Commercial Rooftop Units

Market Transformation Initiative Plan

June 22, 2026

CalMTA is a program of the California Public Utilities Commission (CPUC)
and is administered by Resource Innovations

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Prepared by:
Rick Olson-Huddle, Strategy Manager
Nick Fiore, Program Manager

Resource Innovations
719 Main Street, Suite A
Half Moon Bay, CA, 94019
(888) 217-0217
info@calmta.org

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Purpose

This Market Transformation Initiative (MTI) Plan describes the business case for investment in the MTI including strategic interventions, intended market outcomes, and evaluation activities that will be implemented during Phase III: Market Deployment. This investment would result in long-term energy efficiency and other benefits for California. The MTI Plan was developed using the findings of Phase II assessment and research, which are detailed in the appendices of this document. Development of the MTI Plan followed the stage gate process described in the approved Market Transformation Framework in D.19-12-021. The research findings and plan elements have been shared with CalMTA's Market Transformation Advisory Board (MTAB) throughout development. The MTAB also had the opportunity to review and provide comments and feedback on the plan, which are included in Appendix I of this plan. All MTAB meetings are public and interested parties will have an opportunity to comment via a California Public Utilities Commission (CPUC) application proceeding.

MTI development documents by phase

Additional information on CalMTA and the MTI development process can be found at https://calmta.org.

The Advancement Plan for this MTI can be found at https://calmta.org/resources-and-reports/.

Contents

List of Abbreviations

Abbreviation	Definition
ACC	Avoided cost calculator
AFDD	Automated fault detection and diagnostics
AFDD+	Enhanced automated fault detection and diagnostics
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BAAQMD	Bay Area Air Quality Management District
BAS	Building automation system
BMA	Baseline market adoption
BMS	Building management system
CalMTA	California Market Transformation Administrator
CalNEXT	California Emerging Technology Program
CARB	California Air Resources Board
CASE	Codes and Standards Enhancement
CBO	Community-based organization
CCC	Connected commissioning and controls
CEC	California Energy Commission
CEE	Consortium for Energy Efficiency
CERI	Commercial Energy Reduction Initiative
CET	Cost Effectiveness Tool
CPUC	California Public Utilities Commission
CRTU	Commercial Rooftop Unit
DOE	U.S. Department of Energy
DR	Demand response
EM&V	Evaluation, measurement, and verification
EPCA	Energy Policy and Conservation Act
EPIC	Electric Program Investment Charge
ERV	Energy recovery ventilation
ESJ	Environmental and social justice
eTRM	Electronic Technical Reference Manual
GHG	Greenhouse gas
HP	Heat pump
HRV	Heat recovery ventilation
HVAC	Heating, ventilation, and air conditioning
IOU	Investor-Owned Utility
IVEC	Integrated Ventilation Economizing and Cooling

Abbreviation	Definition
IVHE	Integrated Ventilation and Heating Efficiency
LAUSD	Los Angeles Unified School District
LMS	Load Management Standards
MN CEE	Minnesota Center for Energy and the Environment
MPIs	Market Progress Indicators
MT	Market transformation
MTAB	Market Transformation Advisory Board
MTI	Market Transformation Initiative
NEEA	Northwest Energy Efficiency Alliance
NLR	National Laboratory of the Rockies
NPV	Net present value
NREL	National Renewable Energy Lab
NYSERDA	New York State Energy Research and Development Authority
OEM	Original equipment manufacturer
PA	Program Administrator
PAC	Program Administrator Cost
PG&E	Pacific Gas and Electric
RFI	Request for Ideas
RTU	Rooftop Unit
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
SCG	Southern California Gas
SCT	Societal Cost Test
SDG&E	San Diego Gas and Electric
TBE	Theory-based evaluation
TMA	Total market adoption
TOU	Time of use
TRC	Total Resource Cost
TSB	Total System Benefit
UES	Unit energy savings
WE&T	Workforce, education, and training

1 Executive summary

CalMTA's Commercial Rooftop Unit (CRTU) Market Transformation Initiative (MTI) aims to accelerate adoption of advanced heat pump (HP) RTUs with variable speed supply fans and connected commissioning and controls (CCC) for energy-efficient heating and cooling in California's commercial buildings. [1] The opportunity for impact is significant: over half of the commercial floor space in California is served by RTUs, which are especially prevalent in small and medium sized commercial buildings. The interventions proposed in this MTI will help these smaller buildings decarbonize in a cost-effective manner and help ensure the heating, ventilation, and air conditioning (HVAC) equipment is better maintained, prolonging the savings for years to come.

This MTI represents a strategic opportunity for California to reduce commercial building energy consumption, reduce peak demand, and unlock grid-supportive flexibility at scale. By increasing the adoption of efficient and flexible HVAC units, this MTI will not only benefit tenants and owners of small buildings, but reduce the need for new transmission and distribution investments, which will increase affordability to all rate payers. The modeling, market research, and stakeholder input from Phase II shows that this MTI demonstrates strong potential to achieve meaningful energy savings, improve installation quality, and reduce operational faults through the adoption of smarter, more efficient RTU equipment.

1.1 Market overview

This section provides an overview of the importance of RTUs in California, how heat pump RTUs are becoming more prevalent, and the opportunity to transform this market to realize energy and demand savings through advanced CRTUs.

RTUs: the commercial building workhorse

RTUs provide HVAC in one packaged piece of equipment. They are used in warehouses, schools, offices, retail buildings, and restaurants. They are especially prevalent in small businesses like restaurants and strip malls, where over 90% of the floor space is conditioned by single-zone RTUs. Looking at all commercial floorspace in California, over half is conditioned by single-zone RTUs, with 40% being leased, and 60% owner-occupied or government owned.[2]

Most of the current stock of RTUs provide heat through a natural-gas-fired furnace, although this trend is changing (as we discuss later in this section). RTUs come with packaged control boards that sequence the fan, heating, and cooling as needed. While it's not uncommon for RTUs to be

[1] Throughout this document, CalMTA has created the term "CRTU" to refer to both the name of the MTI and any RTU that meets the CalMTA definition of an advanced RTU.

[2] See Section 4 Market Characterization for a more detailed description and sources.

connected to a building management system (BMS), most are connected to stand-alone thermostats: either programmable or Wi-Fi enabled.[3,4]

RTU manufacturers offer both mass-market and custom-built equipment. Contractors typically purchase mass-market RTUs from distributors; these units are the most likely to be used in the replacement market. In high performance new construction projects, designers may specify custom RTUs that are shipped directly to the site. While several manufacturers currently offer RTU products with advanced features – such as sensors, controls, variable speed fans, and customer interfaces for fault detection and performance optimization – some of these offerings are typically at a higher cost, custom ordered, and associated with longer lead times.

The target market of this MTI is planned and unplanned replacement equipment in existing commercial buildings served by non-BMS, single-zone RTUs with a cooling capacity of 3 to 20 tons. Key market features and dynamics include:

- Approximately 80% of RTU replacements are unplanned.[5] In this scenario, availability and price are key factors in decision making.
- End users often rely on the advice of contractors for help in unit selection.
- When purchasing a new RTU, most facility managers (66%) were willing to wait for their preferred equipment model, whereas only 15% of building owners shared this preference. Among those who indicated they were willing to wait, facility managers were willing to wait longer for replacements, up to 2.7 months compared to 1.6 months for building owners.

Between 26% and 46% of all RTU replacement sales are heat pumps. We discuss this data next, in the context of a variety of factors.

Heat pump RTUs in California

Sales data from the 18 contractors interviewed by CalMTA in late 2024 indicate that heat pumps and gas packs[6] each accounted for nearly half of RTU sales. CalMTA also interviewed five distributors who indicated 26% of their total RTU sales were heat pumps. The CalMTA Market Characterization Report estimates the heat pump market share in the replacement market falls in the range between 26% and 46% – the share estimated by distributors and contractors,

[3] See Section 4 Market Characterization for a more detailed description and sources.
[4] A building management system is a computer-based control system that monitors and manages a building's HVAC system.
[5] Planned replacements are new RTUs installed prior to the existing equipment failing, and unplanned replacements occur when an existing system fails. See Appendix D: Market Characterization Report Section 3 for a more detailed description and sources.
[6] Gas-heated RTUs are commonly referred to as gas packs.

respectively. However, in the new construction market, heat pumps represent 76% of the RTU market.[7]

Based on 2018 data from ComStock, a commercial building stock model, CalMTA estimated that 64% of the floorspace served by RTUs was gas heated, 25% was heated by electric resistance, and only 9% was served by heat pumps. These proportions are undoubtedly changing due to a variety of factors:

- Title 24 requires RTUs for new construction and major additions to be heat pumps for most building types/climate zones.
- Electrical power requirements are not as big of a barrier as previously thought, especially in warmer climate zones of California. When design-heating load is equal to or less than design-cooling load, no additional electrical power is required for a HP versus a gas pack.
- The Bay Area Air Quality Management District (BAAQMD) has a zero NOx requirement for residential and commercial furnaces, including replacements, scheduled to take effect January 1, 2029. This requirement essentially demands a HP.
- The California Air Resources Board (CARB) has laid out policies and actions to get to carbon neutrality by 2045 or earlier.[8] As part of this effort, they are considering a zero-emission requirement for space and water heaters, which would require a HP.
- The difference in operating costs between gas and electric heating is decreasing. CalMTA's analysis shows that, when factoring in CRTU equipment performance and utility rate structures, heat pump RTUs have lower operating costs than gas-fired RTUs across IOUs, with only one exception.[9]
- Climate goals are pushing corporations, municipalities, and school districts to install replacement HPs. The Los Angeles Unified School District (LAUSD), for example, has been replacing their smaller gas units with HP RTUs and plans to expand to larger tonnages when they become more readily available. Confirming the CalMTA findings, LAUSD discovered that operating costs for the new HP units are lower than for the previous gas units.[10]

The need for improved RTUs

Many RTUs operate inefficiently, consuming more energy and incurring higher operational costs than necessary, and in the most extreme cases, failing early.

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[7] See Appendix D: Market Characterization Report Section 3 for a more detailed description and sources.
[8] Young, Clegern. (2022). California releases final proposal for world-leading climate action plan that drastically reduces fossil fuel dependence, slashes pollution. California Air Resources Board.
[9] See Section 3.4.10 Energy consumption and bill impacts.
[10] Commercial Building Heat Pump Campaign. Case Study LAUSD: Heat Pump Rooftop Unit. U.S. Department of Energy.

Despite their widespread use, RTUs are frequently overlooked by building owners, tenants, and even contractors. Since the units are out of sight on a roof, unless they quit functioning, inefficiencies such as failed dampers can go undetected for years. While Title 24 requires initial acceptance testing and automated fault detection and diagnostics (AFDD), many RTUs do not get set up or commissioned properly.[11] The neglect of RTUs can continue from day one through the lifetime of the equipment; it is very common for owners to skip filter changes and other routine maintenance.

As the number of HPs increase in RTUs and in other equipment, California's winter peak electricity demand is projected to become roughly equal to summer peak electricity demand by 2045.[12] This increase will be even higher if HPs use backup electric resistance heat with high switchover temperatures.[13] This electric resistance heat can greatly increase both utility bills and peak demand, but customers may not be aware since it will not impact heating performance.

1.2 Vision

The CalMTA vision for RTUs includes high-efficiency HPs with variable-speed fans and CCC that improve lifetime efficiency. The goal of this MTI is to accelerate adoption of CRTUs for both planned and unplanned HVAC replacements, delivering significant energy savings, improved occupant comfort, longer equipment life, and grid benefits to support California's decarbonization and electrification goals.

To realize this vision, CalMTA has established a three-tier framework for CRTUs. A CRTU is defined as any unit that incorporates one or more of the following features:

- **Tier 1:** Code-minimum HP RTU equipped with CCC, which is comprised of factory-installed sensors and integrated controls that allow for app-based startup routines, AFDD+, and remote connectivity, including demand response (DR).[14]
- **Tier 2:** HP RTU with a cooling efficiency at least 20% above the federal minimum standard.[15] This tier does not necessarily include CCC.
- **Tier 3:** HP RTU that includes Tier 1 features, Tier 2 features, and has a variable-speed supply fan.

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[11] A 2021 field study found that a combination of factors led to poor installed performance, despite code requirements for AFDD. For more information see: RTU/Economizer Analysis and Field Assessment.
[12] See Section 3.4.8 Mitigating increasing winter peak electricity demand.
[13] The switchover temperature is the ambient temperature at which the unit switches from primary (mechanical) heating to resistance heating (all-electric HP RTUs) or gas heating (dual fuel HP RTUs).
[14] CalMTA defines AFDD+ as automated fault detection and diagnostics beyond current Title 24 requirements, which require the annunciation of economizer faults only.
[15] Tier 2 specifications of cooling efficiency 20% above the federal minimum align with Consortium for Energy Efficiency's Advanced Tier.

CRTU benefits

Each tier of CRTU provides distinct benefits:

- Tier 1: CCC simplifies system setup through user-friendly, app-based software that supports proper commissioning and long-term performance. Integrated AFDD+ and remote connectivity enable ongoing efficiency and proactive maintenance, which also extends the life of the equipment. Including code-minimum models with CCC ensures accessibility across diverse building types, ownership structures, and customer segments – including those in environmental and social justice (ESJ) communities.[16] Remote access allows building managers and service providers to monitor performance, adjust schedules, and troubleshoot issues without being on-site. By offering simpler and more affordable connectivity and controls than traditional BMS, Tier 1 CRTUs will give more customers the ability to participate in DR programs and take advantage of future dynamic rates to enable load shifting and better manage utility bills. CCC also supports improved installation practices, such as optimizing backup heat temperatures, which are critical for maintaining efficiency and comfort during cold-weather operation.
- Tier 2: High-efficiency cooling lowers utility bills for end users and reduces energy use and peak demand for utilities. Since these units are heat pumps, the savings and peak demand reduction will occur in both heating and cooling seasons. Improved performance at low outdoor air temperatures can reduce, or even eliminate, the need for electric resistance backup heat.
- Tier 3: Incorporates all the benefits of Tiers 1 and 2 while adding benefits of a variable speed supply fan. Variable speed fans reduce energy consumption in part-load and ventilation-only situations. Manufacturers have offered variable speed fans for decades, and contractors are very familiar with setup and operation, unlike variable speed compressors, which are less common and more expensive.

Manufacturers are already producing equipment that meets some or all CRTU criteria, but adoption remains limited. CalMTA anticipates that Tier 1 CRTUs will gain traction first, given their relatively low incremental cost, while Tiers 2 and 3 are expected to see broader uptake in later years. As the market embraces these targeted features, the overall adoption of HP RTUs is expected to rise.

1.3 Strategic interventions for Phase III

Based on what CalMTA learned during Phase II research, several strategic interventions were identified as important to achieve lasting change in the market. To overcome market barriers and drive adoption, the following interventions are proposed for Phase III:

[16] For the CRTU MTI, CalMTA refers to ESJ communities as identified through the CalEnviroScreen's SB535 DAC results dictionary.

1) Engage with manufacturers to develop affordable RTUs, launch a large-scale demonstration project, and continue the advancement of HP RTUs for the replacement market.
2) Distributor and contractor engagement to build availability and comfort with CRTU features.
3) Coordinate with energy efficiency programs outside of CA (e.g., CEE, MN CEE, DOE, NEEA, SEEA) to encourage manufacturers to include CRTU features when developing products.
4) Increase training for contractors and marketing to business owners to increase awareness and comfort with CCC and variable speed fans.
5) Coordinate with California voluntary programs to create consistent incentive offerings.
6) Coordinate with California regulatory programs (Codes and Standards Enhancement (CASE), the California Energy Commission (CEC), and Code Readiness) to add CCC to appropriate codes, standards, or policies.

Through these strategic interventions, California can accelerate the adoption of all three CRTU tiers.

1.4 Recommendations

A variety of current factors make this a critical time for this MTI: higher sales of HP RTUs, manufacturer investment in controls, and the critical need to manage the upcoming winter peak that will occur as California continues to decarbonize space heating. The CRTU MTI offers a critical lever for transforming a market segment that currently trends toward lowest-cost, code-minimum replacements.

