 per ton for greater than 135,000 Btuh and less than 240,000 Btuh, the incentive covers 11 percent of the IMC. The project team's experience implementing upstream HVAC programs have shown that the HVAC market responds to sales of high-efficiency equipment with an IMC coverage percentage (i.e., incentive divided by IMC) of 75 to 85 percent or higher. This is driven by customers overcoming the barrier of exceedingly high installation costs. Distributors noted that customer decisions are based on installed first costs — rather than IMCs — and payback periods. Distributors also advised that customer payback periods range from one to three years, depending on installation costs, meaning that the customer expects the annual energy savings to pay for the difference in cost in one to three years. The payback range depends on the customer's risk assessment of their business, cost of money, interest rates, and the state of the economy, i.e., inflation. Given the current high-risk economy, customers want investments to pay back quickly, e.g., within one year.

Product availability and lead times are improving due to new U.S. DOE refrigerant requirements. This will increase product availability over the next 6 to 12 months. Unfortunately, equipment costs will increase from higher efficiencies and new refrigerants. Stocking decisions are primarily driven by customer demand and code compliance, as previously explained. Public institutions are willing to pay higher installation costs for HP RTUs. Private companies make decisions based on installation costs and payback period. Some public institutions, e.g., colleges and universities, have limited capital budgets due to decreases in enrollment. Without increased demand through enhanced utility incentives, distributors are unlikely to stock high-efficiency HP RTUs in meaningful quantities. Updates to program incentives and requirements should help remedy this situation.

There is a persistent lack of awareness and acceptance among contractors, engineers, and end users. Misconceptions about HP RTU performance, particularly regarding heating capacity, continue to deter adoption along with unsubstantiated and perceived impacts of higher operational costs. Tailored educational initiatives targeting key decision-makers are essential to shift perceptions and foster market confidence. Key decision-makers mentioned by interviewed distributors included the facility directors, property managers, and maintenance supervisors since these are the personnel in charge of overseeing the project implementation at the ground level.

Retrofitting with HP RTUs often necessitates costly electrical panel upgrades where defrost cycling and activation of auxiliary electric resistance heat during periods of cool weather increases power demands. This technological constraint can be a deterrent, particularly when auxiliary electric resistance heating is required to meet heating loads. This occurs when buildings or zones have high ventilation rates or cold ambient temperatures initiate electric resistance heat.

Current building design practices favor air conditioner and furnace RTUs over HP RTUs, particularly in single zone applications. For multizone HVAC systems, VAV with terminal reheat from a boiler or zone electric resistant heat is the common design practice. The limited availability of HP RTUs greater than 20 to 25 tons restricts their applicability in large commercial settings. Additionally, fixed-capacity HP RTUs lack the flexibility to serve these complex environments, while larger and more advanced HP RTUs are prohibitively expensive and limited in availability. This scarcity, combined with the inflated cost and extended lead times, poses a significant barrier to scaling up adoption across diverse building types. With the nation's movement towards electrification, manufacturers have started producing units larger than 20 to 25 tons as well as variable capacity heat pumps. Some of these products will become available in 2025.

Most importantly, as explained in the Acceptance and Awareness section, private companies are unmotivated by California's electrification policies. Instead, private companies are making decisions based on low first cost and payback on investments of one to three years. Therefore, we strongly recommend that utilities offer an incentive high enough to engage private organizations to convert air conditioner and furnace RTU's to HP RTUs. As previously stated, incentives need to cover 75 to 85 percent of the $465 IMC.

Addressing these barriers through coordinated market, technology, and policy interventions is essential to driving the adoption of HP RTUs and advancing California's climate and electrification goals. By enhancing financial support, improving market education, and fostering technological innovation, stakeholders can create a more favorable environment for HP RTU adoption and contribute to a sustainable future. The strongest market push is needed in the private sector, as they are currently not responding to California's electrification goals. The Title 24-2022 prescriptive option has driven an increase in code minimum installations in both the private and public sectors for units under 20 to 25 tons. However, a utility incentive is needed to encourage the stocking and upselling of significantly higher-efficiency units. Midstream HVAC utility incentive programs have proven, since 1997, to dramatically increase sales and installations of higher-efficiency units.

Recommendations

Based on the culmination of distributor interviews, market research, and an investigation of barriers to HP RTU adoption, the project team recommends the following:

1. Focus on single-zone distribution systems: Prioritize replacing single-zone packaged air conditioner and furnace systems (6 to 25 tons) with HP RTUs in commercial applications. Additionally, develop documentation on the operational cost benefits of transitioning from AC RTUs to HP RTUs, as current data is lacking.
2. Study DOAS: For larger multizone applications, such as medium to large offices and hospitals, schools, colleges, and other building types with high ventilation requirements, we recommend investigation into DOAS with and without heat recovery. This approach can effectively manage large ventilation loads using waste heat recovery, enhancing cost-effectiveness and overall system benefits.
3. Increase program incentives: Currently, the Comfortably California incentives cover only approximately 25 percent of the IMC for HP RTUs. To boost adoption, we recommend increasing incentive amounts 75 to 85 percent (or higher) of the IMC for higher IMC coverage. The average IMC received from market actors was $465 per ton.
4. Identify projects without auxiliary heat: The greatest potential to increase HP RTU installations lies in pursuing additional research to better understand when panel upgrades are required. We recommend documenting enhanced design practices that allow HP RTUs to be installed in retrofit situations without auxiliary heat and conducting educational classes tailored for various market actors. This would allow future incentive programs to target sites and enhance the number of sites that can install an HP RTU without auxiliary heat, eliminating the need for panel upgrades and increasing the number of sites that can convert to HP RTUs.
5. Enhance supply-chain education: Offer additional education to distributors and contractors by providing training and literature on the benefits of HP RTU technology. Education topics should include how current heat pump technology differs from older heat pump technology, how to calculate lower operational costs, cool weather performance (i.e., capacity at various low temperatures), and updates to system design. Heat pump technology has advanced significantly in the past few decades, yet misconceptions about poor heat pump performance from prior decades linger today. Distributing marketing materials to local contractors can increase familiarity, leading to a higher likelihood of increased stocking and upselling of HP RTUs in the California market. Customer education is also needed to enhance understanding of the benefits of heat pump technology, including lower operating costs, cool climate performance, lower supply air temperatures, and proper thermostat operation. Customers in charge of overseeing project implementation at the ground level are of particular interest for targeted material, including commercial facility directors, property managers, and maintenance supervisors.
6. Add VRF to the California measure offering (California eTRM): Multizone building applications currently screen out the commercial heat pump RTU measure. To reach California's climate

