CalMTA

Efficient Rooftop Units (ERTUs)

Market Transformation Advancement Plan

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

Contents

Initiative Name:	Efficient Rooftop Units (ERTUs)
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Date:	February 2, 2024

This Advancement Plan describes CalMTA's recommendations for information to be developed and research conducted during Phase II: Program Development for the ERTU Market Transformation Initiative (MTI). CalMTA will finalize the Advancement Plan after reviewing comments received from the Market Transformation Advisory Board (MTAB) and the public via the California Public Utilities Commission (CPUC) Energy Division's Public Documents Area website.

CalMTA will use data and research collected in Phase II to further inform and refine the proposed Market Transformation (MT) Theory, intervention strategies, and metrics and data that will be used to assess incremental impact for this MTI to determine if it should advance to Phase III: Market Deployment. CalMTA will prepare a full MTI Plan for approval by the CPUC if it recommends advancing this MTI to Phase III. This MTI Advancement Plan contains:

1) Key characteristics of the proposed MTI (e.g., description, target market, barriers, opportunities MT theory, and possible interventions)
2) Identified gaps in knowledge that need to be filled before CalMTA can determine whether to recommend advancing the MTI Phase III: Market Deployment
3) Initial cost estimate and work plan for activities in Phase II that will fill the knowledge gaps.

1 Executive Summary

Commercial heating, ventilation, and air conditioning (HVAC) systems represent a significant percentage of energy consumption in California buildings. Roof Top Units (RTUs[1]), defined in Section 2 below, make up approximately two-thirds of commercial buildings' HVAC systems. Commercialized Efficient Roof Top Units (ERTUs) can achieve 10-40%[2] energy savings compared to standard RTUs, yet product availability and adoption of these units remains low. Given that RTUs are the most installed HVAC system in commercial buildings, CalMTA's preliminary analysis finds that this MTI has an estimated Total System Benefit (TSB)[3] of $1.715 billion over the 20-year lifecycle of the initiative.

The following primary barriers limit adoption of ERTUs:

[1] https://energy350.com/wp-content/uploads/2018/12/ACEEE-Advanced-RTU-Controls-presentation.pdf (p. 8).
[2] Northwest Energy Efficiency Alliance RFI Submission.
[3] For further details and explanation on TSB inputs and assumptions, see Appendix 1.

- Low product availability
- Minimal perceived benefit to manufacturers in advancing ERTUs
- Ineffective product differentiation
- Nuanced installation techniques
- Concerns about cost and affordability.

Several opportunities exist to overcome these barriers and accelerate market adoption, including:

- Partnering with other energy efficiency programs and organizations to advocate for and influence manufacturer product development roadmaps, particularly improvement of efficiency and controls
- Capitalizing on new and upcoming refrigerant restrictions
- Utilizing California's new construction building code to require more efficient heat pump RTUs to become the new standard, as well as partnering with California's Codes and Standards Advocacy team to advocate for other advanced Title 24 requirements
- Establishing a network of skilled installation technicians through workforce, education, and training (WE&T), with a focus on environmental and social justice (ESJ) communities.

The ERTU Advancement Plan identifies research and pilot efforts needed to develop the initiative's overall strategic approach by identifying the prioritized performance improvements, and further characterizing the technology, workforce, and supply chain. These efforts will inform the development of an initiative that can influence the efficiency and grid benefits of ERTUs and pave the way to incorporate those advancements into state and federal codes and standards.

2 Product, Service, or Practice Definition

RTUs are defined as single-zone forced-air systems that package the evaporator, condenser coils, fans, and heating components into a single unit to serve a building's heating, cooling, and ventilation needs. Three main design improvements addressing supply efficiency, heat recovery, and an improved shell can deliver an estimated 10–40% energy savings beyond the minimum required by existing code. Greater savings and grid benefits can be achieved through the addition of advanced controls. The additional components that enable this system to save energy may include:

- Insulated RTU box (to R-12)
- Low leakage dampers and improved economizer design
- Increased heat pump efficiency through sizing or variable speed capability
- Use of energy or heat recovery (E/HRV)

- Controls improvements such as integrated sensors, web-connected thermostats, automated fault detection tools, and climate-optimized control strategies.

Photo: Danfoss

3 Market Transformation Theory and Opportunity

3.1 Market Opportunity

Two-thirds of commercial buildings in the United States are conditioned by RTUs, which are most common in low-rise small- to medium-sized buildings. In California, both the new construction and replacement market have long been dominated by mixed-fuel RTUs that combine a cooling-only compressor system with a gas furnace. However, existing and proposed policies and programs are beginning to drive heat pump RTUs into the market. An opportunity exists in California to transition RTUs to more efficient equipment while continually increasing the product efficiency over time. This effort will partner with existing programs, California's Codes and Standards Advocacy team, and related market transformation efforts to accelerate the acceptance of more efficient equipment, advocate and influence manufacturer product lifecycles and support the continued advancement of state and federal codes and standards.

While federal standards regulate the mechanical components in RTUs, they do not include heat recovery or address shell losses of the rooftop unit and several other aspects of RTU performance, many of which can be addressed through updates to Title 24. Efficiency features can now be captured using a rating developed by the Canadian Standards Association (CSA Group), a leader in standards development, in collaboration with the Northwest Energy Efficiency Alliance (NEEA), Natural Resources Canada and other industry and efficiency experts. Today, these design features are typically only available in premium RTUs, which are a small portion of this commoditized, cost-competitive market.