Over the past year, CalMTA has begun making real strides in bringing market actors to the table. Manufacturers are signaling strong interest in participating in CalMTA's planned demonstration project scoped in this plan, and the Consortium for Energy Efficiency (CEE) has already woven key CCC features into its preliminary updated RTU specifications. These early wins show that momentum is building. In addition, CalMTA regularly meets with representatives from state Investor-Owned Utilities (IOUs) and other program leads. By continuing to collaborate with national market actors and California efficiency programs, CalMTA expects to amplify efforts and achieve greater savings.

This MTI applies state-of-the-art technology to improve operation, maintenance, and efficiency of RTUs similar to the way technology has benefited the automobile industry. Decades ago, car dashboards offered little more than a few vague warning lights. Today, even the most affordable models provide sensors, alerts, and intelligent controls. Manufacturers have fully embraced this shift to advanced electronics, mechanics now rely on powerful diagnostic tools, and consumers have become far more aware and responsive to feedback from their cars. Most importantly,

vehicles themselves have become dramatically more efficient and reliable, proving how transformative the right technology can be. This MTI can have a similar effect on RTUs by bringing this workhorse into the 21st century.

Given the scale of this opportunity, strong cost-effectiveness and affordability potential, and alignment with state climate and electrification goals, CalMTA recommends advancing the CRTU MTI to Phase III.

A summary of investment and projected savings are shown in Table 1.

Table 1. Overview of the Commercial Rooftop Unit MTI

Market	**Commercial building target market**		
Total Phase III investment needed to achieve Total System Benefit (TSB) forecast (2027-2046)	$38,387,000		
Phase III investment over initial CalMTA funding cycle (2027-2031)	$22,339,000		
Phase II investment (2024-2027)	$4,589,000		
Total investment including Phase II and Phase III investment (2024-2046)	$42,977,000		
TSB (2027-2046)	TSB - Energy	TSB - Grid	TSB - GHG
	$170M	$169M	$346M
TSB - Total	$685M		
Cost-Effectiveness (2024-2046)	TRC	PAC	SCT Base/High
	2.65	20.52	3.23/3.47

2 Market transformation theory & opportunity

This section explains how the CRTU MTI aims to transform the market. It begins with a short overview of the product and target market, then describes the theory behind the market transformation approach and the key interventions CalMTA proposes. Finally, it highlights the expected benefits – including impacts on environmental and social justice (ESJ) communities, workforce development, and total system benefits (TSB).

2.1 Brief product definition and benefits

CalMTA defines a CRTU as a single-zone, packaged, forced-air, heating, ventilation, and air-conditioning (HVAC) system with between 3 and 20 tons of cooling capacity that serves a commercial building and meets any of the following tiers:

- Tier 1: Code-minimum heat pump (HP) RTU equipped with Connected Controls and Commissioning (CCC). CCC is comprised of factory-installed sensors and integrated controls that allow for app-based startup routines, AFDD+, and remote connectivity, including DR[17,18]
- Tier 2: HP RTU with a cooling efficiency at least 20% above the federal minimum standard.
- Tier 3: HP RTU with variable speed fan, CCC, and a cooling efficiency at least 20% above the federal minimum standard.

2.2 Target market

Primary Market: Existing commercial buildings that utilize single-zone RTUs with 3 to 20 tons of cooling capacity for both the planned and unplanned replacement markets.

Secondary Market: New construction commercial buildings that utilize single-zone RTUs with 3 to 20 tons of cooling capacity.

Although not the primary focus, the initiative acknowledges that the new construction market will be affected by the planned interventions. By altering the features and availability of products sold in California, new construction projects sourcing off-the-shelf equipment will increasingly encounter advanced CRTUs. As CRTU products gain market share driven by the initiative's efforts, the cost differential between CRTUs and code-minimum RTUs is expected to diminish.

2.3 Theory of market transformation

2.3.1 Initiative vision

This initiative envisions the widespread adoption of advanced RTU technology across California, with a focus on driving energy efficiency, customer satisfaction, and industry transformation. The vision includes:

- **Accelerating advanced heat pump adoption:** Capitalizing on the growing market share of heat pump (HP) technology to promote the adoption of sensors and CCC capabilities across all product tiers, including code-minimum units.
- **Advancing variable speed supply fans:** Promoting the adoption of variable speed fans that are cost-effective and result in good part-load savings.
- **Enhancing the customer experience:** Delivering user-friendly technologies that empower smaller businesses to control and monitor their systems easily, maximize energy savings, and ensure optimal equipment performance – both at installation and throughout the equipment's lifecycle – without requiring significant investment.

[17] CalMTA defines AFDD+ as automated fault detection and diagnostics beyond current Title 24 requirements, which require economizer faults only.
[18] CalMTA will release a detailed list CCC features and requirements prior to Phase III: Program Implementation.

- **Extending the life of equipment:** CCC will identify faults early and promote prompt repairs, which will make equipment last longer and let small business owners get the most out of their equipment.
- **Creating business value for HVAC companies:** Supporting HVAC contractors through the use of CCC that enable high-quality installations, real-time system diagnostics, and reduced labor and travel costs by streamlining service and fault detection.
- **Aligning with California's climate goals:** Supporting energy efficiency and carbon-reduction objectives by offering market partners a unified, strategic path toward widespread advanced HP RTU adoption.
- **Supporting demand flexibility in all seasons:** CRTUs can help reduce traditional summer HVAC peak demand while also helping mitigate winter morning load growth in an increasingly electrified system. High-efficiency heat pumps and connected controls can improve system performance, reduce reliance on electric resistance backup heat, and enable more flexible, grid-responsive operation. This reduces, or potentially eliminates, the need for electric resistance back up heat at lower temperatures. CCC can help improve installation practices, which is critically important for HPs that do require back-up heat.
- **Collaborating nationally:** Working with national stakeholders to advance RTU technology and accelerate the market acceptance of integrated sensors and CCC as a foundational element of next-generation RTU equipment.

As California's rate design evolves toward more electrification-friendly TOU and dynamic rates, customers will be better positioned to respond to price signals and participate in demand flexibility and DR programs. This direction is consistent with the CPUC's Demand Flexibility proceeding, which is focused on advancing electric rate design to support affordability, reliability, and electrification, and with the Commission's guidance on dynamic hourly retail rates. It is also aligned with the CEC's Load Management Standards (LMS), which call for machine-readable rate data, customer education on automation, and utility/CCA development of rates that change at least hourly to reflect grid conditions. In that context, connected CRTU systems can create greater value for customers, contractors, and statewide efficiency efforts by using data, diagnostics, and advanced controls to improve performance and enable more flexible, grid-responsive operation.

2.3.2 Key market barriers

The CRTU MTI faces the following key barriers that must be overcome before broad market adoption can take place. The first two barriers of cost as well as product availability and readiness are expected to be the largest barriers to adoption:

- Higher costs for high-efficiency equipment: Challenges include the upfront cost of equipment and the perception that transitioning from gas to electric systems will increase installation and operating costs.[19]
- Product availability and readiness: CCC and HP RTUs with variable-speed fans are currently only available in certain models from certain manufacturers. Furthermore, distributors are more likely to stock code-minimum units for the unplanned replacement market, which makes up roughly 80% of RTU sales.
- Limited supply chain and customer experience with technologies and benefits: Currently, many customers and contractors lack familiarity with the benefits and use of advanced RTU features. The incorporation of CCC changes the contractor and end-user experience, while also providing access to new data during start-up, operation, and service.
- Divergent product development requests to manufacturers: Manufacturers face conflicting product development requests from various energy efficiency and market transformation initiatives nationwide, which can hinder the development of standardized solutions.
- Split incentives: In leased buildings, the building owner often pays for HVAC equipment but the tenant typically pays for utility bills. The owner, in these cases, would need to pay a higher price for more-efficient equipment but the tenants reap the cost-savings benefit. While this only affects a certain portion of the entire market, it is a significant portion. We plan to include some leased buildings in the proposed demonstration projects to learn more about how to address this barrier. Another CalMTA initiative in development, the Commercial Building Efficiency Accelerator, plans to address this barrier more holistically with solutions such as green leases and on-bill financing.[20]

2.3.3 Market opportunities and key leverage points

This MTI will exploit both market opportunities and preexisting points of leverage. Market opportunities are the market activities and forces that serve as pathways for this technology to reach greater adoption. These are called out in Appendix A: Logic Model and are also mapped to the planned interventions that seek to exploit these opportunities in the strategic interventions below.

- U.S. Department of Energy (DOE) Commercial HVAC Accelerator: This project collaborates with industry stakeholders to accelerate the development and market adoption of cold-climate HP RTUs in partnership with manufacturers. As part of this effort, a multi-phased specification was created to promote the introduction of advanced HPs that integrate controls and sensors.

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[19] CalMTA's bill analysis shows that, in most cases, utility bills drop when replacing gas packs with advanced HP RTUs. See section 3.4.10 for details.

[20] Green leases are commercial real estate agreements that include clauses for the building owner and tenant to share costs and savings from energy upgrades.

- The MTI will utilize the controls specifications developed by this group to promote consistency and enable scalability for manufacturers. While cold-climate HP RTUs are not as critical in California's climate, these units all use variable speed compressors and fans.

- Codes, standards, and test procedures: The CRTU initiative, in collaboration with California Codes and Standards program leads, will actively monitor and engage with evolving state and federal codes, standards, and test procedures to ensure alignment with advanced efficiency goals.
  - IVEC/IVHE metric (2029 Implementation): In 2029, federal standards will require RTUs over 65,000 Btu/hour to be tested with a new procedure and rated with the IVEC/IVHE metrics.[21] The new metrics will offer a more accurate method to differentiate HP system performance, and the new standards will generally be more stringent. In anticipation of this change, the CRTU initiative aims to leverage IVEC to encourage market actors to develop and sell equipment in California that exceeds minimum IVEC thresholds by 20%.
- Advanced Heat Pump Coalition: Although focused on residential equipment, this coalition of energy efficiency organizations and utilities works to enhance the performance and features of HPs. One of the working groups in this coalition focuses on connected commissioning, with features very similar to CCC.
  - Given the overlap in manufacturers between residential and light commercial equipment, the CRTU initiative will explore aligning with the coalition's efforts to create a unified message and consistent requests for startup features across product categories.
- California's momentum in HP adoption: California's rapidly growing adoption of HP technology provides a strong foundation, allowing the CRTU initiative to focus on advancing performance and efficiency rather than building market acceptance. Year-over-year growth in HP RTU installations continues, with preliminary estimates indicating that 26% to 46% of replacement installations in 2024 used HP systems.
- Corporate and municipal sustainability goals: Many corporations and municipalities in California have sustainability goals related to adopting clean energy sources and upgrading to more energy-efficient equipment. Both may track and disclose emissions to meet their targets.
  - The features promoted in the CRTU MTI would help these larger organizations meet their targets by switching to a clean heat source and/or installing more efficient RTUs.
- California Air Resources Board (CARB) and regional air quality district requirements: CARB is considering a zero-emission requirement for space and water heaters. The Bay Area Air

[21] In 2029, Integrated Ventilation Economizing and Cooling (IVEC) will become the federal metric for cooling and Integrated Ventilation and Heating Efficiency (IVHE) will become the federal metric for HP heating.

Quality Management District has a zero NOx requirement for residential and commercial furnaces, including replacements, scheduled to take effect January 1, 2029.

  - These requirements will help promote the adoption of HP RTUs, in general, and will improve the stocking practices for HP RTUs. The CRTU MTI will build upon this natural transition to promote advanced HP RTUs.

Key leverage points are points of aggregation that enable the MTI to reach a broader set of market actors at a reduced level of investment. CalMTA has identified several key leverage points and product benefits that this MTI will utilize to accelerate market adoption. These include:

- Consortium for Energy Efficiency (CEE): CEE has established a Commercial Air Conditioning and Heat Pump Committee, coordinating and partnering across the nation with interested utility and energy-efficiency programs and HVAC manufacturers, dedicated to advancing high-efficiency and cold-climate heat pumps. While cold-climate systems are less relevant to California's market needs, advancements in this technology could support efforts to reduce reliance on electric-resistance strip heating, and the committee's work presents valuable opportunities to influence manufacturers toward producing equipment with higher IVEC scores. The initiative will leverage this platform to advocate for the inclusion of California-specific requirements such as CCC into future CEE efficiency tiers.
- Minnesota Center for Energy and the Environment (MN CEE): MN CEE has launched a market transformation program targeting commercial rooftop equipment. The CalMTA team is actively collaborating with MN CEE, sharing research findings and exploring opportunities for joint research initiatives. A key objective of this partnership is to align product development requests across regions, thereby sending consistent signals to manufacturers and promoting unified market transformation efforts.
- Northwest Energy Efficiency Alliance (NEEA): While NEEA's current focus remains on gas rooftop technologies, indications suggest a potential shift toward incorporating electric HP technologies. The CRTU initiative will continue to monitor NEEA's progress, engage where appropriate, and seek alignment on product development priorities. Particular emphasis will be placed on encouraging the integration of sensors and controls into NEEA's future market transformation programs to align strategies and create consistency for manufacturers.

This MTI will benefit from California utility programs that provide incentives on commercial HVAC equipment or specifically seek to drive heat pump adoption. CalMTA sees the Investor-Owned Utilities' (IOU) Statewide Upstream and Midstream HVAC Program as a critical point of leverage and alignment. Because this program has been rebid under a new Program Administrator, CalMTA is proactively working to ensure that planned MTI activities inform and add value to the redesigned version of the Statewide Upstream and Midstream HVAC program.

2.3.4 Conditions that would trigger transitioning out of market

Once this MTI achieves the market conditions detailed below, the market will have sufficient momentum to allow CalMTA to begin to transition out of the market while continuing to monitor adoption progress. This is the point in time when funding levels reduce substantially while benefits continue to grow. The conditions below inevitably involve a significant degree of judgement. We will rely on our Market Transformation Advisory Board (MTAB) and public processes to assure the timing of transition is appropriate. For details on tracked Market Progress Indicators (MPIs) and milestones, see Appendix F: Evaluation Plan.

- HP RTUs with variable speed fans and performance ratings at least 20% above the IVEC baseline are now available and gaining market acceptance. While these units may have higher upfront costs, those costs can be effectively neutralized through incentives or modified rate structures and/or offset through long-term energy savings and operational efficiencies.
- The majority of equipment stocked for the unplanned replacement market includes CCC.
- HVAC contractors are leveraging fault detection and CCC to streamline diagnostics, improve response and repair time, and optimize system performance, resulting in improved customer satisfaction and lower service costs.
- Demand response and load flexibility functionality is an integrated standard feature, with most RTUs sold equipped to support grid-interactive operations.

2.3.5 Market end state

CalMTA envisions a market end state where the following scenarios exist:

A majority of single-zone HP RTUs installed in California contain all CRTU features.[22]

- Units with CCC are shown through third-party evaluations to have better energy performance due to reduced installation errors and optimized performance.[23]
- Integrated sensors and controls offer customers a cost-effective pathway to building management and enabling greater visibility into HVAC system performance, including connected commissioning, fault detection, ongoing monitoring and remote system control to allow for operational optimization, and enhanced energy savings.
- HVAC contractors recognize the value of CCC, are adequately trained in CCC, and are using them to unlock new service offerings and business opportunities; connected commissioning is a standard installation practice.

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[22] Market share of 30% by 2040 for CRTUs with all features is a market progress indicator (MPI) for this MTI. For details on tracked MPIs and milestones, see Appendix F: Evaluation Plan.

[23] Market share of 50% by 2035 for single-zone HP RTUs with CCC is an MPI for this MTI. For details on tracked MPIs and milestones, see Appendix F: Evaluation Plan.

2.3.6 Environmental & social justice approach

This MTI recognizes that ESJ communities are disproportionately impacted by both the upfront costs and the complexity and installation quality of HVAC replacements, particularly when replacements occur during time-sensitive scenarios. By focusing on cost-neutral design strategies (e.g., integrating low-cost sensors) and advocating for consistent, affordable product tiers that include CCC, the initiative seeks to embed equity into both product design and market delivery.

The CRTU initiative is grounded in the belief that equity must be embedded from the outset through product design, supply chain engagement, public procurement, and training access. While ESJ-specific strategic interventions are addressed in more detail in Sections 2.5 and 2.6, this approach reflects a commitment to ensuring that affordability, accessibility, and cultural relevance are not treated as downstream concerns but as core design criteria. This MTI plans to:

- Ensure accessible and affordable pathways to acquire and install advanced HP RTUs in both ESJ communities and the broader market. CalMTA will partner with manufacturers to develop products that integrate CCC and will use demonstration projects in ESJ and non-ESJ communities to better understand how these products perform in practice and what is needed to support equitable adoption. These features should be standardized across all CRTU product tiers to streamline installation and deliver broad-based benefits. By focusing on affordability and broad access to these features, we mitigate costs and reduce adoption barriers – especially for ESJ communities that might otherwise be excluded.
- Develop inclusive training and outreach materials: Create market-based training materials that prioritize training accessibility for installation contractors located in and/or serving ESJ communities. Design outreach material that addresses a diversity of learning needs such as language, literacy, and technological fluency.