goals, we recommend adding VRF to supplement current commercial fuel substitution efforts.

7. Document new system design specifications for HP RTUs in multizone applications: The second largest potential for expanding HP RTU installations lies in researching and documenting HVAC system designs that utilize HP RTUs in multizone applications. This would significantly enhance the use of HP RTU technology in the greater-than-20-to-25-ton category, which is currently limited.

By implementing these recommendations, we aim to overcome current barriers, drive market transformation, dramatically increase installations (e.g., with HP RTUs that don't need auxiliary heat and greater use of larger-sized units in multizone applications) and promote the adoption of heat pump technology in California's commercial sector.

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Appendix B: Focused Midstream Pilot Flyer

Calling for distributors:
Incentives available for commercial packaged unitary heat pumps

How It Works

1. **Enroll as a pilot distributor** in the CalNEXT Packaged Unitary Heat Pump Incentive Pilot by contacting sestupinian@energy-solution.com.
2. **Verify equipment eligibility.** Equipment must meet all requirements as indicated under Equipment Eligibility (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.** Please maintain invoice documentation and capture the customer installation address.
5. **Submit the application for incentive.** Energy Solutions 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

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

Incentives are quickly reimbursed—within two weeks of application submission.

Keep your competitive edge by offering lower prices on high quality equipment.

Provide your input on future incentives for this equipment throughout the state.

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

ET23SWE0073: Supply Chain Engagement for Increasing Packaged Unitary Heat Pump System Adoption v240911

Packaged Unitary Heat Pump Incentive Pilot

Equipment Eligibility

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.

Size Category (Cooling BTUH)	Minimum IEER	Minimum COP	Incentive per ton
≥ 65,000 and < 135,000 BTUH	15.0	3.4	$300
≥ 135,000 and < 240,000 BTUH	14.5	3.2	$300
≥ 240,000 BTUH	13.5	3.2	$300

Incentive

$300

per ton

for qualifying equipment

Incentives are limited to a maximum of $15,000 across all eligible equipment installed at any single location.

Enrollment

Invited distributors who sell qualifying equipment to commercial facilities in the California investor-owned utilities electric service territory are eligible to participate.

Pilot Duration

This is a short-term pilot scheduled to operate from July 1, 2024 through February 28, 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.

If you have questions or would like to enroll in the pilot, contact us at (510) 482-4420 x937 or email sestupinian@energy-solution.com.

Energy Solutions

Appendix C: California Title 24 Regulations Around Commercial RTU HPs

Introduction to Title 24 Regulations

In compliance with Title 24 of the California Code of Regulations, specific requirements must be met for HP RTUs within the range of 5.4 to 60.3 tons to ensure energy efficiency and proper functionality in commercial buildings. This section outlines the key regulations and mandatory requirements set forth in Title 24, focusing on heat pump efficiency, control systems, and design criteria.

Heat Pump Efficiency Requirements

According to Section 110.2 - MANDATORY REQUIREMENTS FOR SPACE-CONDITIONING EQUIPMENT, manufacturers must comply with the following minimum efficiency standards as outlined in tables 110.2-B, 120.1, 120.2, and 140.4 of Title 24, 2022.

Heating and Conditioning Requirements

Heat Pump Controls: Heat pumps with electric resistance booster heaters must prioritize the heat pump over the resistance coil. The electric resistance coil may only activate during defrost mode or transient events such as system startup or changes in temperature setpoints. This control capability must be provided by manufacturers and included in the design by engineers.

Central Energy Management Control System (EMCS): All heating systems, including heat pumps, must be managed by an EMCS or a setback thermostat, which allows programming of temperature setpoints for at least four periods within a 24-hour timespan.

Optimum Start/Stop Controls: Systems with direct digital controls down to the zone level must employ an optimum start/stop sequence. This reduces energy consumption during high-emission periods, particularly in the mornings before sunrise.

Design and Operational Requirements for Title 24 Compliance

Demand Control Ventilation (DCV): For designs with an occupancy of 25 people/1,000 ft^2 or more, RTUs must include DCV. Exceptions are provided for specific high-density applications like classrooms and call centers.

Damper Leakage: The maximum allowable damper leakage rate is 10 CFM/ft^2. at 1.0 iwg.