A national collaborative currently engages with this market through a tiered specification that provides both prescriptive and performance-based paths. The Consortium for Energy Efficiency (CEE) is expanding this specification to include heat pump RTUs (HP RTUs).

3.2 Target Market

The MTI proposed by CalMTA will target small-to-medium commercial buildings, both new and existing construction, which utilize single-zone RTUs, the majority of which are 25 tons or less.

3.3 Key Market Barriers

Multiple barriers limit ERTU adoption in this complex market, including the following:

- Manufacturers do not have a mechanism to differentiate efficient RTUs that also have advanced whole-box efficiency measures.
- Limited products are available for the replacement market, with longer product lead times.

Additional barriers include upfront cost, lack of building owner/operator awareness of products and features that deliver efficiency, and contractor knowledge and experience specifying and installing systems with these advanced designs and controls.

3.4 Points of Leverage and Strategic Interventions

The RTU market offers several key points of leverage, which can be addressed through the following strategic interventions:

- Engage manufacturers on product development, availability of affordable products, and a product specification that supports better equipment design and purchase decisions
- Partner with distributors and manufacturer representatives to drive adoption and support education and acceptance among contractors
- Support marketing, training partnerships, workforce development tactics, and incentives to motivate the supply chain to promote and sell more efficient RTUs with improved controls
- Leverage other market transformation and research efforts, such as CalNEXT, in California and at the national level, to create cost-sharing opportunities, collaborate on product specifications and market outreach
- Coordinate with California's Codes and Standards Advocacy team and subject matter experts (SMEs) to influence state and federal codes, as well as voluntary standards, to require RTU efficiency measures and achieve the long-term goal of all RTUs meeting the higher efficiency specification.

Additional potential points of leverage were identified through MTAB review and public comment. These will be confirmed and considered as we refine the market transformation theory during Phase II.

3.5 Market Vision/End-State

This MTI envisions a future state in which:

- Controls and physical/design improvements are integrated into ERTUs.
- The market values these improvements.
- This technology is widely adopted by small- and medium-sized existing commercial building owners and operators.
- A skilled and diverse workforce exists to service and install equipment.

Over time, the product will evolve and premium heat pump RTUs will be the best practice in the commercial building segment, supported by federal and state codes and standards.

3.6 Key Market Assumptions

The following market assumptions inform this MTI and Advancement Plan:

- Widely known manufacturers (e.g., Trane and Daikin) with a significant market share produce ERTU equipment with varying and optional energy savings components (i.e., low leakage dampers, box insulation, heat/energy recovery) and have well-established distribution networks across California.
- California continues to invest in electrification opportunities in commercial buildings.
- Opportunities exist to collaborate and leverage state and federal codes and standards to advance equipment efficiencies.

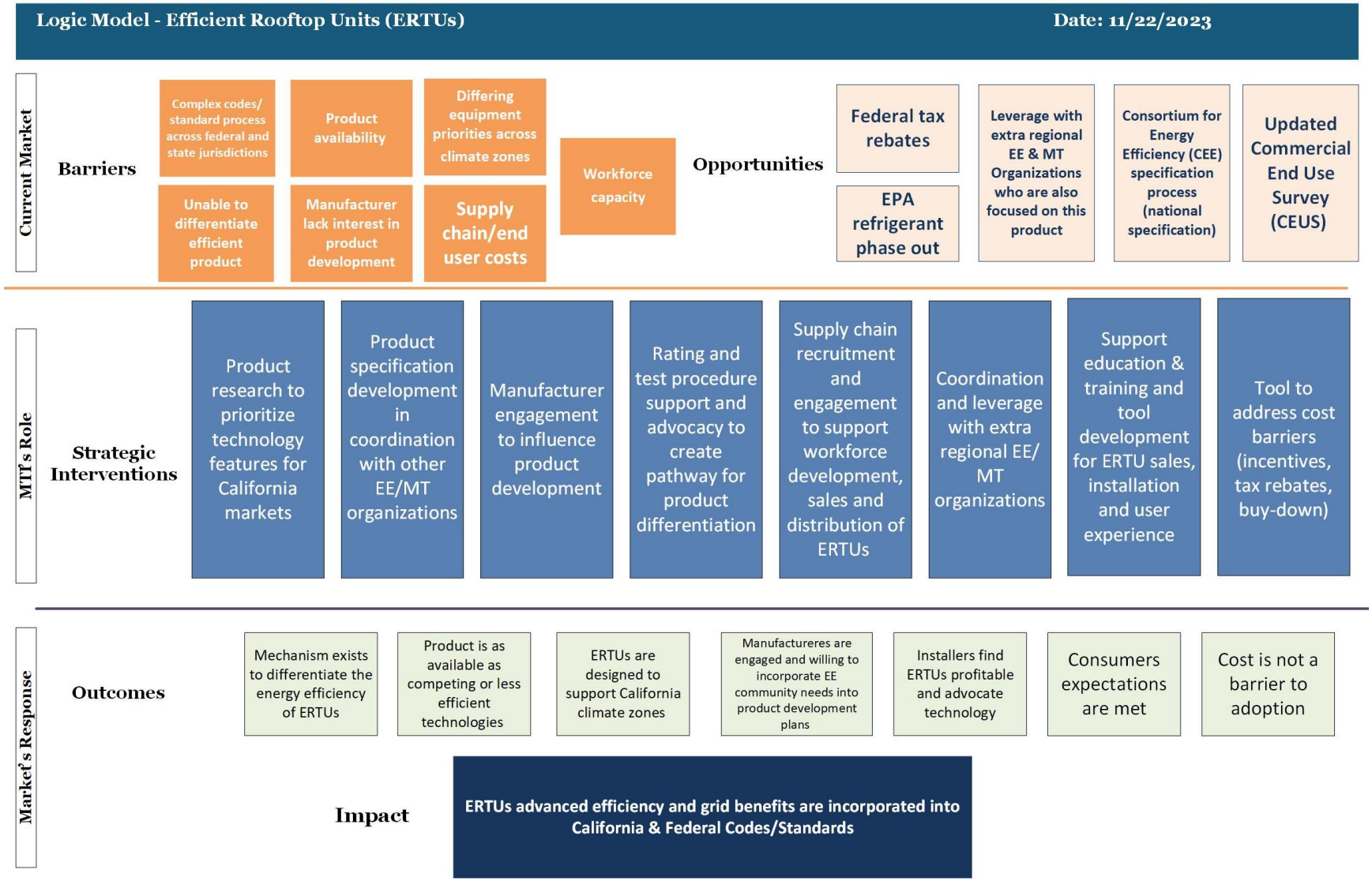
3.7 Diffusion and "Lastingness" Mechanism