2.3.7 Theory/Assumptions

The following conditional statements explain the theory of market change for this MTI and the key assumptions the theory is based on.

- **If** major manufacturers receive consistent market signals and coordinated requests from California partners and programs, **then** they will be incentivized to develop RTUs specifically optimized for the replacement market, including the integration of CCC. This outcome is based on several key assumptions:
    - Sensors and controls are commercially available and can be integrated at scale.
    - The size and influence of California's market is sufficient to justify targeted investment in product development tailored to the state's specific needs.
    - California stakeholders – including utilities, program implementers, and policy advocates – can align around a common vision and shared understanding of current market conditions and the trajectory of HP adoption.

If major manufacturers see RTU programs building demand and consistent product tiers from national partners, **then** manufacturers will see value in volume production and that will reduce first-cost barriers for HP technology with variable speed fans and IVEC +20%. This outcome is based on several key assumptions:

- Achieving meaningful cost reductions for advanced HP technology and higher IVEC tiers requires broad industry consensus to drive production at scale.
- Consistently defined product tiers will provide manufacturers with the clarity needed to align product development with the goals and expectations of the energy efficiency and market transformation community.

If California programs can align around a common RTU product roadmap, **then** market confusion will be reduced and the adoption of advanced CRTU HP technology will be accelerated. This outcome is based on several key assumptions:

- The product roadmap will articulate a clear, shared long-term vision for RTU technology, delineating roles and responsibilities across programs and enabling coordinated market and regulatory actions.
- A unified vision and aligned efforts will send strong, consistent signals to market partners, fostering collaboration and accelerating the development and adoption of advanced CRTU HP technologies.

If contractors recognize the value of equipment with CCC and adapt their business models to take advantage of these technologies and data analytics, particularly when available at comparable cost, **then** contractors will become advocates and help promote CCC to their customers, gaining both market share and the increased trust and use of CCC by end users. This outcome is based on several key assumptions:

- Contractors play a pivotal role in influencing customer purchasing decisions.
- The integration of sensors and controls into RTU equipment can be achieved with minimal impact on overall cost.
- Sensors and controls will open new business opportunities for contractors, reduce labor requirements for diagnostics and maintenance, and equip them with tools to optimize system performance at the time of installation.
- Remote fault detection will reduce the need for truck rolls by identifying replacement parts from off-site
- Contractors will schedule maintenance and non-critical service calls based on proximity to other HVAC systems in their network.
- Interfaces for both contractors and customers will be intuitive and user-friendly, ensuring ease of adoption and engagement.

If manufacturers are incentivized and rewarded for including CCC in lower-cost products, **then** stocking practices across the distribution network will shift, leading to increased market adoption of advanced CRTU technologies. This outcome is based on several key assumptions:

- Minimal cost increase for products that include sensors and controls.
- Differentiated upstream incentives for unplanned replacement products will motivate manufacturers to incorporate sensors and controls into their offerings and create clear benefits for their distribution and contractor partners to stock and promote these products.
- Making CRTU products more available will allow contractors to recommend them more frequently and customers more inclined to adopt.

If RTU products incorporate a start-up application, **then** a greater percentage of installations will be completed correctly, ultimately resulting in increased energy savings. This outcome is based on several key assumptions:

- Sensors and controls will include capabilities that can be leveraged during installation to verify proper setup and functionality.
- Technicians will prefer using the start-up application instead of reading the manual and/or going from memory.

If RTUs incorporate AFDD with simple notifications, **then** end users and/or contractors will act on the notifications and system performance will be optimized, ultimately resulting in increased energy savings. This outcome is based on several key assumptions:

- In the event of a fault or performance issue, customers or contractors will receive timely notifications and take appropriate corrective action to ensure the system continues to operate efficiently.
- Appropriate staff- either at end-user, contractor, and/or manufacturer, will be trained, directed, or compensated to respond to faults.

If a measure package and California Electronic Technical Reference Manual (eTRM) savings numbers for advanced CRTU equipment specific to this MTI are produced, **then** existing California programs will offer incentives for products aligned with the CalMTA program and adoption will increase.[24] This outcome is based on several key assumptions:

- Savings for controls and sensors can be established with acceptable accuracy and assurances.
- Ongoing coordination and collaboration with supporting California programs.

[24] The eTRM is a statewide repository of California's energy efficiency deemed measures, including supporting values and documentation." (see https://www.caetrm.com/login/?next=/)

2.4 Strategic interventions

Below are the strategic interventions that this MTI will deploy to overcome barriers in the commercial building market. The list includes a general description of the intervention, market barriers the intervention will work to address, market opportunities it will exploit, and key outcomes. Many of the interventions will work to support multiple outcomes as detailed in Appendix A: Logic Model. Please also see the "Evaluability Map" Attachment to Appendix F for details on the outcomes, their associated MPIs, and expected milestones.

Strategic intervention 1  [25]	**Engage with manufacturers to develop affordable RTUs, launch a large-scale demonstration project, and continue the advancement of HP RTUs for the replacement market.** This intervention will center on sustained engagement with manufacturers, implemented through a three-fold strategy. 1. CalMTA will collaborate with manufacturers on the development of a large-scale (approximately 150-units) demonstration project in both ESJ and non-ESJ communities aimed at understanding and defining the business case for contractors. Manufacturers and distributors will help identify forward-thinking contractors who will be more interested in experimenting, adopting, and eventually promoting CCC. Insights from this effort will inform future initiative activities, including supply chain engagement, education, training, and marketing, while grounding program design in real-world experience. CalMTA will monitor a portion of these installations to prove out savings. We expect to install some units in leased buildings to help understand any barriers and opportunities to overcome split incentives. 2. CalMTA will work to establish long-term partnerships with manufacturers to co-develop a shared product vision and influence future product development cycles. 3. CalMTA will work with manufacturers to design incentives that encourage the development and sale of RTU products that include CalMTA's targeted features. This approach is intended to stimulate product innovation, foster market competition, influence stocking practices, and establish a long-term pathway to obtain shipment data that informs ongoing program design and market tracking. As manufacturers

[25] Icon represents interventions with a focus on equity considerations.

	respond to these incentives, they are expected to encourage their distribution partners to stock and promote equipment with CCC, and eventually, Tier 2 and Tier 3 technology – even for unplanned replacement applications. The incentives will be contractually required to lower the cost for the end user, but may be offered to the manufacturer, distributor, or contractor, depending on feedback from all parties. CalMTA recognizes that this activity will require close coordination with any external programs offering midstream or upstream incentives on RTU products to maximize leverage and ensure there is no duplication of effort. The goals of this engagement are to: • Influence manufacturers to incorporate CCC into products designed specifically for the unplanned replacement market, with a strong focus on intuitive, user-friendly interfaces that address the needs of end users, installers, and HVAC contractors. The CCC features should avoid the poor interfaces that are commonly found on HVAC control boards that require arcane submenus with hidden setpoints. • Develop a qualified products list to distinguish which products meet the features required by CCC. • Understand the impact of curb adaptors.[26] While curb adaptors can add cost to an RTU replacement, they are used very frequently and do not add significant time. The use of curb adaptors is not unique to the features that CalMTA is proposing. Some manufacturers provide guides on how to use curb adaptors, and ready-made curb adaptors for common baseline units. Other manufacturers design their RTUs to fit common footprints. The demonstration project will help us understand the impact of curb adaptors, and whether we need to coordinate with manufacturers to address this potential barrier. • Advocate for the adoption of high-efficiency HP RTUs and advancing products that exceed minimum performance standards. • Gain insight into manufacturers' cost structures and business models to identify pathways for reducing the cost premium associated with standard units equipped with CCC, as well as Tier 2 and 3 technologies. • Establish data-sharing agreements with manufacturers to enable ongoing market insights and performance tracking, tailored to California's unique commercial HVAC landscape.

[26] A curb adaptor creates a connection between a new RTU and an existing rooftop curb. This avoids the potential requirement of major roof modifications.

	• Partner with manufacturers to ensure CCC becomes a standard feature across all RTU product tiers, benefiting both ESJ communities and the broader market. By focusing on affordability and global access to these features, we mitigate costs and reduce adoption barriers – especially for ESJ communities that might otherwise be excluded. While several manufacturers currently offer RTU products with advanced features – such as sensors, controls, variable speed fans, and customer interfaces for fault detection and performance optimization – some of these offerings are typically at a higher cost, custom ordered, and associated with longer lead times.
Market barrier(s) addressed and opportunities to exploit	**Barriers** • Limited supply chain and customer experience with technology package and benefits • High cost (equipment/installation) • Product availability and readiness **Opportunities** • DOE Commercial Building HVAC Accelerator Project – collaborative effort with manufacturers to advance RTU products • Manufacturers existing momentum towards incorporating sensors and controls into various product lines • Opportunity for manufacturers to differentiate themselves by providing new tools/resources to their customers (HVAC companies) providing real impacts to ROI • Data collected by these more advanced systems has potential value to energy efficiency community to provide performance data, support quality assurance/control requirements, etc. • California's and other national efforts to electrify
	Outcomes

Short-term outcomes (1-3 yrs)	CalMTA demonstration project assessing business case opportunity for CCC and variable speed fan RTUs launches in California in partnership with manufacturers, distributors, and contractors. This project will also help validate savings for both CCC and variable speed fan RTUs. Manufacturers see value in partnership and engage on product refinement and feature development in alignment with the MTI product definition.
Medium-term outcomes (4-8 yrs)	Multiple manufacturers incorporate sensors and CCC into a broader suite of HP RTUs capturing the unplanned replacement market with minimal effect on pricing. Products provide easy-to-use end-user and contractor interfaces with seamless and reliable connectivity. Distribution and standard supply chain channels stock, sell, and promote with CRTU features; inclusive of the unplanned replacements. HVAC installers and workforce embrace and market benefits of CCC. Customers understand and see value in CCC, including DR and time of use (TOU) benefits.[27]
Long-term outcomes (10+ yrs)	Market share of single-zone HP RTUs meeting Tier 3 requirements is over 30% by 2040.

Strategic intervention 2	**Distributor and contractor engagement to build availability and comfort with CRTU features** This intervention will begin by engaging distributors and contractors to support the initial demonstration project. Through partner manufacturers, CalMTA will identify key distributors and contractors to participate. Over the longer term, as contractors and distributors become more familiar and comfortable with CCC and variable speed fans, efforts will shift toward supporting and monitoring stocking practices for RTUs with advanced

[27] Time of use (TOU) plans are energy pricing plans that adjust the cost of electricity based on the time of day and season.

	features. We expect the demonstration project partners to eventually become advocates for CRTU features, helping to promote CCC, high-efficiency cooling, and variable speed fans to customers and other contractors and distributors. CalMTA will work with advocate distributors to train more contractors and help influence manufacturers. As more contractors gain experience and see the benefits of all the products – especially CCC – they will request these features from other distributors, which will again motivate manufacturers to develop and provide more features with their RTUs. It is anticipated that manufacturer incentives (see previous strategic intervention) will have a cascading effect. As manufacturers respond to these incentives, they are expected to encourage their distribution partners to stock and promote equipment with CCC and eventually, variable speed fans, including for unplanned replacement applications. This diffusion of influence down the supply chain is essential to transforming the product mix and supporting widespread market adoption.
Market barrier(s) addressed and opportunities to exploit	**Barriers** • Product availability and readiness • Limited supply chain and customer experience with technology package and benefits **Opportunities** • California's growing movement towards HP RTUs
	Outcomes
Short-term outcomes (1-3 yrs)	Demonstration project that documents the contractor business case and validates energy savings for CCC, variable speed fans, and efficient cooling inclusive of ESJ communities.
Medium-term outcomes (4-8 yrs)	Distribution and standard supply chain channels stock sell and promote CalMTA CRTU product; inclusive of the unplanned replacement market. HVAC installers and workforce embrace the market benefits of CCC to customers and these augment the business model.

	Customers understand and see value in CCC, including DR & TOU benefits. HVAC installers and workforce are trained, trusted, and available for installations across California without cost-premiums in ESJ communities. Incentives address incremental cost barrier for CCC, high-efficiency cooling, and variable speed fans.
Long-term outcomes (8-10+ yrs)	Market share of RTUs with CCC increases and equipment costs are on par with competing product. Market share of single-zone HP RTUs meeting Tier 3 requirements is over 30% by 2040

Strategic intervention 3	**Coordinate with energy efficiency programs outside of CA (e.g., CEE, MN CEE, DOE, NEEA, SEEA) to encourage manufacturers to include CRTU features when developing products** Existing energy efficiency programs are currently engaged with RTU technologies, with most efforts focused on improving HP efficiency or modifying equipment design to increase insulation or integrate energy recovery ventilation (ERV) or heat recovery ventilation (HRV) technologies. However, due to California's mild climate, these design modifications are not expected to yield cost-effective avoided costs within the state. This intervention will prioritize identifying synergies with national and regional efforts and actively working to influence them to incorporate CCC into program designs, specifications, and market transformation strategies while advocating for variable speed fans and advancing IVEC ratings. The CRTU features can add value to other programs, whether the program is focused on the same technologies or not. A key area of engagement will be the DOE Commercial HVAC Accelerator program. The specification developed under this initiative challenges manufacturers to produce cold-climate RTUs, which require variable speed fans and align well with CRTUs. Notably, Phase II of the DOE's effort also calls for enhanced AFDD – further reinforcing CalMTA's direction. Ultimately, this intervention seeks to create a unified and coordinated signal to the manufacturing community, accelerate support for the adoption of sensors and controls, and achieve the scale necessary to drive down

	equipment costs when incorporating variable speed technologies. By aligning national and regional efforts, the energy-efficiency industry will be better positioned to make advanced RTU technologies cost-competitive with standard offerings. CalMTA will continue to coordinate with the Advanced Heat Pump Coalition's working group on Connected Commissioning. This working group's efforts closely align with CalMTA's CCC. While the Coalition has a focus on residential equipment, they have been working with the National Laboratory of the Rockies (NLR) for several years and have raised the awareness of proper startup with manufacturers that also make RTUs.[28]
Market barrier(s) addressed and opportunities to exploit	**Barriers** • Divergent product development asks of manufacturers • High Cost (Equipment/installation) **Opportunities** • Consortium for Energy Efficiency (CEE) existing working group creating tiers for heat pump RTUs • DOE Commercial HVAC Accelerator • Advanced Heat Pump Coalition
	Outcomes
Short-term outcomes (1-3 yrs)	Shared industry tiers/specifications incorporate variable speed fans, increased cooling performance, and inclusion of CCC. Manufacturers see value in partnership and engage on product refinement and feature development.
Medium-term outcomes (4-8 yrs)	Multiple manufacturers incorporate controls into a broader suite of HP product, capturing the replacement market with minimal effect on pricing.

[28] The National Renewable Energy Lab (NREL) was renamed to the National Laboratory of the Rockies (NLR) in December, 2025.

Long-term outcomes (8-10+ yrs)	Market share of single-zone HP RTUs meeting Tier 3 requirements is over 30% by 2040.

Strategic intervention 4 	**Increase training for contractors and marketing to business owners to increase awareness and comfort with CCC and variable speed fans** Building on insights from the demonstration project, CalMTA will develop targeted installer training and education materials to support the supply chain and leverage trusted channels for installer engagement. In parallel, training content and messaging will be shared with manufacturers to influence their educational materials, fostering consistency across various learning pathways. Additionally, we will provide these resources to existing California programs focused on advancing RTU technologies, further reinforcing aligned messaging and technical guidance. As described in the Distributor and supply chain intervention, CalMTA will work with advocate distributors to train contractors. By approaching installer education from multiple angles – through distributors, manufacturers, and state programs – the initiative aims to create a cohesive and consistent training experience that supports broad market adoption. However, simply creating materials is not enough. To effectively meet the diverse needs of California's workforce, training efforts must ensure broad access. This includes offering resources in multiple languages, accommodating various learning styles, and delivering content through established workforce education and training market actors including those working in ESJ communities. To achieve this, CalMTA will partner with distributors, existing workforce development programs, small business industry stakeholders, known local training hubs and community-based organizations (CBOs) establishing a foundation of accessibility, trust, and relevance. When successful, this effort will universally empower the installer community in both ESJ and non-ESJ locations with the knowledge, confidence, and experience to support advanced CRTU technologies. As installers recognize the business value and benefits of these systems, they are expected to become key advocates, helping customers understand the advantages, addressing concerns, and ensuring optimal functionality of their new equipment.