Fault Detection and Diagnostics (FDD): RTUs 4.5 tons and larger with an economizer must monitor system operations and report failures. The FDD system must show the status of:

- Free cooling availability
- Economizer enablement
- Compressor enablement
- Heating enablement

The FDD must detect and notify the operator of the following faults via local annunciation and a building communication system (BACnet®):

- Air temperature sensor fault/failure
- Improper economizing (both when required and not required)
- Damper malfunction
- Excess outdoor air
- Additional Considerations for RTU Design
- Cooling Options: Options include return/exhaust fan or gravity damper.

Economizer Requirements: Full indoor air quality (IAQ) monitoring with airflow measurement, DCV with CO_2 sensors, and economizer control using dry bulb or single enthalpy sensors.

Damper Type: Ultra-low leakage dampers are required.

Heating Restrictions: No electric heating is permitted, except for electric resistance booster heaters as outlined.

Variable Frequency Drive (VFD): While not mandatory, many manufacturers include VFDs to enhance energy efficiency.

Table 12 below includes requirements for efficiency with AHRI 340/360 test procedures for distinct types of heat pumps according to table 110.2-B of Title 24-2022[34].

[34] More information can be found on T24-2022 here: https://www.energy.ca.gov/sites/default/files/2022-08/CEC-400-2022-010_CMF.pdf

Table 12: Requirements for Efficiency and Test Procedure for Various Types of Heat Pumps According to Title 24

Equipment Type	Size Category	Rating Condition	Efficiency
Air Cooled (Cooling Mode), both split system and single package	≥ 5.4 ton and < 11.3 ton		11.0 EER 14.1 IEER
Air Cooled (Cooling Mode), both split system and single package	≥ 11.3 ton and < 20 ton		10.6 EER 13.5 IEER
Air Cooled (Heating Mode) Split system and single package	≥ 5.4 ton and < 11.3 ton (cooling capacity)	47° F *db/43° F **wb outdoor air	3.4 COP
Air Cooled (Heating Mode) Split system and single package	≥ 5.4 ton and < 11.3 ton (cooling capacity)	17° F db/15° F wb outdoor air	2.25 COP
Air Cooled (Heating Mode) Split system and single package	≥ 11.3 ton (cooling capacity)	47° F db/43° F wb outdoor air	3.3 COP
Air Cooled (Heating Mode) Split system and single package	≥ 11.3 (cooling capacity)	17° F db/15° F wb outdoor air	2.05 COP

* = Dry-bulb
** = Wet-bulb

Appendix D: Commercial Heat Pump RTUs Logic Model Highlighting Activities and Outcomes for Higher Technology Adoption

Attached in the following pages is the memo documenting the background research supporting the creation of the **Logic Model Infographic**

October 18, 2024

MEMORANDUM

From: Amruta Khanolkar, Jenna Lusczynski, Mostafa Tahmasebi, Noel Stevens, TRC

To: Carey Oster, Caitlyn Fosberg, Energy Solutions

Project: Commercial Heat Pump RTUs Logic Model Highlighting Activities and Outcomes for Higher Technology Adoption

Background and Introduction

This focused pilot aims to increase the adoption of Commercial Packaged Unitary Heat Pump systems (Commercial HP RTUs) ≥ 5.4 tons through a streamlined midstream pilot program. This project aims to increase the adoption of commercial heat pumps (HPs) in California (CA). The target technology will be packaged unitary heat pumps, also known as Rooftop Units (RTUs) as they would be an excellent option for retrofits of the CA building stock. A large portion of commercial buildings in CA use RTU air conditioners (ACs) with furnaces for space conditioning and heat pumps would be suitable drop-in replacements.

This memo presents a logic model (Appendix B) for program design to produce energy savings resulting from increased adoption of electric heat pump rooftop units in California. The identified activities and objectives are targeted to promote both a policy objective and a program strategy to promote the value and self-sustaining presence of HP RTUs in the marketplace. The logic model found in *Figure 9* consists of 4 key elements: Barriers, Activities, Outputs, and Outcomes. We further separate outcomes by the time horizon in which the benefits are expected to occur short-term, intermediate-term, and long-term outcome. While logic models often depict inputs to the market transformation process, for simplicity we exclude inputs from the visual representation, but do discuss inputs in the sections that follow. Finally, the logic model includes arrows to show the interactive and intertemporal (involving different time periods) nature of program activities, outputs, and outcomes. Outputs and outcomes from some program activities result in short term outcomes that require further program or market engagement to provide for additional outputs and longer-term outcomes.

Market Potential

According to SWHC013-02 and SWHC014-02 work papers[35] package systems account for about 95 percent of the unitary market while split systems accounting for only 5 percent: Single-package AC/HPs are common in the commercial sector; the ratio of split-system versus single-package AC/HP in the commercial market sector is approximately 1 in 20. Split-system AC/HPs are more common in the residential market.

There is evidence that the market has not yet incorporated products which are above code standards as industry standard practice. A 2016 Bonneville Power Administration study of sales in the Pacific Northwest found that 97 percent of commercial split system air-cooled heat pumps and 82 percent of commercial package air conditioners were code minimum products[4]. Existing buildings account for about 60-70 percent of the market and the majority of replacements are like-for-like systems in size and type[5].

Any unit greater than 5 tons is very likely to be installed in a commercial setting. According to Air-Conditioning, Heating and Refrigeration Institute (AHRI), about 618,430 unitary products greater than 5.4 tons were sold in 2018 and 2019[6]. Assuming that CA accounts for about 12% of the market as weighted by population, about 74,449 units greater than 5.4 tons were sold in CA across all Investor-Owned Utility (IOU) and non-IOU territories. About 5,076 of these sales passed through IOU rebate programs those years.