Including premium heat pump RTUs will be a best practice in the commercial building segment and will be supported by voluntary and federal/state codes and standards.

3.8 Conceptual Logic Model

Figure 1 on the following page features the logic model developed to provide a preliminary visualization of the ERTU MTI program theory. It includes high-level market barriers and opportunities that inform the draft interventions, as well as expected outcomes and long-term impacts. This model represents the entire "market," with many parties contributing to the advancement of RTUs. CalMTA's role in each of these possible interventions will become clearer after the research phase is complete. The proposed market characterization, product assessment, and pilots conducted in Phase II will verify this logic model's assumptions and draft interventions. Once this work is completed in Phase II, CalMTA will develop a more refined and formal logic model for Phase III: Market Deployment.

Figure 1. Draft MTI Logic Model



3.9 Measuring Market Outcomes

The conceptual logic model depicted in Figure 1 shows CalMTA's current thinking on envisioned MTI outcomes. We expect to refine the logic model during Phase II based on the research we conduct to address current knowledge and data gaps, as described in Section 5: Research and Program Development Plan. This Phase II research will inform the development of an evaluation plan that includes clearly defined market progress indicators, the data sources for tracking those, and the expected timeframe for realizing market transformation progress.

While Phase II research is needed to fill information gaps before we can establish clearly defined MTIs and measurement plans, Table 1 shows our current thinking on likely market progress indicators, some of the possible associated data sources, and the Phase II research that will further inform our evaluation plan.

Table 1. Possible MTI Market Progress Indicators and Data Sources

Likely Market Progress Indicator	Possible Data Sources	Phase II Research that will Inform the MTI
Manufacturer engagement increases	CalMTA Salesforce database Partnership agreements	Manufacturer interviews Subject matter expert (SME) and program administrator interviews
Product availability increases	Installer survey Market actor interviews	Market actor (manufacturer, distributor, installer) interviews
Product specification developed; differentiation mechanism exists that identifies energy efficiency of ERTUs	Empirical data, documents	Market actor interviews SME and program administrator interviews
Workforce capacity (number of trained, capable, working installers) increases	WE&T and CBO partners Installer survey	Manufacturer interviews SME interviews Web scraping
Increasing number of installers recommend ERTUs and find them profitable to sell/install	Installer survey	SME and program administrator interviews
Market share of ERTUs grows	Manufacturers, distributors, installers Industry associations CoStar	Secondary research Market actor interviews

In addition to the preliminary market progress indicators shown in Table 1, CalMTA is working to develop metrics specifically focused on equity and workforce development. During Phase I we kicked off a long-term engagement plan with CBOs and other organizations that serve ESJ communities. Although additional, ongoing engagement will be required to establish the most appropriate equity metrics, Table 2 shows our preliminary thinking on possible equity metrics.

Table 2. Possible Equity Metrics and Data Sources

Possible Equity Metric	Possible Data Sources	Notes
ESJ partner engagement: Number of CBOs/other ESJ market partners engaged in MTI design Number of CBOs/other ESJ market partners engaged in MTI implementation	CalMTA Stakeholder Engagement Database (Salesforce data)	
CBO/ESJ partner satisfaction	CBO/partner survey	Could also include qualitative feedback, such as success stories and lessons learned
Installers trained and employed on ERTU installation that are members of/serve ESJ communities	Training data Post-training survey	

4 Gap Analysis

Several research efforts can fill data and information gaps, including:

- **Understanding energy impacts and potential benefits associated with RTU improvements in California climates:** This work will help inform an updated product definition and product specification to influence manufacturers. It is assumed that the product specification will be made in partnership with other energy efficiency organizations with input from codes and standards advocates and regulators.
- **Market characterization:** This work will provide an understanding of current uptake, installation practices, areas of technology prevalence and product saturation, understanding of benefits and impacts to ESJ communities, and a market baseline. The research will also determine supply chain make-up and dynamics, current manufacturer and distributor partners, competing technologies, the consumer pathway to purchase, decision-maker motivators, and current and future cost assumptions as well as economic analysis.
- **A broader understanding of the building stock and potential technical limitations to ERTU adoption:** Understanding the building stock in greater detail will inform our

manufacturer engagement strategy; marketing, training and education work; and approach to target or beachhead markets.