	Additionally, CalMTA will develop a marketing campaign for property owners, facility managers, and asset managers of commercial buildings. We envision a mix of digital marketing (email campaigns, targeted ads, educational video content) and traditional outreach (direct mail, in-person seminars). Marketing will focus on the different value propositions of advanced HP RTUs for owners: energy savings, guidelines to optimize TOU rates and/or DR programs, return on investment, improved comfort, and simplified maintenance.
Market barrier(s) addressed and opportunities to exploit	**Barriers** • Limited supply chain and customer experience with technology package and benefits • High cost (equipment/installation) **Opportunities** • Existing California programs providing education/training to HVAC industry • Manufacturer and distributor education/marketing channels • Distributor relationships and training facilities/events • Work with existing commercial HVAC and workforce, education and training (WE&T) partners to upskill the workforce to address CRTU features
	Outcomes
Short-term outcomes (1-3 yrs)	N/A
Medium-term outcomes (4-8yrs)	Culturally-relevant WE&T materials developed and incorporated into manufacturer and HVAC industry trainings/education; ensuring accessibility of trainings offered to ESJ communities. HVAC installers and workforce are trained, trusted, and available for installations across the state without cost-premiums in ESJ communities. HVAC installers and workforce embrace the market benefits of remote monitoring, fault detection, and controls to customers and these augment the business model.

	Customers understand and see value in RTU controls packages and utilize the systems interface to manage performance. Installation companies embrace and market benefits of advanced RTU features to customers. HVAC installers and workforce leverage fault detection and controls to service customers and ensure best practices at time of installation, diagnosis, and repair, resulting in a change to their business model.
Long-term outcomes (8-10+ yrs)	Market share of RTUs with CCC increases and equipment costs are on par with competing product. Market share of single-zone HP RTUs meeting Tier 3 requirements is over 30% by 2040.

Strategic intervention 5	**Coordinate with California voluntary programs to create consistent incentive offerings** CalMTA acknowledges and values the important work already underway to advance CRTU technologies across California. While existing programs currently support RTU equipment, progress has been limited as more-advanced equipment has remained a niche product. A key goal of this intervention is to reduce market fragmentation and address manufacturer concerns about inconsistent or conflicting product requests across programs. By fostering alignment and coordination, CalMTA will coordinate with programs to present a unified and strategic front to manufacturers representing not only the largest economy in the country but also the single-most significant opportunity for commercial RTU market transformation in the United States. Consistent messaging will also benefit trade allies and end users across California. This intervention will begin with coordination among key voluntary programs (e.g., statewide HVAC) to identify leverage points, understand current plans, and assess existing materials. When successful, newly launched incentives will be paired with consistent, field-tested marketing and educational tools – creating a streamlined and effective experience for contractors, distributors, and customers alike, while accelerating adoption of advanced RTU technologies.

	This coordination will build on the foundation of the Heat Pump RTU Working Group, launched in 2024 and currently facilitated by Energy Solutions. Through this forum and related collaboration, CalMTA aims to clarify how its MTIs can best support and complement voluntary programs, identify ways in which market transformation efforts can accelerate progress, and understand what would be most valuable to programs like the IOUs' Statewide Midstream and Upstream HVAC Program. We can then work directly with key Program Administrators and implementation teams to validate any assumptions about the added value of this work and identify an actionable path to informing or leveraging these programs. Additionally, CalMTA will work to ensure its activities are aligned with, and informed by, CalNEXT research priorities, and vice versa. CalMTA will support the development of tools and resources necessary for existing energy-efficiency programs to offer incentives for emerging RTU technologies. This includes advanced HP systems and equipment with CCC. These efforts will help reduce upfront cost barriers, demonstrate California's commitment to market partners, and promote consistent messaging and support for trade allies and customers.
Market barrier(s) addressed and opportunities to exploit	**Barriers** • High cost (equipment/installation/operation) • Divergent product development asks to manufacturers • Product availability and readiness **Opportunities** • Statewide Upstream and Midstream HVAC Program • California Heat Pump Partnership • State codes/standards/test procedures expertise in California
	Outcomes
Short-term outcomes (1-3 yrs)	Applicable California programs that support RTUs leverage marketing and education materials and provide straightforward and consistent incentives that aligns with the CalMTA product definition and has a long-term vision for overcoming installation and product costs.

Medium-term outcomes (4-8 yrs)	N/A
Long-term outcomes (8-10+ yrs)	Market share of RTUs with CCC increases and equipment costs are on par with competing product. Market share of single-zone HP RTUs meeting Tier 3 requirements is over 30% by 2040.

Strategic intervention 6	**Coordinate with California regulatory programs (Codes and Standards Enhancement (CASE), the California Energy Commission (CEC), and Code Readiness) to add CCC to appropriate codes, standards, or policies.** Incorporating new features into building codes is one of the most effective ways to drive efficiency improvements. Once requirements are codified, manufacturers will design equipment to meet them. For initiatives aimed at improving equipment performance at the manufacturer level (such as with CRTUs), this approach can yield highly reliable savings. CalMTA acknowledges the IOU teams already working on codes and standards and meets regularly with them. We plan to continue to supporting their efforts by providing unique technical information, market data, and research that is not available elsewhere. Title 24 already requires AFDD for economizers, a component known for high energy use and frequent operational issues. Studies consistently show that economizers often fail or are improperly configured. However, AFDD can also track other conditions such as dirty filters, dirty condenser coils, and improper refrigerant charge that are also common and result in substantial energy waste. Beyond AFDD, CCC has an opportunity to enhance the initial commissioning of RTUs and improve compliance with acceptance testing requirements. App-based startup and commissioning tools could help ensure equipment is installed according to manufacturer specifications, with proper airflow, damper operation, and control setpoints. Data collected through these apps could also serve as documentation for acceptance testing, potentially replacing or supplementing traditional forms.

	As part of this intervention, CalMTA will work with California regulatory programs, manufacturers, and AHRI to develop a standard for CCC. This could be an extension of AHRI-1390: Commercial Smart Grid Interface, which is currently under development, or a new standard altogether. Variable speed fans are unlikely to be mandated at the federal level. Federal standards generally focus on establishing minimum performance thresholds rather than prescribing specific technologies. Title 24 has a requirement for 2-stage fans on single zone systems, already, so there is a potential for increasing that requirement. Looking ahead, federal standards may raise minimum cooling efficiency levels but given that the most recent updates take effect in 2029, the next increase would not occur before approximately 2036.
Market barrier(s) addressed and opportunities to exploit	**Barriers** • Divergent product development requests to manufacturers • Product availability and readiness **Opportunities** • California Heat Pump Partnership • State codes & standards expertise in California
	Outcomes
Short-term outcomes (1-3 yrs)	N/A
Medium-term outcomes (4-8 yrs)	N/A
Long-term outcomes (8-10+ yrs)	Relevant elements of CCC get incorporated into codes, standards, or state policies.

2.5 Environmental & social justice communities

This MTI will deepen its responsiveness to the needs of ESJ communities by expanding access to CRTUs with advanced features that reduce operational costs and improve building performance. It will focus on reducing the cost and complexity of CRTU adoption through equity-informed product design, and alignment with trusted training industry channels. ESJ impacts are woven throughout all strategic interventions, but the following encapsulate those that will directly work to benefit ESJ communities.

- **Strategic Intervention 1** focuses on encouraging manufacturers to develop CRTU product lines – across multiple tiers, including unplanned replacement options – that integrate sensors and CCC features. These features will deliver accessible, building-management-style functionality to cost-conscious customers, enhancing confidence in system performance, energy efficiency, and reliability. As a foundational element of this intervention, the MTI will conduct in-field demonstration projects, with at least 40% (60 out of 150) of installations sited in ESJ communities, to document savings, inform business case development for contractors, and identify equity-specific adoption barriers.
- **Strategic Intervention 4** will partner with workforce development organizations, CBOs, and trusted industry channels to design inclusive training pathways. This includes multilingual and accessible training materials, deployment of resources through local training hubs, and prioritization of small contractors and community-rooted workforces that serve ESJ communities. Over time, this intervention aims to ensure that HVAC installers are trained, trusted, and available statewide, without cost premiums in ESJ communities.

Beyond these targeted interventions, the MTI will align with existing community-based and ESJ advocacy organization's outreach networks and ensure that ESJ communities are supported enough to benefit from the long-term affordability and reliability offered by advanced CRTU systems. The MTI will also continue to work with CalMTA's Equity Sounding Board and other advisory partners to ensure ESJ perspectives shape ongoing implementation.

2.6 Workforce development

This MTI is focused on increasing the adoption of advanced HP RTUs in a commercial retrofit market historically dominated by gas products. While this transition does not require large-scale workforce expansion or retraining, it does call for targeted upskilling of the existing HVAC workforce to ensure proper installation, commissioning, and long-term servicing of new technologies.

One of the key equity outcomes of this MTI is ensuring that HVAC installers are trained, trusted, and available statewide, including in ESJ communities, without added cost burden. This requires not just curriculum design, but strategic coordination across supply chain actors, public sector programs, and local training partners to ensure broad coverage and workforce readiness.

To meet this need, the MTI will collaborate with existing workforce development programs and leverage current training infrastructure available through manufacturers, distributors, and trade associations. Additionally, the MTI will engage with CBOs, implementers, and trainers to help ensure technology-specific training content is accessible through multilingual and multi-format curriculum to installers. Resources will be delivered through these entities as well as established training channels such as community colleges, technical schools, union and non-union apprenticeship programs, and local training hubs to ensure that small contractors and workforce participants from, and serving, ESJ communities are equipped to participate in and benefit from the growing demand for CRTU installations.

2.7 Total system benefit & cost-effectiveness forecast

CalMTA estimated the TSB and cost-effectiveness for the CRTU MTI, including the Total Resource Cost (TRC), Program Administrator Cost (PAC), and two Societal Cost Test (SCT) results. The initiative is cost-effective under the TRC, PAC, and SCT perspectives (Table 2).

Table 2. MTI cost-effectiveness estimates – CRTU

TRC	PAC	Base SCT	High SCT
2.65	20.52	3.23	3.47

Table 3 shows MTI TSB – in total and broken down by energy, grid, and greenhouse gas (GHG) impacts. The MTI will deliver an estimated $685 million in TSB over the 20-year period from 2027 to 2046. This includes $170 million in energy benefits, $169 million in grid benefits, and $346 million in abated GHG emissions calculated using TRC values specified by the CEDARS Cost-Effectiveness Tool (CET) to calculate benefits.[29]

Table 3. CRTU TSB estimates

TSB ($M)	Energy ($M)	Grid ($M)	GHG Non-Refrigerant ($M)	GHG Refrigerant ($M)
685	170	169	346	N/A[30]

To develop the TSB and cost-effectiveness estimates, CalMTA developed a model to forecast incremental units of market adoption resulting from the MTI, discussed in more detail below.

[29] CEDARS is the California Energy Data and Reporting System; CET is the official publicly available tool used to assess cost-effectiveness of energy efficiency programs in California.

[30] CalMTA does not attempt to calculate any avoided cost benefit due to refrigerants since we are only considering normal replacement, and it is assumed that the proposed CRTU products and baseline commercial AC products will have similar refrigerant characteristics.

2.7.1 Market adoption forecast

This section summarizes CalMTA's forecast of the baseline market adoption (BMA) and total market adoption (TMA) of CRTUs. BMA represents the expected "naturally occurring" market adoption, considering current and anticipated market, regulatory, and technological trends. TMA includes the additional adoption resulting from strategic interventions detailed in this MTI plan.

To estimate BMA and TMA forecasts for the CRTU MTI, CalMTA employed a logit-based market share model.[31] The CRTU market adoption model forecasts market share based on economic and non-economic inputs that drive product preference - cost being the most salient of these - as well as two inputs that constrain consumer choice, based on two documented market barriers: limited CRTU availability; and awareness of the value proposition for CRTUs. The model uses a nested structure to separate the product selection decision into two stages: the first stage represents the choice of heating fuel; and the second stage represents the choice of technology when a heat pump is chosen in Stage 1.

The following equation summarizes CalMTA's approach to forecast baseline market adoption of CRTUs in any given year:

$$s_i = \frac{\alpha_i * e\text{^}(c_i) * \gamma}{\sum_{i=1}^{I} \alpha_i \; e\text{^}(c_i) * \gamma}$$

Where:

s_i = market share for product i

α_i = share weight of product i

c_i = total cost of ownership of product i, which includes the upfront cost of equipment, permitting, labor, and other installation costs, plus discounted energy bill and operating costs

γ = logit exponent parameter which defines the sensitivity of product market share to the magnitude of the price ratio of product alternatives.

e = Euler's number, denoted as "e," is a mathematical constant approximately equal to 2.71828. It is the base of natural logarithms and is widely used in mathematics, particularly in calculations involving exponential growth and compound interest.

Consumer decisions are modeled as a two-stage decision process for those with existing gas-fired packaged CRTUs. First, the consumer chooses between a gas-fired packaged CRTU (gas pack) or a HP CRTU, which is assumed to be a code-minimum model (the most prevalent type currently available). Conditional on the selection of the HP alternative, consumers face a

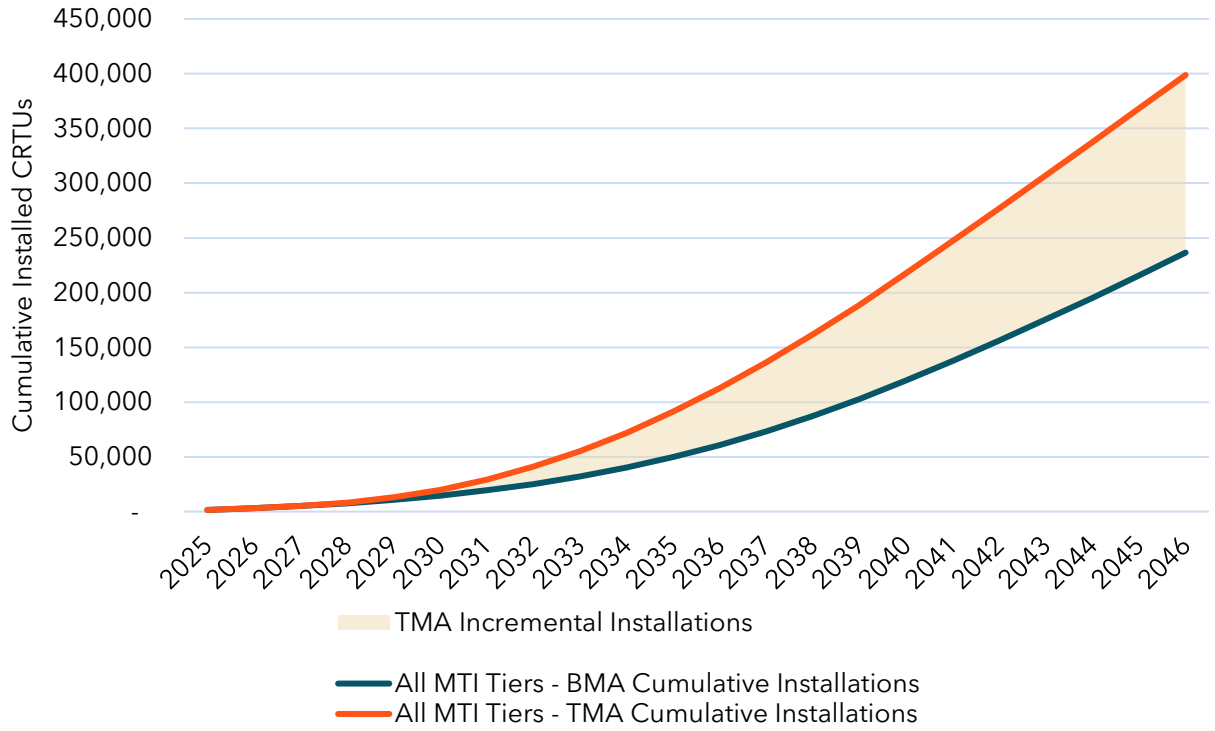
[31] The use of logit-based market share models is grounded in the random utility framework established by McFadden, D. (1973). *Conditional Logit Analysis of Qualitative Choice Behavior.* In P. Zarembka (Ed.), *Frontiers in Econometrics* (pp. 105–142). Academic Press. See Appendix B. Market Forecasting and Cost-Effectiveness Modeling Approach for additional details.

secondary choice between the code-minimum and higher-efficiency CRTU alternatives. Consumers with existing electric CRTUs choose only between the code-minimum and higher-efficiency HP, or CRTU, alternatives.