Market Transformation Logic Model

Figure 9 below separates barriers into technology, market, and program/policy barriers. We discuss each of these in the sections that follow. 5 distributors, 2 implementors, and 1 manufacturer were interviewed, and the below section summarizes the feedback received from these market actors.

Technology Barriers and Findings

This section summarizes the Technology barriers identified by the market actors that reflect technical limitations of the existing Technology Landscape to displace existing technologies leading to widespread adoption of HP RTUs. TRC identified a number of technological barriers to increased adoption of HP RTUs. The main pain points identified by the contractors and program implementers are:

- Electrical constraints for retrofit applications: One of the barriers for going from a RTU with gas heating to all electric HP RTUs is that it may require electrical panel upgrades to accommodate the increased electric load. Market actor interviews revealed that one of the most dominant technologic constraints HP RTUs confront are those that substantially increase electrical panel load requirements. These include increased load due to defrost cycling (particularly in colder climates in Northern California and need for cooling in Southern California).
- HP RTU Interviews also found there was a need for a variety of technological advancements including need for variable capacity compressor to modulate discharge temperature, HP RTUs with variable refrigerant flow (VRF), variable frequency drives (VFDs) and demand control ventilation (DCV). DCV modulate the airflow to meet the need at any given time. Numerous market actors cited the need for larger (>25 ton) and multi-zone HP RTUs to address segments of the market not currently suitable to existing systems.

Market Barriers and Findings

From the supply chain interviews, we identified that the market barriers represent physical, financial, perceptional (awareness and acceptance), and information constraints that prevent the adoption for HP RTUs from expanding within the current market. TRC identified market barriers that impact the economics of specifying HP RTUs, awareness and acceptance of the technology among contractors, specifiers, engineers, and workforce readiness to adapt to install HP RTUs as they become more attractive alternatives. The following section describes the first cost, installed cost, acceptance & awareness, and market intelligence barriers.

First Cost and Installed Cost

Cost is the predominant market barrier impacting adoption of HP RTUs. The replacement market for heating and cooling is largely constrained to like-for-like replacement due to the relatively high installation and equipment costs discussed below. The market actor interviews report that the acquisition costs of HP RTUs are still greater than furnace plus air conditioning, leaving them at a competitive disadvantage from a price perspective.

While the cost differential between HP RTUs and competing technologies is substantial, the relatively high acquisition cost of HP RTUs is only one source of cost differences. In gas to electric replacements, the higher installation cost due to electrical upgrades further limits the market. This is largely due to installation cost pressure resulting from the need for electrical panel upgrades that may be required to handle additional loads. In such cases the customer and installer are more likely to go for like-for-like replacements with new gas units.

Market actors report a range of other factors that add to installation costs beyond panel upgrades. In northern regions, the need for defrost cycling can also increase electrical load requirements, thereby, making panel upgrades necessary. Multiple market actors also mentioned the need for larger systems or systems with additional features like defrost cycling, multi zone units, variable refrigerant flow (VRF) and demand control ventilation (DCV). While larger systems or systems with additional features may be custom built, the cost and lead time necessary for securing these custom-built systems creates a market barrier as timeliness is a key consideration for the technology to remain competitive. Plus, larger systems will add additional load on the exiting building roof, so additional consideration are necessary for structural and seismic purposes.

Depending on the efficiency and size of RTU heat pumps, equipment cost can vary. *Table 13* and *Figure 8* compare the average equipment cost for code minimum, typical efficiency, and highest efficiency models at different capacities[2]. As an example, price difference between code minimum models and high efficiency heat pumps is between \$600 to \$800 per ton. This price difference is also noticeable between typical efficiency and high efficiency heat pumps, ranging from \$400 to \$700 per ton.

Table 13. Typical Costs of HP RTUs by Efficiency

HP RTUs, Fuel Substitution 5.4 tons-11.2 tons		
	Retail Price ($/ton)	**Comfortably CA Incentives**
T24 Code Minimum	\$1050-\$1055	No Incentive
Typical efficiency	\$1206-\$1243	\$165/ton
Highest Efficiency	\$1700-\$1780	\$165/ton