- **An HVAC workforce assessment and pilot** will provide an understanding of leverage point to increase workforce development activities, potential collaboration and funding opportunities, best practices for WE&T and recruitment, and the HVAC industry's approach to filling workforce gaps.

The research will inform a full MTI Plan and allow CalMTA to refine savings and cost-effectiveness model assumptions as well as the baseline market adoption forecast. It will also inform the development of an evaluation plan that includes clearly defined market progress indicators, the data sources for tracking those, and the expected timeframe for realizing market transformation progress. A description of proposed research objectives and activities can be found in Sections 5.1 and 5.2.

5 Research and Program Development Plan

5.1 Market and Technology Research

CalMTA will work with relevant partners (e.g., CalNEXT, the United States Department of Energy [DOE], NEEA) to ensure the development of this MTI leverages existing or planned research efforts. Data and other information needed to develop a full MTI Plan are shown in Tables 3, 4, 5, 6, and 7.

Table 3. Research Objectives, Tasks, and Final Deliverables

Research Objective	Phase II Research Task					
	Secondary Research	Purchaser/ Decision-Maker Interviews	Manufacturer/ Subject Matter Expert (SME) Interviews	Installer and Distributor Interviews	Delphi Panel	Deliverable Informed by Research
Characterize the RTU Market (supply side) Estimate the market share, product mix, features and make-up of RTU products, by fuel type, fan speed, capacity, and other attributes Identify large and small manufacturers that offer products meeting specifications as well as barriers to either offering the product or scaling-up production Understand how products are distributed from manufacturers to end-users and the time needed to deliver a standard RTU vs. an efficient model Estimate the average number of RTUs replaced each year and forecast the number of incremental replacements driven by a need to change refrigerant Understand how installers talk about RTUs and what drives their recommendations to buyers Understand installer capacity	✓		✓	✓		1. Market Characterization 2. Baseline Market Adoption Forecast 3. Impact and Cost-Effectiveness Forecast 4. Evaluation and Data Collection Plans 5. MTI Plan
Characterize the RTU Stock and Current Experience Estimate the market penetration of the technology in (1) new construction and existing buildings and (2) different regions (e.g., ESJ community status and climate zone) Determine if decision-makers have perceived or actual concerns about the technology	✓	✓		✓		1. Market Characterization 2. Baseline Market Adoption Forecast 3. Evaluation and Data Collection Plans

Research Objective	Phase II Research Task					
	Secondary Research	Purchaser/ Decision-Maker Interviews	Manufacturer/ Subject Matter Expert (SME) Interviews	Installer and Distributor Interviews	Delphi Panel	Deliverable Informed by Research
Estimate the percent of buildings with RTUs that are owner-occupied vs. leased vs. vacant Estimate the fraction of leased RTU buildings where tenants pay the utility bill						
Characterize RTU Purchase Decision-Making Determine standard practice(s) in new construction and replacement of RTUs Understand the key considerations and sources of influence (e.g., facilities staff or installers) for decision-makers when selecting an RTU and how they vary by owner-occupied vs. leased buildings Understand the scenarios where the technology is most likely to be adopted (e.g., owner-occupied, LEED or ENERGY STAR® building)	✓	✓		✓		1. Market Characterization 2. Baseline Market Adoption Forecast 3. Evaluation and Data Collection Plans 4. MTI Plan
Assess Regulatory and Financial Landscape Identify jurisdictions that require or will soon require all-electric new construction and retrofit equipment Understand why the DOE concluded its Advanced RTU campaign in 2019 and how it met its MT objective Estimate incremental installation/hardware costs as the market for this technology scales up Understand incentives, financing, and tax benefits available to support RTU purchases	✓		✓			1. MTI Plan 2. Evaluation and Data Collection Plans
Develop Market Baseline Forecast	✓	✓	✓	✓	✓	1. Baseline Market Adoption Forecast

Table 4. Research, Initial Cost Estimate, and Estimated Timeline

Research Task	Schedule (Estimated Weeks from Launch)	Initial Cost Estimate	Deliverables Informed by this Task
(1) Secondary Research	Weeks 11-37	$52,000	Market Characterization, Baseline Market Adoption Forecast, Impact and Cost-Effectiveness Forecast, MTI Plan
(2) Decision-Maker Interviews	Weeks 22-34	$54,000	Market Characterization, BMA Forecast, Impact and Cost-Effectiveness Forecast; MTI Plan
(3) Manufacturer or SME Interviews	Weeks 14-26	$39,000	Market Characterization, BMA Forecast, MTI Plan
(4) Distributor/Contractor Interviews	Weeks 18-34	$70,000	Market Characterization, MTI Plan
(5) Delphi Panel	Weeks 36-44	$35,000	Baseline Market Adoption Forecast
(6) Data Purchase		$75,000	
Total Estimate		**$325,000**	

5.2 Strategy Development and Testing

5.2.1 Technology

When completed, this work will improve CalMTA's understanding of technical opportunities and limitations to improving the efficiency and potential grid benefits of RTU equipment while informing future interventions aimed at any technical or installation barriers uncovered.