Model assumptions were informed by findings from the market characterization report. The TMA forecast reflects outcomes resulting from the MTI market interventions, as indicated in the CRTU program theory and logic model, and by the market progress milestones described in this MTI Plan. CalMTA also considered the estimated impact of the MTI on fuel substitution, under three policy scenarios. These assumptions are described in greater detail and documented in Appendix B: Market Forecasting & Cost-Effectiveness Modeling Approach.

Figure 1 illustrates the estimated annual baseline and total market cumulative adoption levels.

Figure 1. Estimated BMA vs TMA Cumulative CRTU Installations – All Tiers



In the final step of the adoption forecast process, CalMTA calculated the net incremental unit adoption, which is equal to TMA minus BMA, minus estimated adoption associated with Program Administrators' (PAs) verified savings (this includes all PA programs statewide; for IOUs, this includes program incentivized units CalMTA estimates will be reported in CEDARS). The net incremental adoption is summarized in the equation below:

$$Y^{N.Incremental} = Y^{TMA} - Y^{BMA} - Y^{PA}$$

Where:

Y represents cumulative adoption of CRTU products over the forecast period of 2025 to 2046.

$N.incremental$, TMA, BMA, and PA represent net incremental adoption attributed to the MTI, Total Market Adoption, Baseline Market Adoption, and verified PA claimed savings, respectively.

Table 4 summarizes TMA, BMA, PA-verified units, and net incremental adoption in terms of units of CRTU products.

The approach summarized above estimated BMA, TMA, and net incremental adoption at a statewide level.

Table 4. Forecast of adoption of CRTUs (2025 - 2046)

RTU Tier	BMA	TMA	PA-Verified	Net incremental
Tier 1 - Code Min HP+CCC	147,782	158,056	0	10,274
Tier 2 - Code+20%	38,594	87,095	9,333	39,168
Tier 3 - Code+20%+VS+CCC	50,212	153,739	19,773	83,754
Total	**236,587**	**398,890**	**29,106**	**133,196**

Note: Unit adoption may not sum to total due to rounding.

A detailed explanation of the methodology and approach, models, inputs, assumptions, and results are provided in Appendix B.

3 Product definition & assessment

Although RTUs are one of the simplest types of equipment used for space conditioning in non-residential buildings, there are many ways to improve their performance, efficiency, and grid impacts. Since each of these product improvements can add cost, CalMTA focused on features and attributes with the greatest benefits to California ratepayers.

Figure 2. A commercial building rooftop unit

3.1 Product definition

This MTI will focus on increasing the adoption of high performance products, increasing the cooling efficiency of units by 20%, and integrating sensors, analytics, and cloud-connectivity with a simple, app-based tool to ensure optimal installation and commissioning, long-term operational efficiency, increased load flexibility and occupant comfort, and to leverage remote monitoring tools to reduce faults and errors as well as provide information to HVAC technicians.

Due to feedback received from MTAB and public commentary processes, the product definition was revised by removing the requirement for an inverter-driven variable speed compressor for Tier 3 and instead requiring only a variable speed supply fan in addition to the requirements for Tier 1 and Tier 2 for CCC and cooling performance respectively. Specific details and discussion for this change are found in Appendix I.

3.2 Summary of key findings

CalMTA's Phase II product assessment research produced the following key findings, which informed the design of this MTI.

Finding 1: The largest opportunities for non-residential RTUs in California are 1) increasing adoption of HPs, 2) increasing cooling efficiency, 3) integrating variable speed supply fans, and 4) incorporating factory-installed sensors and connectivity to enable app-based startup, remote monitoring, and enhanced automated fault detection and diagnostics (AFDD+).

Finding 2: Efficient RTU designs that include energy or heat recovery and enclosure insulation that are used to boost unit efficiencies in cold climates are generally not cost-effective in California due to the moderate climate; there are other performance enhancements that are better suited to California's climate and energy priorities.

Finding 3: RTUs are regulated at both the federal and state level and market interventions therefore need to consider both sets of regulations. Federal standards apply equally to equipment used in both new construction and existing buildings, while California's codes and standards have significantly different requirements for new construction and replacement.

Finding 4: Although there are many options for non-residential RTUs with CCC, manufacturers have not aligned on consistent standards, strategies, and user interfaces.

Finding 5: Despite Title 24 requirements for AFDD, many existing RTUs do not operate as intended.[32] However, operational performance can be improved with effective AFDD, customer notifications, and remote access for technicians.

Finding 6: High switchover temperature HPs with backup electric resistance heat strips can increase energy consumption and customer bills, but customers may not be aware since it will not impact heating performance.[33] Correctly sized HPs with correctly configured controls can reduce or eliminate the need for electric resistance heating across California.

3.3 Key product features and attributes

3.3.1 Cooling efficiency

This MTI proposes that to meet CRTU requirements units should be 20% more efficient than federal cooling efficiency standards in place when the unit is sold. Based on data from the most recent federal appliance standard ruling on commercial units, there are units on the market today that can meet this requirement. Table 5 shows the current federal minimum standard and the proposed 20% efficiency increase. Using a cooling efficiency target based on federal standards will help program participants and partners understand program requirements even as federal standards are updated.

[32] A 2021 field study found that a combination of factors led to poor installed performance, despite code requirements for AFDD. For more information see RTU/Economizer Analysis and Field Assessment.
[33] The DOE defines the switchover temperature as the "ambient temperature at which the unit switches from primary (mechanical) heating to resistance heating (all-electric HP RTUs) or gas heating (dual fuel HP RTUs)."

Table 5. Current federal minimum cooling efficiency metric and proposed cooling efficiency metric by capacity range

Capacity Range (Btu/h)	Capacity Range (tons)	Federal Standard Current Minimum/2029 Minimum	Proposed 20% efficiency increase
<65,000	<5.4	13.4 SEER2	16 SEER2
≥65,000 and <135,000	≥5.4 and <11.25	14.1 IEER / 13.4 IVEC	17.3 IEER / 16 IVEC
≥135,000 and <240,000	≥11.25 and <20	13.5 IEER / 13.1 IVEC	16.8 IEER / 15.7 IVEC

3.3.2 Variable speed supply fans

CalMTA's product definition includes a variable speed supply fan, which can further improve energy efficiency during both heating and cooling seasons relative to constant and two-speed fan systems. While Title 24 requires two-speed fan control for systems greater than 65,000 Btu/hour cooling capacity, further savings can be gained on the HVAC system performance by incorporating a fully variable supply fan, especially during part load operating conditions.

3.3.3 Remote monitoring, enhanced automated fault detection and diagnostics (AFDD+), and load flexibility

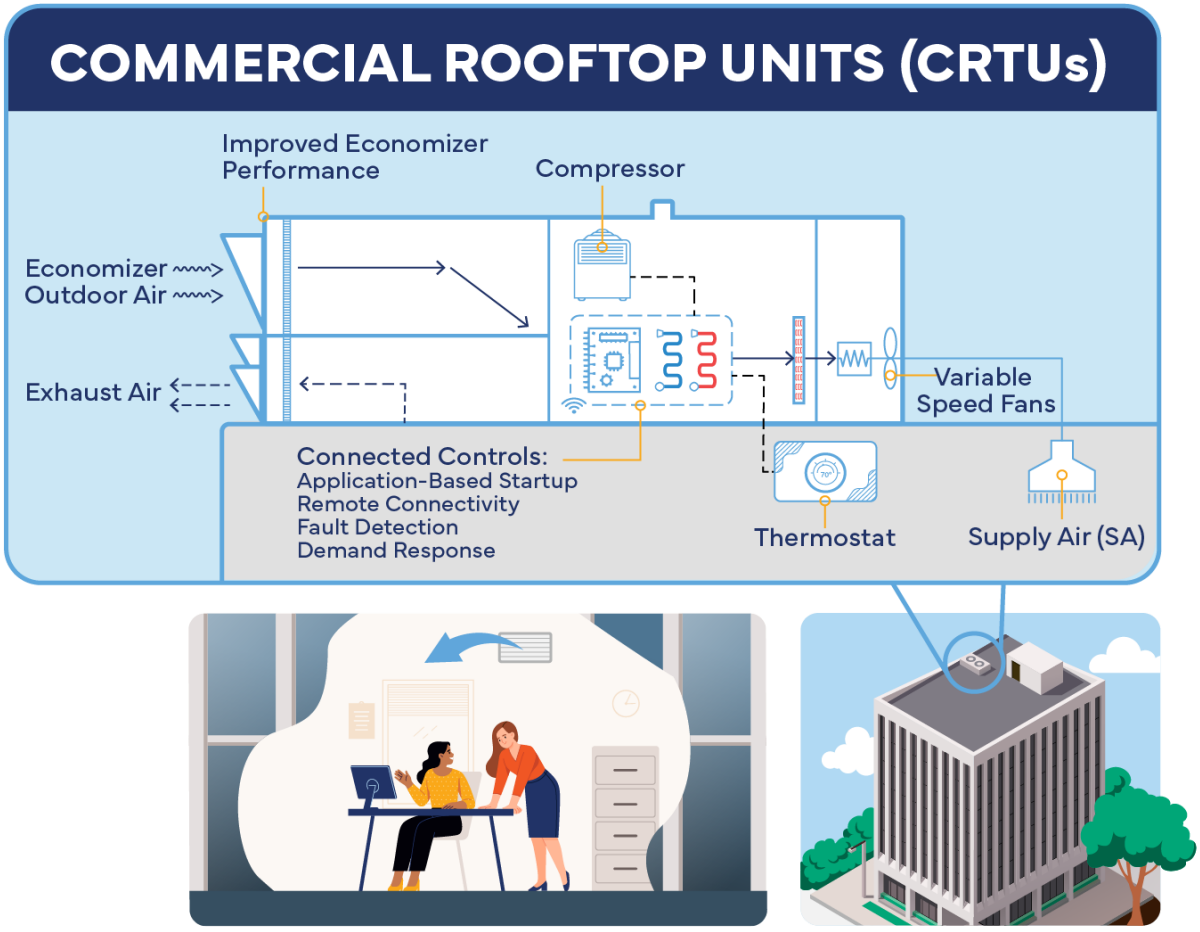
CalMTA's product definition seeks to incorporate factory-installed sensors and connectivity, allowing building managers and HVAC service providers to better understand RTU performance, schedules, and to detect faulty equipment and operational inefficiencies remotely without having to be on-site. Over the long term, this technology can also enable market participants to diagnose and resolve RTU performance issues using machine learning and automation.

Many of the same connectivity and control functions used to support fault detection and optimize long-term performance of variable speed fans can also support load flexibility. By having more control over the airflow, VS fan RTUs can "turn down" without having to "turn off." Remote connectivity can adjust setpoints and let the entire unit to provide ventilation without necessarily providing heating or cooling.

3.3.4 App-based startup commissioning

The same sensors and connectivity that enable long-term remote monitoring and AFDD+ can also support improved startup and commissioning, which is particularly important for advanced HPs to optimize energy performance. Reducing the complexity of the startup process with a user-friendly, app-based software can lead to HVAC units that are more likely to be set up and commissioned properly.

Figure 3. Illustration of a CRTU showing key features



3.4 Product performance and research summary

3.4.1 Federal efficiency standards

The key performance metrics for heating and cooling in HP RTUs are rated efficiency and capacity. Packaged RTUs are governed by Federal Appliance Standards, which focus on the efficiency metrics of the product. Under the Energy Policy and Conservation Act (EPCA), federal preemption prohibits individual states from creating regulations that are more stringent than the federal minimum efficiencies for covered products, including RTUs.

There are separate federal test procedures and metrics governing RTUs with cooling capacity of less than 65,000 Btu/hour and RTUs with cooling capacity between 65,000 Btu/hour and 760,000 Btu/hour. Minimum efficiency standards for products between 65,000 Btu/hour and 760,000 Btu/hour are further divided into three groups, shown in Table 6. In 2029, the efficiency metrics for RTUs with cooling capacity above 65,000 Btu/hour will change from IEER and COP to IVEC

and IVHE. Current efficiency requirements and metrics for four different size categories are shown in Table 6.

Table 6. Minimum federal efficiency standards for HP single package HVAC products

Size Category	Current Efficiency Metrics	2029 Updated Efficiency Metrics	Test Procedure
< 65,000 Btu/h	13.4 SEER2	13.4 SEER2	AHRI 210/240
≥ 65,000 Btu/h and < 135,000 Btu/h	14.1 IEER 3.4 COP	13.4 IVEC 6.2 IVHE	AHRI 340/360
≥ 135,000 Btu/h and < 240,000 Btu/h	13.5 IEER 3.3 COP	13.1 IVEC 6.0 IVHE	
≥ 240,000 Btu/h and < 760,000 Btu/h	12.5 IEER 3.2 COP	12.1 IVEC 5.8 IVHE	

3.4.2 California Title 24 building energy efficiency standards

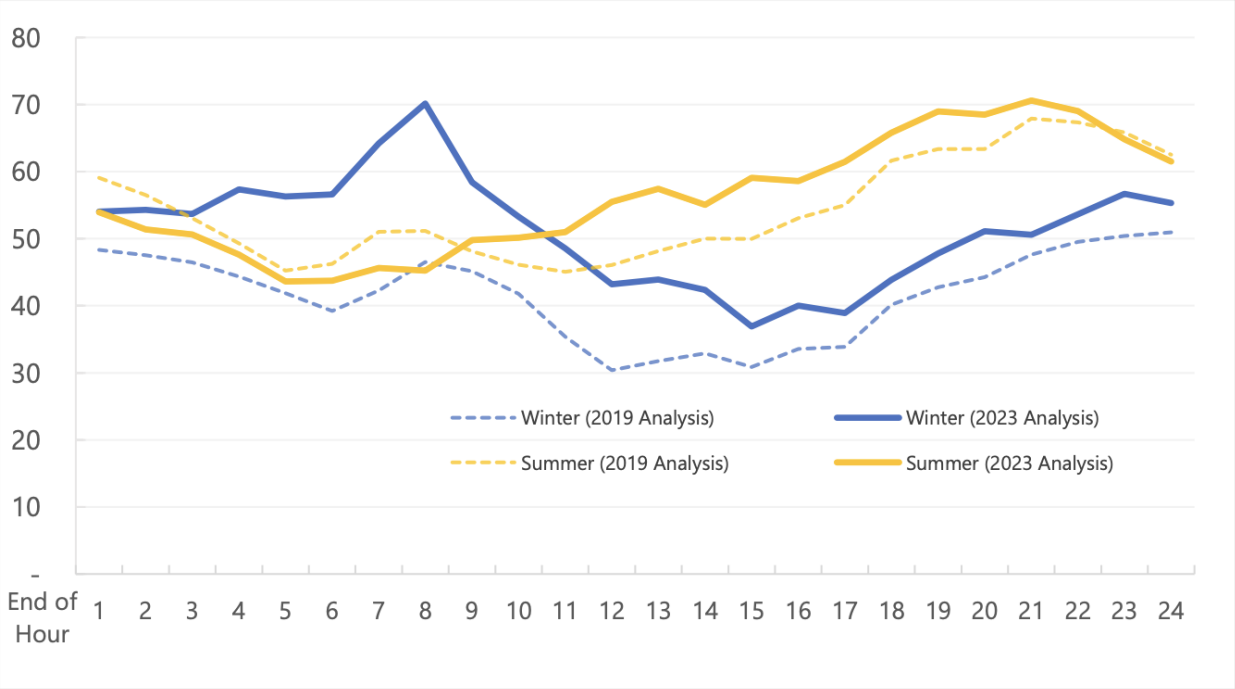
While California is preempted from creating more stringent energy standards for RTUs, regulations can be developed that cover a component or aspect of RTU performance that is not recognized as a federally covered product, such as economizers fault detection, DR-capable controls, and field verification of RTU installations (acceptance testing). California can also develop prescriptive compliance options that exceed the federal minimum if there is another viable compliance option that does not exceed the federal minimum. For new construction, prescriptive standards adopted in 2022 require single-zone HVAC systems (including RTUs) to be HPs in most building types and climate zones.