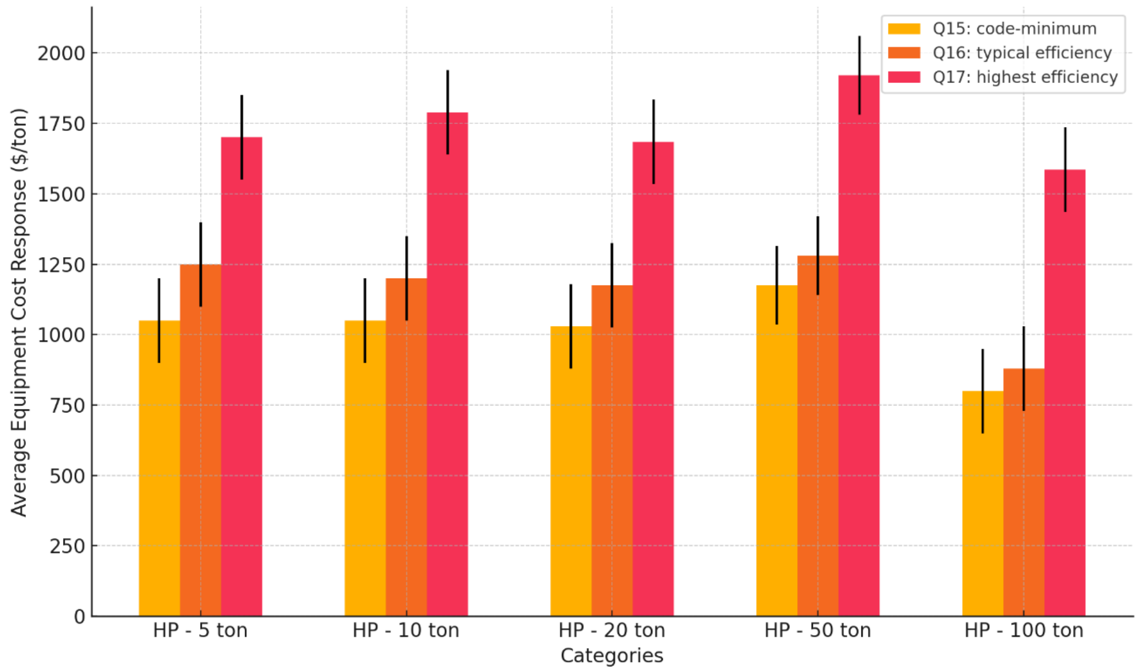

Figure 1. Average Equipment Costs for Code Minimum, Typical Efficiency, and Highest Efficiency Heat Pumps

According to an industry standard practice study of AC and heat pump systems[1], typical efficiency and highest efficiency, relative to code minimum requirement is provided in the following table.

Table 14. Performance Metrics for Various Efficiency Tiers of Heat Pumps

	HP<5.4 ton (SEER) T24 2023	5.4 ton<HP<11 ton (IEER)	11 ton<HP<20 ton (IEER)	20 ton<HP<63.3 ton (IEER)
T24 Code Minimum	14	14.1	13.5	12.5
Typical efficiency	14.3	15.5	14.6	13.7
Highest efficiency	19	19.4	18.3	16.9

These cost barriers lead the research team to conclude that the immediate market includes buildings with smaller heat loads (i.e. southern California) or that currently already have electric heating systems (e.g. electric resistance heat). The longer-term strategy for expanding HP RTU adoption requires technological advances to overcome these installation cost challenges.

Acceptance and Awareness

HP RTUs face numerous information barriers related to awareness and acceptance of the technology in the market. HP RTUs are not commonly considered in the new construction market, and face uncertainty regarding cost/performance tradeoff in the replacement market. The information barrier is compounded by a lack of awareness about technology benefits, marketing materials resulting in distributors being cautious to stock larger sized HP RTUs and contractors resistant to specifying them due to awareness and acceptance about the technology and lack of installation guidance. Limited stocking by distributors also results in further resistance from contractors to specify HP RTUs.

Market Intelligence

The research team identified an additional information barrier common to most new technologies. An important characteristic of a mature market is there is perfect or near perfect information that lowers the cost of doing business by eliminating risk associated with the exchange of goods and services. Mature markets such as lumber, paper, food, commodities, and even information technology many other goods have well documented sales, pricing, and shipment data to inform manufacturer, distributer, retailer, and contractor/end user decisions.

Data reporting shipments, prices or the value of shipments or products are commonly available for many consumer goods. Data often differentiate products, sales, and prices by key attributes, such as size, make, model, and even efficiency rating. This market intelligence helps distributors/retailers plan merchandizing and promotional practices, and reduces risk associated with increasing the availability of goods. Changes to retailer marketing helps educate and inform end-use customers regarding the benefits of different products. On the other end of the supply chain, market data also reduces risk to manufacturers who look to the market for demand signals to increase production. Finally, state and federal code and standard agencies' ability to update and improve product testing procedures and codes to better reflect potential increasing efficiency levels of the portfolio of products sold is constrained by the availability of market data. In Absence of this market intelligence information, market actors throughout the supply chain assume increased risk for manufacturing, shipping, stocking, and specifying equipment.

Program and Policy Barriers and Findings

Market actor interviews found that existing midstream programs create an additional barrier as the programs place unnecessary administrative burden on participants such as burdensome paperwork and installation tracking. Additionally, market actors argued that the efficiency requirements (code cost-effectiveness test) of local programs constrain expanding HP RTUs, particularly in new construction.

Comfortably California has an incentive program for commercial HP RTUs. These incentives are provided in the following tables. Most commonly, market actors mention that incentive amounts for HP RTUs are too low to supersede the higher cost of these units, which make them less competitive since the cost is higher. Considering the price point for different efficiency tiers of RTU HPs, this shows a big gap between the typical retail price vs what the incentives cover (approximately 15 percent coverage only). This highlights the disinterest and low participation the program experienced. Note that the Comfortably CA efficiency requirements are higher than the code minimum requirements as well as the CA Technical Resource Manual (TRM) for

Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution | ETRM (caetrm.com). See *Table 15* below for the comparison.

Table 15. Incentives and Program Requirements for 3 Efficiency Tiers of HP RTUs 134kBTU/h-239kBTU/h

HP RTUs, Fuel Substitution				
	Comfortably CA Incentives	**T-24 requirement**	**Comfortably CA program requirement**	**TRM[7] program requirement**
HP RTUs 65kBTU/h-134kBTU/h	$165/ton	14.1 IEER, 3.4 COP	16 IEER, 3.4 COP	15 IEER, 3.4 COP
HP RTUs 135kBTU/h-239kBTU/h	$50/ton	13.5 IEER, 3.3 COP	15.5 IEER, 3.2 COP	14.5 IEER, 3.2 COP
HP RTUs 240kBTU/h-759kBTU/h	175/ton	12.5 IEER, 3.3 COP	14 IEER, 3.2 COP	13.5 IEER, 3.2 COP