Our technical assessment will focus on the following objectives:

1) Conducting a **technical-potential assessment** to understand energy efficiency and GHG reduction opportunities specific to California climate zones, leveraging energy modeling
2) **Characterizing the impact and benefits to California** associated with energy savings, GHG reduction, and grid benefits for the various advanced control strategies, leveraging energy modeling and laboratory testing
3) Conducting **laboratory testing to** assess equipment performance across climate zones, the benefits of recovery systems, component sizing, emission impacts, and lifecycle testing
4) **Developing a product specification** and possible tiers based on technical potential and impacts/benefits, leveraging findings from energy modeling and laboratory testing
5) Conducting **field testing or pilot(s)** to understand real-world performance of ERTUs meeting product specification and identify any difference from laboratory test results.

CalMTA will leverage technical assessment findings in MTI Plan development. Specifically, gathered and analyzed data will inform an updated product description and specification with possible product tiers that prioritizes MTI efforts in pursuing opportunities for savings and improved performance across ventilation, cooling, heating, fan/controls, and connectivity/flexibility. This prioritization exercise will help identify the areas of largest potential impact while defining a product that will ultimately be tested in the field to understand real-world experience, including performance, installation needs, and end-user satisfaction. This work will also inform collaboration with other energy efficiency organizations working to advance RTUs by identifying areas of synergy in influencing manufacturer product roadmaps.

The table below outlines Technical Assessment Objectives (column 1) and describes the Purpose/Relevance (column 2), which ensures that each research objective is necessary and directly relevant to the MTI. To address the objectives above, multiple Technology Assessment Methods (column 3) will be deployed. CalMTA will leverage modeling assessment tools, conduct laboratory and in-field testing to understand real world performance, assess installation barriers, efficacy of manufacturer training, and HVAC installer experience.

Table 5. Summary of Technology Assessment Activities

Technical Assessment Objectives	Purpose/Relevance	Technology Assessment Methods
Conduct technical potential assessment to understand energy efficiency and GHG reduction opportunities specific to California climate conditions, leveraging energy modeling	Updated product description, product specification, prioritized technology features/controls to inform impact/benefit analysis, laboratory- and field-testing plan	Literature review[4] Data analysis and modeling Technical potential assessment
Characterize the impact and benefits to California associated with energy savings, GHG reduction, and grid benefits for the various advanced control strategies, leveraging energy modeling and laboratory testing	Updated product description, product specification, stakeholder engagement approach	Data analysis and modeling Literature review (see footnote 3) Laboratory testing
Conduct laboratory testing to assess equipment performance across climate zones, benefits of recovery systems, component sizing, and emission impacts; conduct lifecycle testing	Updated product description, product specification, field testing plan, manufacturer engagement approach	Laboratory testing Literature review (see footnote 3)
Conduct field testing to understand real-world performance of ERTUs meeting product specification and identify areas of difference from laboratory testing	Updated product description, product specification. Stakeholder engagement approach, education and training materials and	Field study Laboratory testing

[4] Literature reviews will be conducted in conjunction with the Market and Technology Research described in Table 1. Budgets are not included in Table 4.

Technical Assessment Objectives	Purpose/Relevance	Technology Assessment Methods
	approach, installer recruitment approach, overall MTI plan and strategy	

Table 6. Summary of Technology Assessment Needs, Initial Cost Estimate, and Estimated Timeline

Assessment Task	Schedule (Estimated Weeks from Launch)	Initial Cost Estimate	Deliverables Informed by this Task
(1) Technical Potential Assessment	Weeks 1-36	$40,000	MTI Plan; updated product plan, lab testing approach
(2) Data Analysis and Modeling	Weeks 12-48	$70,000	MTI Plan; updated product plan
(3) Laboratory Testing (up to three units)	Weeks 26-64	$315,000	MTI Plan; updated product plan
(4) Field Study[5]	Weeks 40-92	$356,000	MTI Plan; updated product plan
Total Estimate:		**$781,000**	

5.3 Strategy Pilots

CalMTA has determined that the ERTU MTI requires additional research and development before a detailed strategy pilot can be recommended. The market characterization and technology assessment work detailed above will help determine the need and scope of any potential strategy pilot. If CalMTA determines a strategy pilot is necessary, it will submit documentation for public comment and review through the CPUC's website.

5.4 Environmental & Social Justice, Workforce Development, Education & Training Approach

This MTI offers an opportunity to create higher wage jobs for ESJ communities. Key outcomes for equity and workforce development include:

- An established approach to workforce development for ERTUs that identifies market partners to support efforts long-term
- Strategies to focus training opportunities on ESJ communities

[5] Assumes ability to leverage CalNEXT and other ERTU pilots, targeting 10 field sites.

- Identification of targeted ESJ communities and exploration or leveraged funds to support installation of ERTU equipment for field testing (e.g., placing a target number of field test units in ESJ communities to further our understanding of specific ESJ barriers to adoption)
- Education and training efforts/tools for supply chain and trade allies in partnership with trusted allies in ESJ communities, offered in multiple languages, leveraging best practices in adult learning, and supported by diverse supply chain
- Available incentives and cost-reduction strategies that leverage available dollars and target buildings within ESJ communities, ensuring that ERTUs do not create a cost burden to communities and businesses.

6 External Program Review and Stakeholder Engagement

For each MTI, CalMTA conducted an initial analysis to identify areas of potential overlap and opportunities for collaboration between MTIs and existing programs focused on the market segment in question. Our external program review for the ERTU MTI revealed multiple local, state, and national programs exploring more efficient RTU technology. The team will work closely with California allies as well as energy efficiency partners to leverage resources, combine research efforts where applicable, identify and collaborate on product enhancements and accelerate adoption of ERTUs. This collaboration is aimed at limiting market confusion and maximizing investments.