3.4.3 Mitigating increasing winter peak electricity demand

As shown on Figure 2, California's winter peak electricity demand is projected to become roughly equal to summer peak electricity demand by 2045. However, these projections may in fact be conservative because they assume that heat pumps will use very little electric resistance backup heating, while field data and lab tests indicate that HPs – including RTUs – may rely heavily on backup resistance heating, particularly during morning warmup and during the coldest hours of the year, especially when operational controls are not configured appropriately.[34] By reducing or eliminating the need for backup resistance heating through improved startup and controls configuration, as well as ongoing monitoring, CCC technology can help mitigate increases in winter peak electricity demand for HPs.

[34] Higa, et al. (2024). Yeah, But It's a Dry Cold: Applicability of Cold Climate Heat Pumps in California. Southern California Edison.

Figure 4. Projected summer and winter peak electricity demand in California in gigawatts[35]



3.4.4 Iterative energy modeling

The CalMTA team relied primarily on energy modeling for this evaluation of energy savings, but also considered other factors such as input from existing reports, publications, and industry white papers as well as input from manufacturers and other market actors to ensure that the key features and attributes identified in the CRTU MTI product definition are available in the market, align with original equipment manufacturer (OEM) business models and product development cycles, and can realistically be integrated into a wider range of products over the course of the MTI. Several rounds of energy modeling were performed using EnergyPlus, the open-source DOE software, with American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 90.1-2004 DOE reference building models to represent typical commercial buildings.

Before finalizing a product definition, an initial phase of energy modeling was performed for a list of potential measures. This process was used to help identify the improvements with the largest impact both in energy savings and avoided costs, while screening out other potential improvements. To reduce modeling time and effort for the preliminary assessment, three building prototypes were modeled for three climate zones. The CPUC's Avoided Cost Calculator (ACC) was used to determine the 30-year avoided cost in net present value (NPV) for the initial modeling

[35] Source for figure: (2023). Countdown to 2045: Realizing California's Pathway to Net Zero. Southern California Edison.

phase to provide a means to prioritize product attributes with the highest benefit to California. Once the product definition was developed, more detailed energy modeling was conducted to reflect all 16 CEC climate zones and multiple building prototypes.

3.4.5 Energy consumption and bill impacts

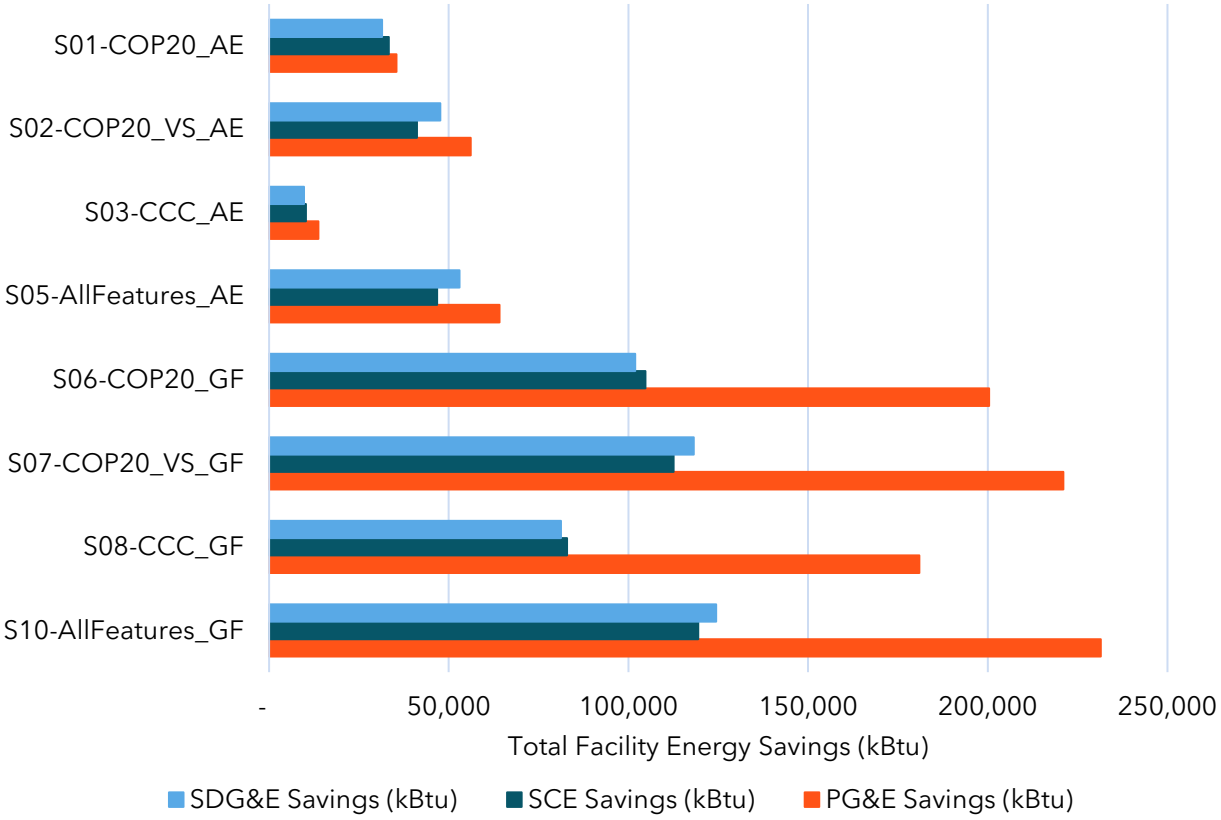
Energy consumption was modeled for baseline and proposed equipment for all 16 climate zones and five building prototypes and then weighted based on the relative contribution of each building type, climate zone, and modeling case to develop the final unit energy savings (UES) hourly profiles which were then used to calculate the final avoided costs, bill impacts, and TSB for this MTI. Table 7 shows the modeled measure with the baseline and proposed equipment type used for both energy modeling and the bill impact analysis.

Table 7. List of energy modeling measures with proposed and baseline equipment

Measures	Proposed equipment type	Baseline equipment type
S01-COP20_AE	Cooling efficiency exceeds federal minimum by 20%	Code-minimum HP RTU
S02-COP20_VS_AE	Cooling efficiency exceeds federal minimum by 20% + variable speed supply fan	Code-minimum HP RTU
S03-CCC_AE	Code-minimum HP RTU + Integrated monitoring with remote access and control, app-based startup commissioning, automated fault detection and diagnostic capabilities.	Code-minimum HP RTU
S05-AllFeatures_AE	Cooling efficiency exceeds federal minimum by 20% + variable speed supply fan + Integrated remote monitoring, control, and diagnostics, AFDD, and app-based startup commissioning	Code-minimum HP RTU
S06-COP20_GF	Cooling efficiency exceeds federal minimum by 20%	Code-minimum AC + furnace
S07-COP20_VS_GF	Cooling efficiency exceeds federal minimum by 20% + variable speed supply fan	Code-minimum AC + furnace
S08-CCC_GF	Code-minimum HP RTU + Integrated monitoring with remote access and control, app-based startup commissioning, AFDD capabilities.	Code-minimum AC + furnace
S10-AllFeatures_GF	Cooling efficiency exceeds federal minimum by 20% + variable speed supply fan + Integrated remote monitoring, control, and diagnostics, AFDD, and app-based startup commissioning	Code-minimum AC + furnace

The total facility gas and electricity savings (normalized to kBtu) by measure can be found on Figure 3.

Figure 5. Annual total facility energy savings by measure in commercial buildings by IOU



Bill impacts were calculated for commercial customers using average rates for Pacific Gas & Electric (PG&E), Southern California Edison (SCE), Southern California Gas (SCG), and San Diego Gas and Electric (SDG&E) to ensure that these proposed improvements will not significantly increase monthly bills. Energy efficiency measures using the same fuel will typically result in bill savings for consumers. Fuel substitution, however, can sometimes increase customer bills due to the higher cost of electricity relative to natural gas under certain rate structures.

Although two of the electrification scenarios resulted in a small net increase in total energy bills, this analysis suggests that the spark gap is less of a concern for commercial HVAC than it is in other sectors, such as single-family homes.

For CalMTA's study of bill impacts, the team used present-day TOU electricity and tiered natural gas rates published by California's four IOUs. Table 8 shows the total bill impacts by measure. Negative values indicate annual bill savings, while positive values indicate a bill increase. Most measures show a decrease in customer bills. If California transitions to more electrification-enabling rates and moves to increased use of dynamic pricing, CRTUs are likely to deliver even more bill savings to customers.

Table 8. Average annual total facility bill impact by proposed measure, fuel type, and utility

Measure	Electric			Gas			Total*		
	PG&E	SCE/ SCG	SDG&E	PG&E	SCE/ SCG	SDG&E	PG&E	SCE/ SCG	SDG&E
S01-COP20_AE	-4%	-4%	-3%	0%	0%	0%	-4%	-4%	-3%
S02-COP20_VS_AE	-8%	-7%	-6%	0%	0%	0%	-8%	-7%	-6%
S03-CCC_AE	-2%	-1%	-1%	0%	0%	0%	-2%	-1%	-1%
S05-AllFeatures_AE	-10%	-8%	-7%	0%	0%	0%	-9%	-8%	-7%
S06-COP20_GF	3%	-2%	-1%	-63%	-40	-39%	0%	-3%	-2%
S07-COP20_VS_GF	-1%	-6%	-4%	-63%	-40	-39%	-5%	-7%	-5%
S08-CCC_GF	7%	1%	1%	-63%	-41	-40%	3%	-1%	0%
S10-AllFeatures_GF	-2%	-6%	-5%	-63%	-41	-40%	-5%	-8%	-6%

Negative values (green text and shading) indicate bill savings while positive values (red text and shading) indicate an increase to customer bills.

*Commercial building utility costs are dominated by electric utility cost. While gas savings are a large percentage, they contribute a small amount to the overall bill impacts in a mixed-fuel scenario.

4 Market characterization

4.1 Market overview

Table 9 summarizes the target market, as well as who makes, buys, influences and sells RTUs.

Table 9. CRTU Market Overview

Target market	Existing low-rise commercial buildings that already use single-zone RTUs for space heating and cooling. Although not a part of the MTI's target market, RTUs can also be installed in residential applications.
Who makes the product?	Established HVAC equipment manufacturers focus on either custom built or mass-market product lines
Who buys the product?	RTU buyers include building owners and facility managers
How is the product sold?	RTUs must be installed by a C-20 licensed entity. Buyers typically work with an HVAC contractor to select an appropriate RTU. Buyers with their own in-house HVAC staff (e.g., university campuses) may purchase directly from a manufacturer or

Target market	Existing low-rise commercial buildings that already use single-zone RTUs for space heating and cooling. Although not a part of the MTI's target market, RTUs can also be installed in residential applications.
	distributor and self-install. In high performance applications, a designer is involved in specifying a custom-built RTU that is shipped directly to the installation location.
Who and what influences purchase decision?	Approximately 80% of RTU replacements are unplanned. Availability and price are the most influential in unplanned replacement scenarios. Building owners are less likely to plan replacements while facility managers tend to plan RTU replacements on a schedule.

4.2 Target market

The MTI target market includes non-residential buildings with existing RTUs. Non-residential buildings in California occupy approximately 8.8 billion square feet.[36] Based on data from ComStock, a commercial building stock model developed by the NLR,[37] 54% of floorspace in California is conditioned by single-zone RTUs; this translates to a total floor area of 4.8 billion square feet. A 2014 California Saturation Study found 53% of commercial HVAC units are package single-zone systems, which is consistent with the ComStock results.[38]

Nearly 80% of floor space conditioned by single-zone RTUs is found in single-story buildings, and 16% in two-story buildings. According to ComStock data for California, RTU-conditioned floor space is found in many types of buildings (Figure), with warehouse buildings comprising the most total square footage of RTU-conditioned floor area. Note that ComStock does not include certain building types such as grocery stores and religious worship.[39]

Figure shows the proportion of square footage conditioned by single-zone RTUs in each building type. In restaurants and strip malls, over 90% of floor space is conditioned by single-zone RTUs. Other building types that often use single-zone RTUs include small offices and warehouses.

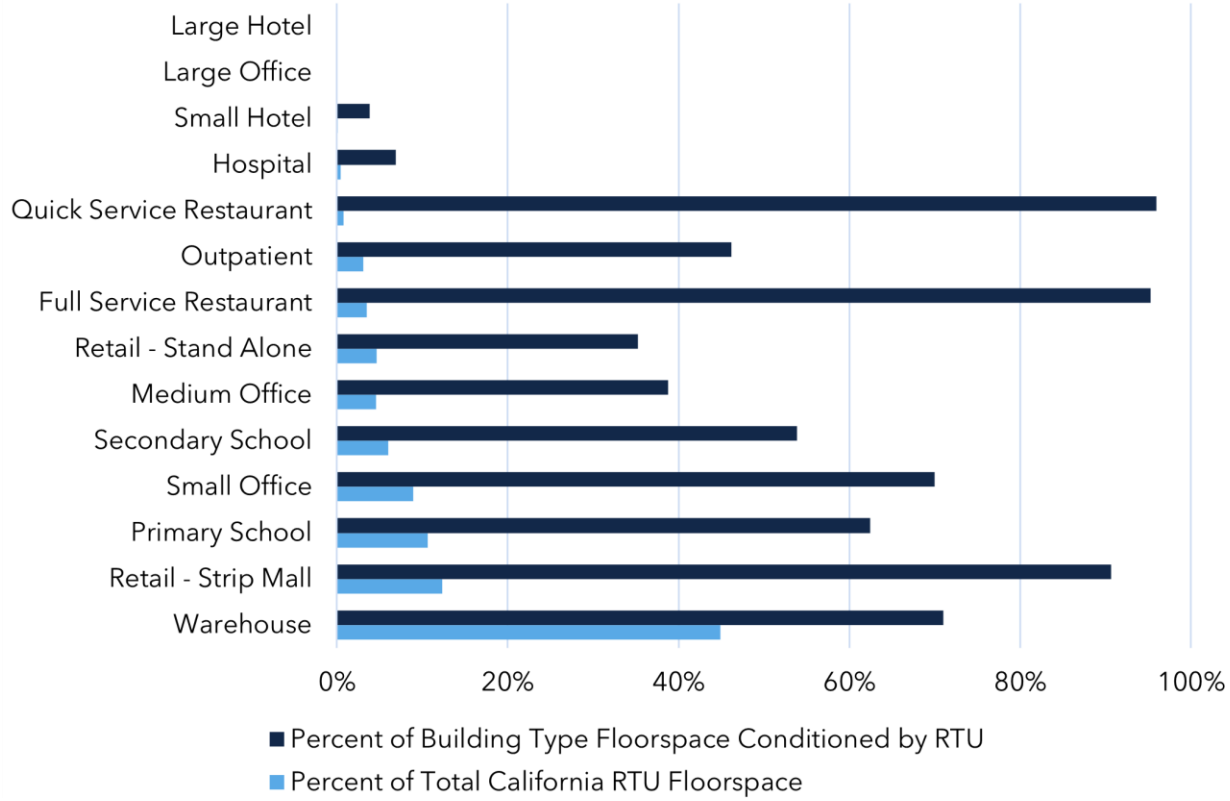
[36] California Energy Commission. February 2024. https://www.energy.ca.gov/sites/default/files/2024-02/2022%20CEUS%20Final%20Report_ada.pdf

[37] The ComStock dataset used is release #2023_2. More information about ComStock and its data sources and limitations can be found at: https://comstock.nrel.gov/

[38] Itron, California Commercial Saturation Survey. August 2014. California_Commercial_Saturation_Study_Report_Finalv2.pdf

[39] Accessed 7/25/2025 https://nrel.github.io/ComStock.github.io/docs/resources/explanations/building_types_not_included.html

Figure 6. California statewide saturation and distribution of single-zone RTU conditioned floor area, by building type



Source 1: Comstock, California baseline metadata (U.S. commercial sector circa 2018)

4.3 Current market state summary

This section presents key findings related to the current California RTU market. See Appendix D: Market Characterization Study, section 3, for additional details.