Table 4. Incentives and Program Requirements for 3 Size Ranges

HP RTUs, Non-Fuel Substitution			
	Comfortably CA program requirement	**Comfortably CA Incentives**	**Category**
Cooling Capacity (Btu/h) ≥ 65,000 & ≤ 134,000	11.5≤EER<12	$10/ton	Unitary Large Equipment
	EER≥12	$15/ton	
Cooling Capacity (Btu/h) ≥ 135,000 & ≤ 239,000	11.5≤EER<12	$15/ton	Unitary Large Equipment
	EER≥12	$20/ton	
Cooling Capacity (Btu/h) ≥ 240,000 & ≤ 759,000	10.5≤EER<10.8	$20/ton	Unitary Large Equipment
	EER≥12	$25/ton	

In order to be cost competitive with other HVAC system types, the incentive amount would need to be increased to ~$1,000 to $1,500/ton for 5-to-20-ton units, and at least $1,000/ton for 20–25-ton units. It was also stated that people are risk adverse, and purchasing and installing HP RTUs may be out of their comfort zone. It will be helpful to utilize this pilot as a successful case study to assist in gaining more market share.

AHRI database findings:

As part of current market analysis, we examined the AHRI product database for unitary systems that matched the criteria of this pilot study. We analyzed 2,182 active units with unique model numbers, focusing on specific criteria based on capacity and efficiency ratings. The capacity range of the units analyzed spanned from 5.4 tons to 63.3 tons. During our analysis, we identified 501 duplicate units which were found across different brand names but shared the same exact specifications and performance metrics. To ensure accuracy, we excluded these duplicates by retaining only one instance of each model number. The analysis further broke down the number of units in each capacity range:

- 74 units within the 5.4-11.3 tons range,
- 70 units within the 11.3-20 ton range, and
- 1,537 units within the 20-63.3 ton range.

  Additionally, we categorized the refrigerant types used in these units,

- 120 units using R-410A,
- 30 units using R-454B, and
- 1,531 units using R-32.

The Comfortably California program requires units in the 5.4 to 11.3 ton capacity range to have a minimum of 16 IEER and 3.4 COP, with 29 products in the market meeting these specific performance requirements. For the 11.3 to 20 ton capacity range, the program specifies that units must have at least 15.5 IEER and 3.2 COP, and the analysis identified 48 units that meet these criteria. In the 20 to 63.3 ton capacity range, where the program sets a minimum requirement of 14 IEER and 3.2 COP, there are 1,533 products available in the market that comply with these performance standards.

- **California Title 24 Regulations Around Commercial RTU HPs**

Introduction to Title 24 Regulations

In compliance with Title 24 of the California Code of Regulations, specific requirements must be met for rooftop unit (RTU) heat pumps within the range of 5.4 to 60.3 ton to ensure energy efficiency and proper functionality in commercial buildings. This section outlines the key regulations and mandatory requirements set forth in Title 24, focusing on heat pump efficiency, control systems, and design criteria.

Heat Pumps Efficiency Requirements

According to Section 110.2 - MANDATORY REQUIREMENTS FOR SPACE-CONDITIONING EQUIPMENT, manufacturers must comply with the following minimum efficiency standards as outlined in Table 110.2-B, 120.1, 120.2, 140.4 of Title 24, 2022.

Heating and Conditioning Requirements

- **Heat Pump Controls:** Heat pumps with electric resistance booster heaters must prioritize the heat pump over the resistance coil. The electric resistance coil may only activate during defrost mode or transient events such as system startup or changes in temperature setpoints. This control capability must be provided by manufacturers and included in the design by engineers.
- **Central Energy Management Control System (EMCS):** All heating systems, including heat pumps, must be managed by an EMCS or a setback thermostat, which allows programming of temperature setpoints for at least four periods within a 24-hour timespan.

- **Optimum Start/Stop Controls:** Systems with direct digital controls down to the zone level must employ an optimum start/stop sequence. This reduces energy consumption during high-emission periods, particularly in the mornings before sunrise.

Design and Operational Requirements for Title 24 Compliance

- **Demand Control Ventilation:** For designs with an occupancy of 25 people/1,000 sq. ft. or more, RTUs must include DCV. Exceptions are provided for specific high-density applications like classrooms and call centers.
- **Damper Leakage:** The maximum allowable damper leakage rate is 10 CFM/sq. ft. at 1.0 iwg.
- **Fault Detection and Diagnostics (FDD):** RTUs 4.5 tons and larger with an economizer must monitor system operations and report failures. The Fault Detection and Diagnostics (FDD) system must show the status of:
    - Free cooling availability
    - Economizer enablement
    - Compressor enablement
    - Heating enablement

The FDD must detect and notify the operator of the following faults via local annunciation and a building communication system (BACnet®):

- Air temperature sensor fault/failure
- Improper economizing (both when required and not required)
- Damper malfunction
- Excess outdoor air

Additional Considerations for RTU Design

- **Cooling Options:** Options include return/exhaust fan or gravity damper.
- **Economizer Requirements:** Full indoor air quality (IAQ) monitoring with airflow measurement, DCV with CO_2 sensors, and economizer control using dry bulb or single enthalpy sensors.
- **Damper Type:** Ultra-low leakage dampers are required.
- **Heating Restrictions:** No electric heating is permitted, except for electric resistance booster heaters as outlined.
- **Variable Frequency Drive (VFD):** While not mandatory, many manufacturers include VFDs to enhance energy efficiency.