Organizations outside of California currently exploring and involved in ERTU advancements include:

- **Air-Conditioning, Heating, and Refrigeration Institute (AHRI):** AHRI appears to be working on a product standard for unitary heat pump equipment. As product specification work continues, AHRI could be a partner in encouraging advanced specification in partnership with industry.
- **NEEA/Center for Energy and Environment (Minnesota CEE)/Nicor Gas:** These organizations are working together to advance the efficiency and benefits of RTU equipment and design and implement a market transformation initiative. The CalMTA team will coordinate closely with this work to share best practices, lessons learned, collaborate on research, and, prior to initiative launch, seek to align on product specification and create a motivated and collaborative voice for the manufacturing community.
- **DOE's Office of Energy Efficiency and Renewable Energy:** A new test procedure is in development for ERTUs that considers many product features identified in this MTI. CalMTA will ensure coordination with DOE test procedure and manufacturers engagement.

- **American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):** ASHRAE appears to be conducting work on a new metric, Total System Performance Ration (TSPR), which is defined as 'a ratio of annual heating and cooling loads to the annual carbon emissions associated with the energy consumed by the HVAC system."[6]

Key coordination opportunities with stakeholders working in California are summarized in Table 7.

Table 7. Summary of California Program Stakeholders

Program – Organization/ Stakeholder Segment	Coordination Approach
California Investor-Owned Utilities (IOUs) and Program Administrators	Review and share CalMTA Advancement Plan Work with identified subject matter experts to coordinate MTI plan and tactics Encourage integration of ERTUs in applicable local programs such as Pacific Gas and Electric Company (PG&E)'s HVAC Upgrade incentives or the statewide upstream, midstream program, Comfortably CA, administered by San Diego Gas & Electric's (SDG&E), and statewide workforce, education, and training programs
CalNEXT	Review CalNEXT existing research findings and conduct 1:1 outreach to the team to understand questions and areas of future research Maintain regular cadence of meetings to share research plans and explore for overlap and cost-sharing opportunities
California's Energy Codes and Standards Enhancement (CASE) Program and the Codes and Standards Advocacy Program	Participate in established groups to support the standardization of product performance and efficiency metrics Conduct 1:1 outreach to understand partners' current work and/or upcoming activities while exploring collaboration opportunities Coordinate involvement with industry and trade association groups, such as AHRI or the Appliance Standard Awareness Project

We will develop a regular cadence for communication and coordination with these program administrators and implementers to avoid duplication of efforts, facilitate mutually beneficial information/data-sharing, and identify key leverage opportunities to enhance each other's program efforts.

[6] https://buildingenergyscore.energy.gov/documents/TSPR_Training_Presentation_Slides_2020-06-03.pdf

7 Risks and Possible Mitigation Approach

Table 8 identifies potential risks that need to be tracked and mitigated to make the initiative successful.

Table 8. MTI Risk Review

Initiative Risk	Severity	Mitigation Approach
HVAC manufacturer consolidation causes market delays and data gaps, and limits supply chain attention and participation.	Medium	Consolidate market research asks Create flexible approach to data plan Explore alternative data sources (e.g., HVAC component data to inform baselines, market growth)
Purchasers are not motivated by advanced ERTU benefits and continue to buy less efficient competing technologies.	Medium	Develop holistic data collection process to monitor full category sales of RTUs and monitor adoption rates of competing technologies Create approach to cost parity with nonefficient technologies Build awareness of technology opportunities leveraging industry events and trusted resources Focus on government agencies as purchasers with climate reduction goals and mature procurement process
ERTU are more expensive than traditional RTUs, creating a barrier to adoption for businesses with limited resources, especially those operating in ESJ communities.	High	Collaborate with IOUs to support ERTUs as part of incentive offerings Create statewide incentive/promotion/buy-down opportunities Build scale within localized markets and exploit for cost savings
Energy efficiency organizations are uncoordinated, resulting in market confusion and competing product development requests.	High	Collaborate with NEEA/CEE Minnesota, CEE, and others to create consistent approach to product specifications Create and manage relationships at energy efficiency organizations with goals Create or participate in already established regular cadence of meetings aimed at collaboration and coordination Host joint meetings with energy efficiency partners and manufacturers

Initiative Risk	Severity	Mitigation Approach
		Leverage industry events to showcase coordinated efforts of energy efficiency community

8 Initial Cost Estimate, Timing, and Expected Results

Table 9 summarizes all budget items from Tables 4, 6 and 7 in Section 5.

Table 9. MTI Advancement Plan Initial Cost Estimate Summary

Section	Cost Estimate
Market and Technology Research	**$325,000**
(1) Secondary Research (Weeks 32-58)	$52,000
(2) Decision Maker Interviews/Surveys (Weeks 44-56)	$54,000
(3) Manufacturer or SME Interviews (Weeks 35-46)	$39,000
(4) Distributor/Contractor Interviews/Surveys (Weeks 40-55)	$70,000
(5) Delphi Panel (Weeks 47-51)	$35,000
(6) Data Purchase	$75,000
Technology Assessment	**$781,000**
(1) Technical Potential Assessment (Weeks 1-36)	$40,000
(2) Impact and Benefit Analysis of features/control strategies (Weeks 12-48)	$70,000
(3) Laboratory Testing (up to three units) (Weeks 26-64)	$315,000
(4) Real world Performance Field Study (assumes ability to leverage CalNEXT and other ERTU pilots for cost-share) (Weeks 40-92)	$356,000
Market Pilots	
(1)	
(2)	
(3)	
Total	**$1,106,000**

ERTU products are currently manufactured and available for purchase. However, to ensure a product that best meets the needs of California climates the Advancement Plan proposes testing and research across heating and cooling seasons to understand real world performance and installation barriers. The team is exploring existing or planned research by other partners that can be leveraged to accelerate the timeline below. However, it is likely that this initiative will not be ready for a full MTI plan in the 2024 calendar year. Figure 2 provides a preliminary Gannt chart for activities beginning in Q1 of 2024.