4.3.1 California market size

Based on top-down and bottom-up analysis using independent data sources, there are an estimated 47,000 annual single-zone RTU shipments to California. The existing RTU stock in California is estimated to be between 740,000 to 1 million RTUs. See Appendix D for details.

4.3.2 California RTU characteristics

Based on 2024 California permit data, more than half of new RTUs have under 5.4 tons of cooling capacity and 77% of are installed in hot-dry climates (climate zones 7-15). See Appendix D, Figure 2 and 3, for details.

Recently interviewed HVAC contractors indicated all-electric heat pump RTUs had a market share of 50%. Distributors reported all-electric heat pump RTUs represented 26% of their recently sold

units, with gas packs having the largest share at 73%. See Appendix D, Figures 7 and 8, for details.

RTUs with variable speed compressors were relatively rare, with contractors reporting variable speed HP RTUs having under 10% market share. None of the five distributors interviewed stocked inverter-driven HP RTUs. See Appendix D, section 3.6, for more information.

4.3.3 RTU controls

HVAC control boards and thermostats play important but different roles in controlling RTUs. The control board is akin to the brain of the system, receiving signals from the thermostat and other sensors to coordinate and control a broad range of functions (i.e., fan speed), while thermostats measure temperature in the conditioned space (in a single zone) and call for heating or cooling from the HVAC system. RTU thermostats range from manual thermostats to internet-connected controls to thermostats that allow integration with building automation systems (BAS). NLR estimates that in the United States, 60% of commercial buildings over 50,000 square feet have a BAS, but only 13% of buildings under 50,000 square feet have adopted the technology.[40]

CalMTA's interviews with 18 contractors about how RTUs sold in the past year were controlled found Wi-Fi-connected thermostats were the most common (44%). Contractors still use manual thermostats in some instances (19%). One contractor elaborated that they typically only install manual thermostats for customers who are either replacing an existing manual system or who are not comfortable with programmable or Wi-Fi controls. Only one contractor said they rarely install units controlled with BAS thermostats. Distributors also reported the majority of RTUs are sold with Wi-Fi-connected thermostats (52%). Distributors estimated that they sold a quarter of RTUs without a thermostat, indicating that the existing thermostat would likely be re-used in those sales.

CalMTA surveyed building owners and facility managers about existing RTU controls. Most building owners were closely split between BAS thermostats (33%) and Wi-Fi-connected thermostats (30%), while facility managers reported using less sophisticated controls, with manual thermostats being the most common (45%). See Appendix D, Figure 14, for full results.

4.3.4 Remote monitoring system

Most contractors (nearly 75%) were familiar with internet-enabled RTUs with onboard sensors that allow for remote monitoring and fault detection. However, of those who were familiar with remote monitoring systems for RTUs, just under a quarter recommended them. The majority did not recommend these systems or recommended them with caveats.

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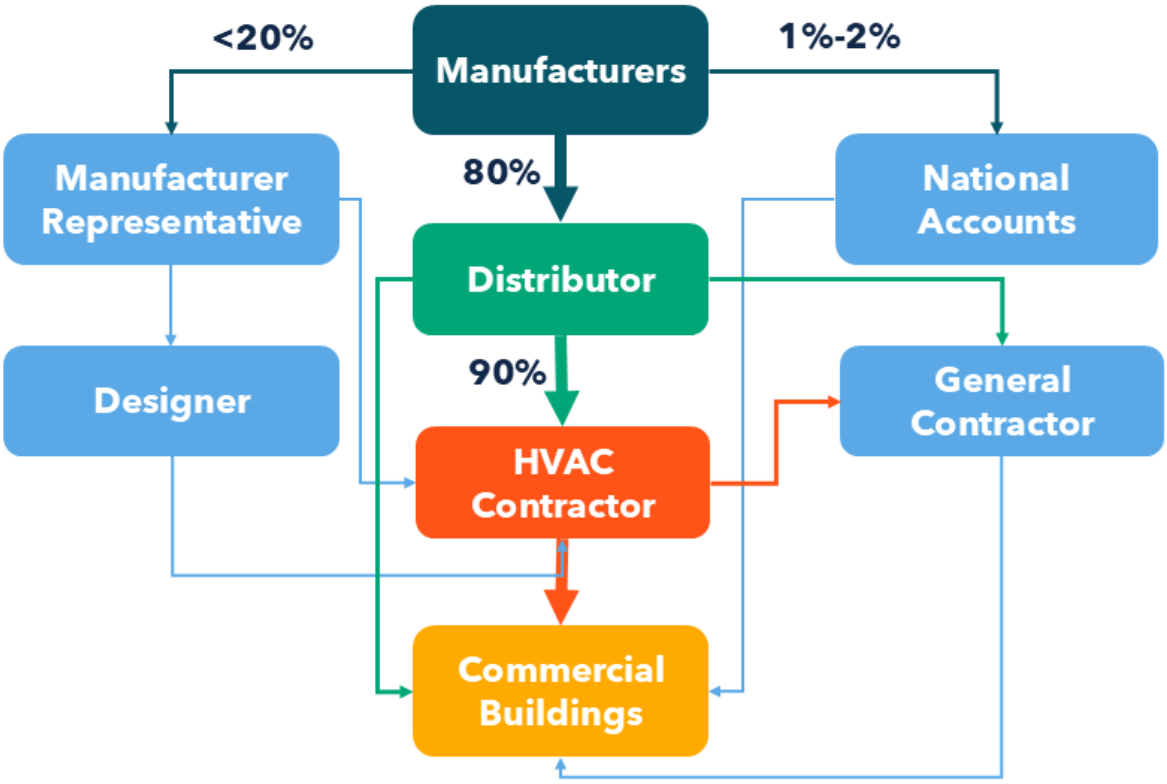
[40] Clean Energy Manufacturing Analysis Center. 2022. *Commercial Building Sensors and Controls Systems: Barriers, Drivers, and Costs.* https://www.nrel.gov/docs/fy22osti/82750.pdf

4.4 Supply chain map

Based on CalMTA's primary and secondary research, an RTU purchase from the manufacturer to the end user (Figure 5) can take one of several pathways, with an estimated 80% of units moving through distributors.

Figure 7. RTU Supply Chain Map



These pathways depend on the type of project (custom design/build versus like-for-like replacement), type of customer (small business versus national chain account), existing relationships, and brand loyalty. A primary pathway is from manufacturers to distributors, then to HVAC installation contractors, and finally to commercial buildings. Other possible pathways include direct sales from manufacturers to large national accounts, such as McDonald's or Best Buy, or from an HVAC contractor to a general contractor in new construction.

4.4.1 RTU manufacturers

Table 10 provides a list of brands that offer commercial RTU products, grouped by common ownership. The bold names are those generally considered to be major brands/manufacturers.

Table 10. Brands that offer commercial RTU products

• AAON • Bosch/York • **Carrier/Bryant/ACIQ** • **Daikin North America/Daikin Applied**	• **Johnson Controls/ Champion Heating and Cooling/TempMaster/ Fraser-Johnston** • **Lennox/Allied Commercial**	• Rheem/RUUD/Russell/ Sure • **Trane** • Tuttocool

In Minnesota, a 2023 study identified Carrier, Lennox, and Trane as the three major RTU manufacturers.[41] Combined with Bryant and York, these brands had 89% of the RTU market share in Minnesota and were typically sold through distributors (either an independent or a manufacturer-specific distributor). The study also found that AAON and Daikin Applied comprised a smaller share of the market (approximately 7%) and focused more on selling premium high-efficiency products through manufacturer representatives. A 2005 NEEA study reported similar market shares, with Trane (50%), Carrier (30%), Lennox (15%), and York (5%) as the most prominent light commercial manufacturers in the Northwest.

4.4.2 HVAC workforce

The California Employment Development Department projects annual employment between 2020 and 2030 to increase from 31,220 to 35,400 HVAC workers. Building equipment contractors will employ the majority (88%) of these workers, with the remaining workers employed by schools, federal and local government, lodging, hospitals, and durable goods wholesalers.[42,43]

HVAC installation businesses in California must have a C-20 license before a company can charge any customer $500 or more for HVAC-related work.[44,45] The California Department of Consumer Affairs Contractors State License Board maintains a list of all active C-20 license holders, which includes over 11,300 businesses in California and other states. Nearly all (98%) businesses are based in California, and 43% are businesses located in disadvantaged communities.[46] While most (59%) contractors only have a C-20 license, some C-20 holders also have other types of licenses as well, with B (general contractor), C36 (plumbing), and C10 (electrical) being the most common. Table 11 shows the most common combinations of C-20 and other licenses.

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[41] Cadeo. September 8, 2023. "High-Performance RTU Market Characterization."
[42] Building equipment contractors (NAICS code 2382) primarily install or service building equipment that is part of a building's mechanical system (such as electricity, water, heating and cooling).
[43] Occupation Code 49-9021 Heating, Air Conditioning, and Refrigeration Mechanics and Installers.
[44] Contractors State License Board. September 30, 2024. "Before Applying for a License When No Exam is Required."
[45] Contractors 2024, *op. cit.* "C-20 - Warm-Air Heating, Ventilating and Air-Conditioning Contractor."
[46] Disadvantaged communities are identified through CalEnviroScreen.

Table 11. Common C-20 license combinations

License type	Proportion of organizations
C-20 Only	59%
C-20 and B General Contractor	20%
C-20 and C36 Plumbing	16%
C-20 and C10 Electrical	12%

Most C-20 businesses are either corporations (51%) or sole owners (44%). On average, sole owners with C-20 licenses have 4.5 employees, while corporations with C-20 licenses have 22.7 employees.[47] C-20 licenses are typically held at the organizational level rather than the individual level – not every contractor on a given job will have a C-20 license; rather, their employer holds the license.

At mid- to large-sized residential and light commercial HVAC companies, workers either specialize in installation or service. Installers set up new HVAC systems while the service side conducts preventative maintenance and troubleshooting on existing systems. In addition to these core staff, there are office and sales/estimator staff who provide quotes. Smaller companies often have staff performing a wider range of duties than a larger company.

4.5 RTU purchasers

CalMTA asked contractors to describe their typical customer base for RTU sales. Among the 20 contractors interviewed, building owners are the most commonly reported RTU buyers (12 mentions), followed by property or facility managers (4 mentions). Contractors also noted other RTU buyers including general contractors and schools.

4.5.1 Planned and unplanned replacements

A recent market study estimated that in replacement scenarios, 75% to 95% of new RTUs were replace-on-failure, whereas 5% to 25% of new RTUs were planned.[48] The study also found that small businesses that tended to be more cost conscious were more likely to proceed with a replace-on-failure model, whereas large retail and national accounts were more likely to plan their replacements. Replace-on-failure typically resulted in opting for standard equipment given its availability and price point, while planned replacements increased the likelihood that the customer would opt for high-efficiency equipment due to the extra time and budget for ordering equipment from manufacturers.

[47] CalMTA analysis of C-20 data joined with purchased data from Data Axle.
[48] Cadeo. 2023. *op.cit.*

CalMTA's contractor interviews found similar rates of planned/unplanned replacements,[49] with 72% of RTUs being unplanned replacements.

According to contractors interviewed by CalMTA, while some end-use customers sought fuel substitution, in most unplanned replacements, contractors not only replaced the existing RTU with another RTU (rather than a different type of HVAC system like a variable refrigerant flow), but they also usually replaced the RTU with a product that was similar or identical to the previous system. While customers sometimes preferred the same product they previously had (i.e., they are already comfortable with it), the reason for installing a similar system was often to limit the need for additional renovations (i.e., ductwork or curb changes), thereby minimizing cost.

4.6 Purchase behaviors by type of decision maker

CalMTA surveyed building owners and facility managers whose buildings in California had at least one RTU. When purchasing a new RTU, most (66%) facility managers were willing to wait for their preferred equipment model, whereas only 15% of building owners shared this preference. In contrast, 85% of building owners prioritized purchasing readily available models, compared to just 34% of facility managers.

In a follow-up question, respondents were asked how long they would be willing to wait for a new RTU. Facility managers were willing to wait longer on average – up to 2.7 months – compared to 1.6 months for building owners. See Appendix D, section 6.3, for more information.

5 External program alignment & coordination

Following guidance provided in the Market Transformation (MT) Framework attached to CPUC D.19-12-021, CalMTA intends for the CRTU MTI to complement, add value to, and minimize overlap with existing programs serving the target market for the technology. Throughout MTI development, the team pursued and will continue to pursue substantial coordination, outreach, engagement, and collaboration with key groups and intends to identify points of alignment that: 1) eliminate duplication or redundancy in market activities; 2) ensure that the MTI adds value to the market and fills any gaps needed to drive long-term market change; and 3) increase scalability and the efficiency with which desired results are achieved by leveraging existing work.

Important aspects of CalMTA's approach to achieving these coordination and alignment goals with external programs are summarized below. A more detailed description of this work can be found in Appendix E: External Program Alignment & Coordination.

[49] Planned replacements are new RTUs installed prior to the existing equipment failing, and unplanned replacements occur when an existing system fails.

5.1 Collaboration at all phases of MTI development

Engagement with key parties related to the CRTU MTI occurred at each stage of CalMTA's three-phase development process. Activities completed prior to finalization of this MTI Plan include:

- **Request for Ideas (RFI) to Phase I MT Idea Selection** (Aug. 2023 – Feb. 2024): After selecting the CRTU idea for initial development following CalMTA's first MTI, the team 1) shared MTI development updates and solicited feedback at MTAB meetings and through the CPUC's Public Document Area website; 2) held recurring meetings with the IOU energy efficiency portfolio directors, IOU Codes and Standards working group, and CalNEXT to maximize alignment and identify additional areas of coordination; and 3) identified a preliminary set of local, state, and national programs for future coordination and inclusion in Phase II activities.
- **Phase II Advancement Plan Research to MTI Plan Finalization** (Feb. 2024 – June 2026): To gain deeper knowledge about other program efforts and their potential impact on the development of the MTI, CalMTA: 1) completed additional research to expand the list of overlapping programs and activities; 2) met directly with key parties to secure at least preliminary agreement on the potential extent of overlap and approach to program alignment; 3) conducted structured interviews with important stakeholders and subject matter experts to inform our market characterization report; and 4) engaged CalMTA's Equity Sounding Board to inform development of equity-oriented interventions and metrics.

After submitting the CPUC application requesting approval for the CRTU MTI Plan and throughout Phase III implementation, CalMTA will continue to engage external programs and entities in this market, which are offering or planning to offer incentives or other aspects related to the MTI, to minimize conflicts and create opportunities for collaboration. Critically, CalMTA will conduct ongoing meetings with IOUs and third-party implementers of related programs to define activities that will avoid market confusion, ensure points of alignment are maintained and leveraged, and identify any need to adjust MTI strategies.

Explicit needs for coordination with existing resource acquisition programs and codes and standards activities will be addressed and prioritized in the RFP used to solicit an implementation contractor for this MTI, as well as the subsequent contract, implementation plan, and in the Market Progress Evaluation Reports used to measure progress toward MTI objectives. These activities, in tandem with work to align with the PAs on savings goals and attribution as defined in the MTI Evaluation Plan, will result in implementation work plans cocreated with PAs and be shared with the CPUC for approval prior to MTI market deployment.

5.2 Related programs and potential alignment approach

In developing the market transformation theory for the CRTU MTI, CalMTA identified several areas where coordination with external programs in California and nationally offer significant opportunity for collaboration or leverage. Table 12 below, which also appears in Appendix E,

summarizes points of alignment, targeted programs that the CRTU MTI is seeking to align with, and reciprocal support that the program may expect from the MTI.