Table 12 includes particular requirements for efficiency with AHRI 340/360 test procedures for various types of heat pumps according to table 110.2-B of [Title 24, 2022](#).

Table 16. Requirements for Efficiency and Test Procedure for Various Types of Heat Pumps According to Title 24

Equipment Type	Size Category	Rating Condition	Efficiency
Air Cooled (Cooling Mode), both split system and single package	≥ 5.4 ton and < 11.3 ton		11.0 EER 14.1 IEER
Air Cooled (Cooling Mode), both split system and single package	≥ 11.3 ton and < 20 ton		10.6 EER 13.5 IEER
Air Cooled (Heating Mode) Split system and single package	≥ 5.4 ton and < 11.3 ton (cooling capacity)	47° F *db/43° F **wb outdoor air	3.4 COP
Air Cooled (Heating Mode) Split system and single package	≥ 5.4 ton and < 11.3 ton (cooling capacity)	17° F db/15° F wb outdoor air	2.25 COP
Air Cooled (Heating Mode) Split system and single package	≥ 11.3 ton (cooling capacity)	47° F db/43° F wb outdoor air	3.3 COP
Air Cooled (Heating Mode) Split system and single package	≥ 11.3 (cooling capacity)	17° F db/15° F wb outdoor air	2.05 COP

* = Dry-bulb
** = Wet-bulb

Conclusion and Recommendations:

- Based on our research findings, air conditioning RTU with heating gas packs are very common in commercial applications with single zone packaged systems. We recommend that this pilot should focus on single zone system replacement with RTU HP for units 20-25 tons. These would be stand-alone installations in Retail and Restaurants that have single-zone RTUs. Currently we are short of a study, that shows installation and operational cost benefits of electrification going from AC RTUs to HP RTUs, we recommend the pilot to document as much information on the financials with these electrification upgrades.
- For larger units, with multizone applications, i.e. medium-large offices and hospitals, we recommend that dedicated outside air system (DOAS) with heat recovery should be studied further as part of the 2024 pilot. This way the large ventilation loads can be covered by the waste heat recovery. This will also help with higher cost effectiveness and total system benefit.
- The California T24 requires the commercial RTUs to meet specific heating and cooling requirements such as prioritizing heat pump controls over electric resistance coils, utilizing a

central energy management control system or setback thermostat for all heating systems, and employing optimum start/stop controls in systems with direct digital controls. Additionally, RTUs must comply with design and operational requirements, including demand control ventilation for high-occupancy designs, a maximum damper leakage rate of 10 CFM/sq.ft. at 1.0-inch water gauge (iwg), and the implementation of fault detection and diagnostic systems for RTUs 4.5 tons and larger. RTU design must also incorporate cooling options, economizer requirements with comprehensive IAQ monitoring, and ultra-low leakage dampers, while adhering to strict heating restrictions that prohibit electric heating, except for designated electric resistance booster heaters.

    - RTU Dedicated Outside Air Systems (DOAS) with heat recovery is above code control capability. It is expected to save on space heating and cooling and would be a good controls strategy to incentivize through the CalNEXT phase 2 pilot program. However, this is currently not part of the phase 1 scope of the pilot, we recommend developing on staged incentive structure and savings potential estimates for the phase 2 of the pilot.

- The statewide program, Comfortably California incentives cover about only 15 percent of the retail price of the HP RTU units. For the pilot, increased program incentives will help with higher pilot adoption and help with scaling of the program. To be cost-competitive with other technologies, we recommend increasing the incentive amounts to ~$1,000 to $1,500/ton for 5-to-20-ton units, and at least $1,000/ton for 20–25-ton units.
- The Comfortably California RTU HP efficiency requirements are higher than California's Technical Resource Manual (TRM) efficiency requirements. This is reducing the number of manufacturers and the products that quality for the rebate incentives. To increase the interest in the program, the program efficiency requirements should be aligned with TRM efficiencies. This means adjusting the Comfortably California efficiency requirements to match TRM requirements. This will allow more HP RTU units to qualify for these incentives.
- To remedy other market barriers, supply chain awareness can be improved by providing distributors trainings and literature which notes the HP RTU technology benefits, marketing materials to be distributed to local contractors, and once distributors have gained more familiarity and awareness, this could lead to stocking more larger sized systems.

Appendix A

Technology Landscape

HP RTUs are ideal for mild climates. While Commercial HP RTUs have been on the market for decades, adoption in California is lower than expected given the generally mild climate that is suitable for heat pump heating. The need for defrost cycling i.e. when the temperature dips below 20°F, the coil freezes, therefore the HP RTU coils need to heat up which leads to constant cycling between heating and cooling and increases the electrical panel requirements due to the increased energy use. Commercial HP RTUs are likely to be good candidates for drop-in replacements for the thousands of RTU air conditioners with gas heating currently installed in California. Currently there are more than 40 manufacturers in the market with commercial units between 5.4 ton to 63.3 ton (most common commercial packaged RTU sizes). The

Table 17 below shows the catalog of representative RTU units in the market, the manufacturer specifications with links to the products.