Figure 2. Overall Timeline/Schedule of Activities (Begins Q1 2024)

Activity	Duration (Weeks)	Timeline (Months)																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19 20	21	22	23		
Market Research																									
(1) Secondary Research	Weeks 11-37																								
(2) Decision Maker Interviews/Surveys	Weeks 22-34																								
(3) Manufacturer or SME Interviews	Weeks 14-26																								
(4) Distributor/Contractor Interviews/Surveys	Weeks 18-34																								
(5) Delphi Panel	Weeks 36-44																								
Technology Assessment																									
(1) Technical Potential Assessment	Weeks 1-36																								
(2) Impact & Benefit Analysis of features/control strategies	Weeks 12-48																								
(3) Laboratory Testing (up to three units)	Weeks 26-64																								
(4) Real world Performance Field Study	Weeks 40-92																								

Table 11 summarizes the initial estimate of MTI lifetime deployment costs, initiative timeline, and expected results.

Table 11. Initiative Market Deployment Initial Cost Estimate and Expected Results

Initiative Cost Estimate ($)	>$25 million	ERTUs are an expensive and complicated technology with a large market to transform. Encouraging change will take significant investment.
Initiative Timeline (Years)	>10 years	Given the long-term investment of RTUs, enacting change in the market will take time.
Estimated Expected Results	TSB: $1.705B TSB Energy: $355M TSB Grid: $720M TSB GHG: $640M	Preliminary analysis shows that an ERTU MTI could result in significant kWh and peak demand benefits, especially in some extreme climate zones within California.

About CalMTA

CalMTA is a program of the California Public Utilities Commission and is administered by Resource Innovations. We work to deliver cost-effective energy efficiency and decarbonization benefits to Californians through a unique approach called market transformation. Market transformation is the strategic process of intervening in a market to create lasting change by removing market barriers or exploiting opportunities, accelerating the adoption of identified technologies or practices. CalMTA-developed market transformation initiatives also aim to advance state goals on demand flexibility, workforce development and equity. Learn more at www.calmta.org.

Appendix 1: TSB Estimation Approach

As adopted by the California Public Utilities Commission, Total System Benefit (TSB) is defined as "the sum of the benefit that a measure provides to the electric and natural gas systems." According to D.21-09-037
1, TSB accounts for increased supply costs as a reduction in benefits and expresses, in dollars, the lifecycle energy, ancillary services, generation capacity, transmission and distribution capacity, and greenhouse gas (GHG) benefits of energy efficiency activities on an annual basis. The 2021 Energy Efficiency Potential and Goals study states that TSB represents the total benefits, or "avoided costs," that a measure provides to the electric and natural gas systems.

TSB is calculated using the savings and load shape of an energy efficiency resource by applying the hourly values for energy, capacity, and GHG compliance costs over the life of the resource, to enable development of the total net system benefits from an initiative.

TSB Estimation by MTI Lifecycle Phase

CalMTA developed a preliminary 20-year estimate of TSB and cost-effectiveness for each market transformation initiative (MTI) submitted through the Request for Ideas (RFI) process that advanced to Stage 2 scoring. The estimates were based on readily available secondary research combined with a Bass modeling approach to estimate baseline and total market adoption curves. The CalMTA team will refine these estimates based on additional research and best practices during Phase II of the MTI Lifecycle, as shown in Figure .

Figure 1. TSB Estimation by MTI Lifecycle Phase

Phase I – Preliminary TSB Estimation Approach

During Stage 2 scoring, the CalMTA team developed a preliminary estimate of TSB associated with Efficient Rooftop Units (ERTUs). For this and all MTIs that advanced to Stage 2 scoring, the team used a systematic approach that included developing preliminary estimates of the following inputs needed for TSB calculations:

- **Preliminary baseline market adoption (BMA) forecast:** The team developed a preliminary 20-year BMA forecast gathered from a small panel of experts who relied on

[1] Adopted from Decision 21-05-031

readily available secondary research and their industry knowledge. Adoption by commercial buildings was forecasted using a Bass model framework.

- **Preliminary total market adoption (TMA) forecast:** For existing commercial floorspace, this forecast estimated preliminary market adoption based on the retirement schedule of current stock of standard RTUs and assumed annual market share of ERTUs. For new commercial floorspace, the team assumed the annual share of ERTUs for the forecast period to come up with preliminary market adoption.
- **Preliminary per-unit energy, grid, and GHG impacts**: The team developed unit impact estimates using hourly simulation models.
- **Preliminary estimates of avoided costs**: The team estimated avoided costs for the 20-year period using the Avoided Cost Calculator.