Table 12. CRTU external program coordination approach

MTI alignment goal	Targeted program(s)	Possible reciprocal support from MTI and CalMTA
Codes and standards programs and other regulatory efforts provide a critical point of coordination and leverage as CalMTA seeks to align MTI activities with California code development/ enforcement and collaborate on engagement with federal test procedures, standards-setting, and qualified product lists. We will seek to understand and encourage opportunities to solidify efficient commercial RTU technology with desired features through code/standards, including collaboration on national standards, test procedures, and messaging.	IOU Codes & Standards Program CEE Commercial Unitary Air Conditioners and Heat Pumps Specification California Air Resources Board (CARB) Bay Area Air Quality Management District South Coast Air Quality Management District (SCAQMD) U.S. Department of Energy/ENERGY STAR While not a regulatory effort, the California Heat Pump Partnership established by the CEC will also be a point of coordination.	Support product development/enhancements at the manufacturer level with a focus on products that include CalMTA's desired features Provide market data as MTI moves into implementation Streamline messaging and point-of-contact for manufacturer engagement and national advocates
Existing **research and development projects/programs** provide leverage for CalMTA to develop and launch the MTI more quickly. Collaboration on research, including pilots, will help stakeholders working in this market better understand product performance and necessary enhancements while minimizing duplication of efforts.	CalNEXT (IOUs' statewide electric emerging technologies program) U.S. DOE Better Buildings Commercial Building Heat Pump Accelerator U.S. DOE National Labs (e.g., Lawrence Berkeley National Laboratory or Pacific Northwest National Laboratory) and research universities (e.g., University of California, Davis Western Cooling Efficiency Center) California Energy Commission Electric Program Investment Charge (EPIC) program NYSERDA NYS Clean Heat Initiative	Share market and pilot data Support product development/enhancements at the manufacturer level

MTI alignment goal	Targeted program(s)	Possible reciprocal support from MTI and CalMTA
Statewide or regional incentive programs that include efficient commercial HVAC products or directly serve the MTI target end-user market can be encouraged to incentivize CalMTA's desired features and lower the upfront cost of adoption.	Comfortably California (IOUs' statewide midstream/upstream HVAC program) Los Angeles Department of Water and Power Business Offerings for Sustainable Solutions Silicon Valley Clean Energy Business Rebates Municipal utility prescriptive RTU incentives (e.g., City of Anaheim and Silicon Valley Power) Southern California Edison Commercial Energy Reduction Initiative (CERI) Program and Willdan's Comprehensive Commercial Program	Facilitate manufacturer connections Share market and pilot data Communicate program participant and implementer feedback to manufacturers to influence product enhancements Provide marketing support (i.e., benefits messaging, educational content, manufacturer assets, collateral templates)

CalMTA views the Statewide Upstream and Midstream HVAC Program as a significant and critical point of leverage for advancing progress toward widespread adoption of RTUs with desired features. Because this program recently went through a transition in PA and implementation contractor, with an RFP currently in development, we anticipate scheduling working meetings with the PA and implementation team after a contract is in place. We have conducted preliminary meetings with PG&E, the new PA overseeing this program, to ensure awareness of our planned MTI activities during the RFP development and procurement process. We anticipate that the solicitation timeline for the Statewide Upstream and Midstream HVAC Program will precede the timeline for approval of and RFP release for the CRTU MTI; our team will ensure ongoing monitoring and engagement to ensure that the future MTI market deployment scope of work reflects areas of leverage and coordination based on the final Implementation Plan for this key external program.

6 Data management

CalMTA will implement a comprehensive data collection and management strategy throughout the MTI's life that includes collection and ongoing management and analysis of these data:

- MTI program data and materials
- Secondary data and information on other program participation
- Qualifying product lists and market actor sales or shipment data

- Data collected via primary research
- MPIs

Data will be organized to allow for longitudinal tracking and efficient access to data for analysis purposes. The data will support market progress evaluation and updates/true-up analyses to MTI incremental impacts and cost-effectiveness, as well as assessment of market trends and progress toward MTI goals.

6.1 MTI program data and materials

CalMTA will create a repository of program data and materials that includes a detailed record of stakeholder and market actor communications; program data, including agreements and data provided by market partners, market adoption, and cost-effectiveness models and forecasts with fully documented inputs, assumptions, and calculations; MTI MPIs; demonstration project participants and end users; and market and product research data and reports.

CalMTA team members log communication with stakeholders, partners, and clients to enable comprehensive tracking and reporting of activities, outreach, and events. This will act as a record of CalMTA's interventions and their timing and a resource for evaluators to monitor MPIs and investigate the causal relationship and impact of interventions.

The CalMTA website also includes a Resources and Reports section that catalogues program material and communications with CalMTA partners and stakeholders.

CalMTA will conduct market and product research in support of specific MTIs, and regularly true up the market adoption forecast by incorporating actual sales or shipment data as it becomes available. These program data, market and technology data, summary findings, and other work products resulting from research conducted by CalMTA and third-party evaluators will be securely stored as part of CalMTA's ongoing data management activities.

6.2 Secondary data and information

CalMTA will collect data from secondary sources regarding population characteristics (such as California commercial building characteristics), market trends, and other programs. Secondary data and information sources may include:

- Trade association industry statistics
- PA Program and CEDARS data
- California Commercial end-use survey
- Evaluation reports from related RTU programs

6.3 Product category sales and shipment data

Data on RTU sales and shipments are critically important for evaluating the MTI incremental impacts, yet such data can be difficult to obtain. Given how crucial it is, CalMTA will negotiate agreements with market partners that include sales or shipment data whenever possible. CalMTA will supplement what can be obtained from market partners with other sources of sales and shipment data that can be purchased or acquired via primary research.

Appendix F: Evaluation Plan provides a detailed description of the sales, programs, and shipping data the MTI will maintain.

6.4 Data collection via primary research

CalMTA will collect primary data through various research activities to generate ongoing market insights to inform MTI strategy and tactics, and support market progress evaluation, including longitudinal tracking of MPIs and assessment of progress toward milestones and outcomes. Appendix F provides detailed descriptions of data collection activities, including:

- RTU buyer surveys
- Building owner and facility manager surveys
- Manufacturer interviews
- Demonstration project interviews
- Stakeholder, SME, and MTI staff interviews

6.5 Market progress indicators

MPIs correspond with the MTI's theory of market transformation, as represented in the Logic Model (Appendix A), and are critical to ongoing market and MTI performance tracking. The data collection described in Section 6.4 will enable CalMTA and evaluators to assess progress against these metrics.

For example, CalMTA will track the market share of CRTUs with various features. Appendix F provides a detailed description of data sources and the MPI assessment and other evaluation activities the MTI will conduct.

7 Evaluation & market research

Ongoing evaluation and market research are essential to the development and successful management of market transformation programs. CalMTA and the CPUC's Energy Division will oversee implementation of rigorous and strategically focused evaluation, measurement, and verification (EM&V) practices, which will enable CalMTA management and stakeholders to gauge the performance of CalMTA and MTIs, verify incremental impacts, and improve the design and success of future MTIs.

Ongoing program evaluation that provides timely feedback to support program decision making, which is also known as "real-time" or "embedded" evaluation, will provide MTI program managers and implementers with continual feedback and allow them to pivot strategies as needed to maximize the value delivered to California ratepayers. Per the Decision and the MTI Evaluation Framework, CalMTA and an independent third-party evaluator each have important evaluation roles in MTI evaluation. CalMTA will conduct ad hoc market research and develop forecasts of MTI incremental impact and CE, while an independent third-party evaluator is responsible for evaluating market progress and causal influence of the MTI, and for reviewing estimates of MTI incremental impacts and cost-effectiveness. CalMTA developed a preliminary plan for third-party evaluation of the MTI with input from the Evaluation Advisory Group, a group of three independent evaluation experts, the CPUC project manager, and the CalMTA market research and evaluation lead (see Appendix F for details). Final evaluation plans will be developed by an independent third-party evaluator to be selected via a competitive RFP process after the MTI advances to Phase III.

7.1 Evaluation approach overview

CalMTA and its third-party evaluator will employ a theory-based evaluation (TBE) approach to evaluating the MTI, which is widely accepted as a best practice for market transformation program evaluation. TBE uses the program theory as the point of reference for market progress evaluation - assessing market progress against the theorized short-, medium-, and long-term outcomes and corresponding MPIs, and the extent to which the market interventions addressed the market barriers identified and caused the outcomes theorized in the Logic Model.

The evaluation will address these high-level objectives:

- Monitor market dynamics and characteristics; assess market developments
- Review and assess the MTI program theory and logic model
- Measure market progress and equity, per the MPIs
- Assess MTI causality per the logic model, using evidence-based assessments that use a "preponderance of evidence" approach and established market transformation evaluation best practices
- Identify gaps in implementation and opportunities to adjust MTI strategy and tactics, to improve MTI effectiveness
- Assess ancillary benefits and costs

- Review CalMTA's baseline market adoption (BMA) and total market adoption (TMA) forecasts, unit energy savings, incremental net MTI impacts and co-created MTI impacts,[50] and cost-effectiveness inputs and assumptions

Through the market evaluation findings, the third-party evaluator will determine if the original BMA forecast, program attribution, and calculation of incremental impacts require adjustment. Additional guidance on these issues can be found in the Market Transformation Evaluation Framework.

7.2 Market progress indicators

The evaluation plan identifies 21 MPIs that correspond with the MTI program theory. While the ultimate market progress indicator is market adoption of CRTUs (CalMTA will track this metric from the outset), this metric can be a misleading indicator of success during the first several years of MTI implementation because market share and adoption will accelerate only after the MTI addresses critical market barriers (such as reduction in incremental cost difference and limited availability) and improved awareness of the benefits. Therefore, to appropriately evaluate market progress and ensure accountability, the evaluator must assess short- and medium-term MPIs that align with the Logic Model, including:

- Number of manufacturers partnering with CalMTA on demonstration projects
- Number of demonstration project CRTUs installed and number installed in DACs
- Incremental installed and equipment-only price of CCC and other CRTU features
- Number of minimum efficiency product lines including CCC as a standard feature
- Percent of customers and contractors self-reporting that CRTU interfaces are easy to use
- Percent of potential RTU buyers who understand and value CCC
- Market share of CRTUs
- Percent of distributors stocking CRTUs
- Percent of HVAC contractors that include CCC in customer bids by default
- Percent of HVAC companies that access customers' CCC to support diagnostics and repairs
- Number of HVAC training organizations that include CRTUs in curriculum
- Number of California EE programs that adopt at least one CRTU tier for incentive eligibility after engagement with CalMTA
- Adoption of CCC in appropriate codes, standards, or state policies

[50] Co-created impacts are the total impacts resulting from an MTI's interventions, including those resulting from collaborations with resource acquisition programs.

Appendix F provides a complete list of MPIs and how they will be assessed. It also describes data sources and evaluation approaches that the third-party evaluator can use to assess market progress, MTI causality, equity, and CalMTA's estimates of MTI incremental impacts and cost-effectiveness. The evaluator will conduct ongoing market monitoring via secondary data analysis and primary research to assess market progress and causality and, importantly, to provide ongoing market insights that provide real-time information to inform MTI strategy and confirm performance or provide recommendations for improvement.

CalMTA identified these primary and secondary data collection activities and associated analysis tasks that would allow the third-party evaluator to evaluate the CRTU MTI, which are described in Appendix F. CalMTA anticipates that the independent third-party evaluator will have suggestions for how to improve upon this plan.

7.3 Ad hoc market research

The planned evaluation activities include a breadth of planned market research activities that will provide ongoing market insights to support refinements to the MTI strategy and tactics. CalMTA expects there will also be a need for ad hoc research to help support timely implementation decisions and program effectiveness. For example, the initiative includes a strategic intervention to build market awareness of the benefits of CRTUs. The market research conducted for the Market Characterization study revealed that certain types of HVAC installers may not be aware of the benefits of CRTUs and it will be necessary to identify compelling messaging on this topic. CalMTA has included a modest budget for ad hoc research needs and will identify specific research studies over the initiative lifetime.

8 Risks & mitigation

This section details the potential risks that could negatively impact the CRTU MTI and CalMTA's plan to monitor and mitigate the risks. The risks listed in Table 13 have been identified as key risks to track. Please see Appendix G: Risk Management Plan for a full list of possible risks for this MTI. We are defining "high," "medium," and "low" for each risk as follows.

For "Probability of Occurring" in the second column, CalMTA is defining:

- **High:** Through our research and discussion with market actors, CalMTA deems this risk having a high probability of occurring. The program needs to monitor closely and identify a solid backup plan with resources that can be deployed to mitigate the risk if it comes to fruition.
- **Medium:** This risk has a medium probability of occurring given what we know about the market. The MTI needs to track and have a mitigation plan.
- **Low:** The probability of this risk occurring is low based on what we know about the market to date. It could have some impact on the need for resources and timing, so the MTI needs to track.

For "Severity" in the third column, CalMTA is defining:

- **High:** If this risk plays out and our mitigation approach is unfeasible, then the success of the MTI may be in jeopardy.
- **Medium:** This may have an impact on the timing or overall success of the MTI, but the MTI will be able to pivot with more time or resources.
- **Low:** This level of risk will likely require a program intervention adjustment, but it will not jeopardize the timing or resources needed.

Table 13. Risks assessment

#	Risk	Probability of occurring	Severity	Mitigation approach
1	**CalMTA's CRTU demonstration project does not reach the expected number of installations or shows lack of customer and/or contractor acceptance of CCC.**	Medium	High	Identify barriers to participation in demonstration project and understand demonstration project participant experiences; work with market actors to set expectations on how the technology works and any long-term tracking that is desired.
2	**End users do not understand CCC and do not respond to faults.** Some units with CCC will have service contractors monitor faults, and some will require end-user awareness and action to correct errors.	Medium	Medium	Develop and share educational materials on what CCC is and is not, how CCC makes RTUs perform better and save more energy than a Title 24 minimum product. Distribute to RTU vendors and other organizations, such as Building Owners and Managers Association.
3	**Educational materials for CRTUs are not integrated into HVAC organizations' training curriculum.**	Medium	Medium	Conduct outreach to training organizations, respond appropriately to feedback.
4	**Contractors do not fully embrace CCC.** Contractors are the ones recommending equipment, and CCC is relatively new. Some contractors may be hesitant to push CCC CRTUs if they don't have experience with them.	Low	High	When working on the demonstration project, identify tech-savvy contractors and consider providing financial incentives directly to contractors. Obtain feedback from contractors on any concerns with CCC.

#	Risk	Probability of occurring	Severity	Mitigation approach
5	**Contractors don't embrace variable speed fans.** Some contractors appreciate variable speed fans, but some consider variable speed too complicated, or not worth the extra cost. This would result in slower and/or limited adoption.	Medium	High	Concentrate on education and training through all of the channels: manufacturers, distributors, and other avenues.

9 Cost estimates

Table 14 contains annual cost estimate by major program activity for the full 20-year program period, representing all Phase III costs required to achieve full market transformation and to validate all impacts. Additional detail, including estimated annual investment by year, can be found in Appendix H: Phase III Cost Estimate.

Table 14. Cost estimates*

Activity	Total Phase III cost estimate
Program implementation including the following line items: • MTI oversight, strategy, and management • Marketing and awareness building • Policy development and support • Supply chain management	$18,627,000
Market Research including the following line items: • Market research • Data collection	$3,405,000
Upstream incentives designed to flow down to consumers	$13,450,000
Downstream incentives that would be provided to consumers	$0
Program evaluation	$2,905,000
Total	**$38,387,000**

*Cost estimates in Appendix B and used in all cost-effectiveness calculations include costs incurred during Phase II: Program Development. Total investments for Phase II and Phase III are estimated to total $42,977,000.

10 Appendices

Link to https://calmta.org/resourcereport/commercial-rooftops-unit-mti-plan/ to access the appendices below.

Appendix A: Logic Model Packet

This appendix includes the MTI's full Logic Model. The Logic Model is a systematic and visual way of presenting CalMTA's understanding of the interventions necessary to remove barriers, expected outcomes of those interventions, and a pathway to the desired end state.

Appendix B: Market Forecasting and Cost-Effectiveness Modeling Approach

This appendix details the inputs, sources, and methods used to develop the market forecasting, TSB, and cost-effectiveness model for this MTI.

Appendix C: Product Assessment Report

This appendix presents the findings on the technology research conducted in Phase II and on behalf of the MTI.

Appendix D: Market Characterization Report

This appendix includes the baseline assumptions and a thorough assessment of the market state, supply chain, market actors, and other programs that support the MTI.

Appendix E: External Program Alignment & Coordination

This appendix describes how CalMTA will communicate and collaborate with key market actors and program stakeholders.

Appendix F: Evaluation Plan

This appendix describes the plan to track the progress and assess the impact of the MTI over time.

Appendix G: Risk Management Plan

This appendix documents the potential risks and obstacles to the MTI and CalMTA's plans to mitigate those risks.

Appendix H: Cost Estimate

This appendix details the budget requirements for the MTI.

Appendix I: MTAB Feedback

This appendix contains feedback on the MTI Plan from the MTAB.