Table 17. RTUs in the Market with Specifications

Product	1	2	3	4	5	6
Refrigerant	R-410A	R-410A	R-410A	R-410A	R-410A	R-410A
Available Capacity Range	3-25 ton	6-60 ton	3-28 ton	6.5-12.5 ton	12.5-25 ton	5-25 ton
Cooling Efficiency (5.4-11.3 ton) IEER	15	Up to 22.5	19.3-20.6	13.2-13.5	NA	14.3-16.5
Cooling Efficiency (11.3-20 ton) IEER	14	Up to 19.9	18-20	NA	16.1 – 18.4	14.3-15.5
Heating Efficiency COP	3.3-3.6		3.33-3.69	3.2-3.4	3.3	3.4-3.7

Figure 8. A catalog of representative RTUs and their performance metrics

AHRI database findings:

As part of current market analysis, we examined the AHRI product database for unitary systems that matched the criteria of this pilot study. We analyzed 2,182 active units with unique model numbers, focusing on specific criteria based on capacity and efficiency ratings. The capacity range of the units analyzed spanned from 65,000 BTU to 759,000 BTU. During our analysis, we identified 501 duplicate units which were found across different brand names but shared the same exact specifications and performance metrics. To ensure accuracy, we excluded these duplicates by retaining only one instance of each model number. The analysis further broke down the number of units in each capacity range:

- 74 units within the 65k-135k BTU range,
- 70 units within the 135k-240k BTU range, and
- 1,537 units within the 135K-759K BTU range.

  Additionally, we categorized the refrigerant types used in these units,

- 120 units using R-410A,
- 30 units using R-454B, and
- 1,531 units using R-32.

The Comfortably California program requires units in the 5.4 to 11.3 ton capacity range to have a minimum of 16 IEER and 3.4 COP, with 29 products in the market meeting these specific performance requirements. For the 11.3 to 20 ton capacity range, the program specifies that units must have at least 15.5 IEER and 3.2 COP, and the analysis identified 48 units that meet these criteria. In the 20 to 63.3 ton capacity range, where the program sets a minimum requirement of 14 IEER and 3.2 COP, there are 1,533 products available in the market that comply with these performance standards.

Appendix B

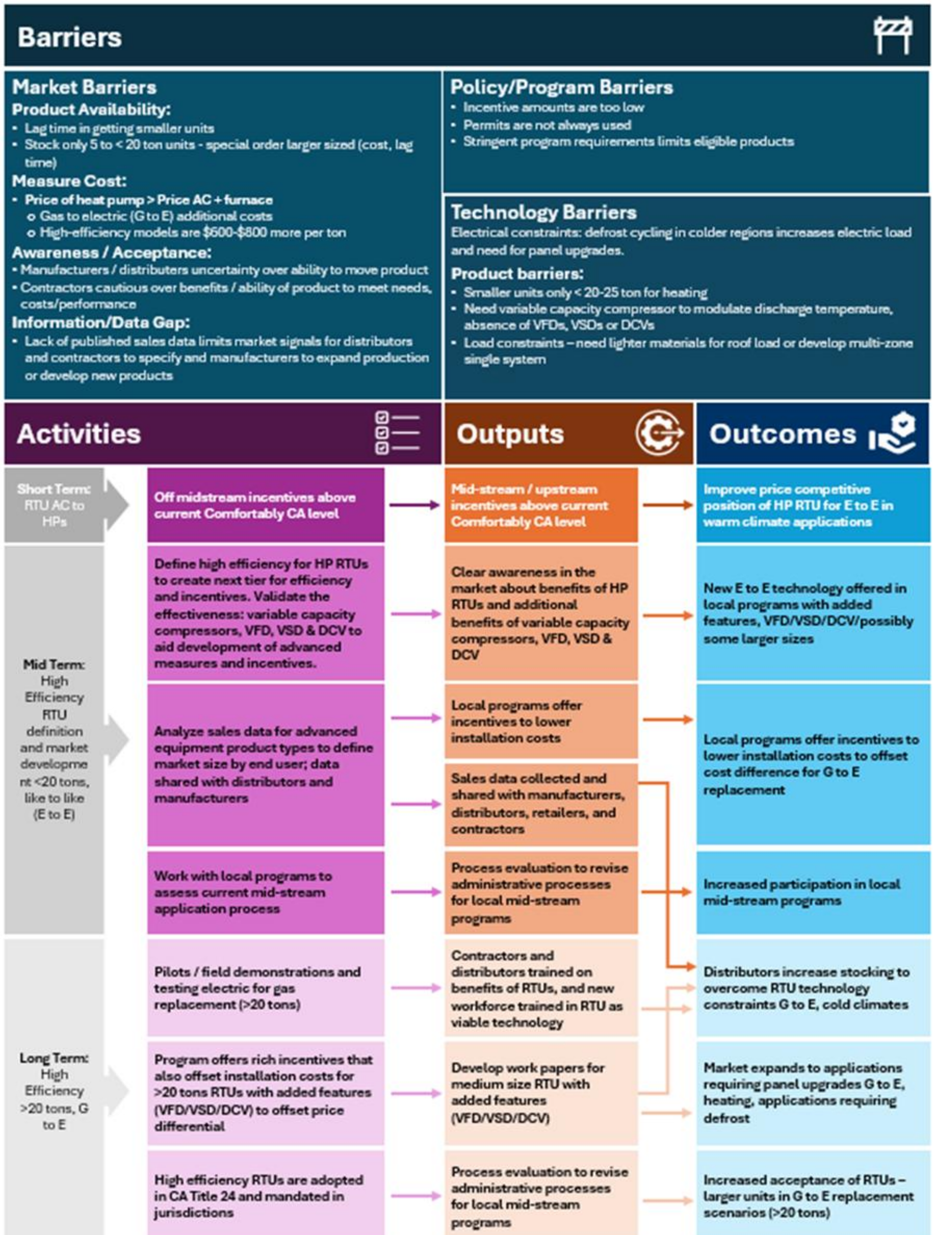

Figure 9. Logic Model

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