MTI-Specific Analysis and Assumptions

BMA Assumptions

The team used a Bass model framework to develop a preliminary forecast of baseline market adoption through 2045. We convened a mini-Delphi panel of experts to forecast market adoption using the three Bass Model parameters: maximum potential market saturation (m), coefficient of innovation (p), and coefficient of imitation (q), which capture the rate of adoption by early and late adaptors, respectively. Panel members estimated the maximum baseline market adoption potential at 5% of small and medium commercial buildings. The key barriers identified by panel members for low natural adoption of ERTUs were high costs and long lifespans of competing technologies.

TMA Assumptions

To estimate the TMA curve for existing commercial space, the team estimated the retirement schedule of current stock of RTUs and assumed an annual share of ERTUs during replacement through 2045. The current saturation of RTUs and vintage are based on ComStock.[2] The team assumed an annual market share of 75% by 2035 increasing to 95% by 2045 in the presence of CalMTA interventions.

For new construction, the team assumed an annual market share of 2% in 2025, increasing linearly to 95% in 2035.

Additional Assumptions

The team used the following assumptions regarding timing of MTI initiation and initial impacts:[3]

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[2] Parker, Andrew, Henry Horsey, Matthew Dahlhausen, Marlena Praprost, Christopher CaraDonna, Amy LeBar, and Lauren Klun. 2023. ComStock Reference Documentation: Version 1. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5500-83819. https://www.nrel.gov/docs/fy23osti/83819.pdf.

[3] The TMA forecast assumed an earlier MTI start than what appears in the ERTU Advancement Plan timeline; the expected impact on long-term impacts and scoring is minimal.

- Start year for initiation of CalMTA MTI: 2025
- Number of years until initial MTI incremental impacts begin: Two

Incremental Market Adoption

Based on the assumptions described above, the team's preliminary estimate of cumulative 20-year TMA was 73,000 buildings. Our initial estimate for cumulative baseline market adoption is approximately 16,000 buildings.

Incremental Adoption by Installation Condition

We identified four representative installation conditions (building type, adopted technology, baseline technology and fuel type) and estimated the proportion of incremental adoption (estimated at 57,000 buildings) in each of these segments (Table 1). The team allocated incremental market adoption based on initial market research.

Table 1. Stage 2 ERTUs – Installation Conditions

Building Type	Adopted Technology	Baseline Technology	Baseline Fuel Type	Distribution of Market Adoption
Commercial	High-Efficiency Heat Pump RTU	New Code Minimum RTU with furnace	Gas	43%
Commercial	High-Efficiency Heat Pump RTU	New Code Minimum HP RTU with backup electric heat	Electric	25%
Commercial	Upgraded Controls / Add-On	Existing RTU with Furnace, operational but inefficient	Gas	4%
Commercial	High-Efficiency Heat Pump RTU	New Code Minimum HP RTU with backup electric heat	Electric	28%

Unit Energy Impacts

Impacts were calculated for adoption for each installation condition. Average annual electric savings for these four installation conditions ranged from 30,112 kWh when the baseline condition involved New Code Minimum HP RTU with backup electric heat to 57,840 kWh per building when upgraded controls/add-on equipment displaced a baseline condition of an existing RTU with Furnace. Therm savings ranged from -396 to 1,268 therms per building.

Incremental Costs

The team conducted secondary research to develop estimates of incremental costs for each of the installation conditions and developed preliminary program cost estimates to inform Total Resource Cost (TRC) and Program Administrator Cost (PAC) calculations.

Preliminary Estimate

TRC and TSB are calculated in line with the IOU energy efficiency requirements. Costs and benefits were modified to accommodate a statewide value, with utility-/climate-zone-avoided

costs averaged by the share of customers from each of the three largest state IOUs and with average values applied to the remaining portion of California served by other utilities. TRC includes all avoided costs categories, including electric/gas/greenhouse gas and refrigerant benefits, program costs, incremental measure costs, etc. The Avoided Cost Calculator and projected lifetimes savings were also used to generate TSB. The preliminary TSB estimates are reported in Table 2, disaggregated for energy, grid, and GHG impacts.

Table 2. Stage 2 Preliminary Lifetime TSB Estimate – Efficient Rooftop Units

Idea Name	TSB ($M)	Energy ($M)	Grid ($M)	GHG ($M)
Efficient Rooftop Units	1,715	355	720	640

The total initiative generates approximately $1.7 billion in lifetime TSB. The largest share of these benefits can be attributed to the grid, with around $720 million in TSB. The next largest share of TSB is attributed to mitigated GHG emissions, with $640 million in TSB. Finally, energy benefits driven by savings related to electricity and natural gas reductions generate $355 million in lifetime TSB.

The team developed preliminary TRC and PAC ratios of 4.12 and 61.24 respectively for the initiative.

Phase II – Refined TSB and Cost-Effectiveness Estimates

The CalMTA team will conduct additional market and technology research on Efficient Rooftop Units during Phase II of the MTI as described in the Advancement Plan. Based on that research, the team will refine TSB and cost-effectiveness estimates for the MTI. These refined estimates and their detailed methodology and assumptions will be included as part of the MTI Plan required for MTI advancement to Phase III. The MTI Plan will also include an evaluation plan and a data collection plan to support ongoing evaluation.

Phase III – Ongoing Updates to TSB and Cost-Effectiveness Estimates

The team will update TSB and cost-effectiveness estimates based on newly available data collected as part of the ongoing data collection plan. An independent third-party evaluator will periodically review CalMTA's TSB and cost-effectiveness models and supporting data and assumptions and make suggestions for improvement, as needed.