2026 Heating, Ventilation, and Air Conditioning Technology Priority Map

Final Report

ET26SWE0003

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Disclaimer

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Abbreviations, Acronyms, and Glossary of Terms

Abbreviation/Acronym	Meaning
AWHP	Air-to-water heat pump
BAS	Building automation systems
Btu	British thermal unit
CalMTA	California Market Transformation Administrator
CASE	Codes and Standards Enhancement
CARB	California Air Resources Board
CEC	California Energy Commission
Cx	Building commissioning
eTRM	California Electronic Technical Reference Manual
FDD	Fault detection diagnostics
GWP	Global warming potential
HP	Heat pump
HVAC	Heating, ventilation, and air conditioning
IOU	Investor-owned utility
MFHP	Multifunction heat pump
RTU	Rooftop unit
SCE	Southern California Edison
SME	Subject-matter expert
TES	Thermal energy storage
TPM	Technology Priority Map
VRF	Variable refrigerant flow

Glossary Term	Meaning
Technology Category	One of six broad technology categories (Whole Buildings, HVAC, Water Heating, Lighting, Plug Loads and Appliances, Process Loads, and Portfolio Enhancements).
Technology Family	Functional grouping that provides description of program role, opportunities, and barriers.
Research Initiatives	Initiative in place of both subgroups and knowledge indices.
Research Initiatives Key	Visual aid explaining if each research initiative is at a level of high understanding, ranked on a low, medium, or high scale.
Rankings	Future Needs: Covers items that are not yet ready for consideration due to having high needs in validation and market analysis. Programs should not be discouraged from submitting proposals for research initiatives with a "Future Needs" classification but instead focus on making a strong argument for how the project outcomes can help fill in the missing gaps for validation or market analysis. Low: Covers items that have lower industry interest and/or uncertain impacts for energy efficiency due to having an expansive data set or information readily available or not being pertinent to the research initiative. Medium: Covers items that are an evolution or offer promise to existing and common technologies for energy efficiency. This can be in the form of needs that are currently being addressed with existing projects or needs that may exist but are not critical to the objectives of meeting efficiency metrics. High: Covers items that have high industry interest and high impacts for energy efficiency.
Definitions	Narrative to provide additional clarification on the technology family scope.
Opportunities	Description of potential impacts and potential research areas.
Barriers	Description of key barriers and potential barriers research.
CALNEXT Priority	Communicates expected level of focus by CalNEXT subject-matter experts. *Note: Priorities will change as research is completed.*

Glossary Term	Meaning
High	High: CalNEXT has highlighted this technology family as having high energy savings with any known barriers surmountable through targeted interventions within the Technology Category and will prioritize funding projects under this technology family.
Medium	Medium: CalNEXT has highlighted this technology family as having moderate to high overall energy savings with known barriers to entry that may be more challenging to address within the Technology Category and will consider funding projects under this technology family.
Low	Low: CalNEXT has highlighted this technology family as having moderate to high overall savings but faces difficult or unknown barriers to adoption within the Technology Category and will not prioritize funding projects under this technology family.

Introduction

The Technology Priority Maps (TPMs) provide the CalNEXT program with a framework to externally communicate priorities, clearly define the central focus areas, and assist with project screening. The TPMs document the impact potential, programmatic research needs, and market readiness of all technology families across each of the end-use technology areas. They drive product ideation and inform project selection. This Final Report covers the revision process for the 2026 Heating, Ventilation, and Air Conditioning (HVAC) TPM.

2026 TPM Key Changes

The HVAC category has seen significant changes over the years, relative to that of other technology areas. Notable recent drivers for these changes include the passage of the One Big Beautiful Bill Act in 2025, which repealed many tax credits and much of the funding for state-administered incentive programs targeting the heat pump market, which were originally signed into law under the Inflation Reduction Act of 2022. In addition, research conducted by California's investor-owned utility (IOU) Codes and Standards Enhancement (CASE) Team related to multiple technology families has impacted the state of knowledge to varying degrees. Finally, the continued need for programs to transition to the Total System Benefit (TSB) metric has implications for both demand flexibility and low global warming potential (GWP) refrigerants.

As for the 2026 TPM update, the CalNEXT program team established a robust process for this initial phase of the TPM development and revisions. Similar to last year, the project team is incorporating a stronger push to gather feedback directly from HVAC subject-matter experts (SMEs) at the beginning of the revision process.

In 2026, the process started with the reformation of the HVAC TPM SME team, with representatives from each of the program team partners: AESC, Energy Solutions, TRC, University of California Davis, and VEIC, with the Ortiz Group providing feedback at the stakeholder outreach stage during the Draft Report. The HVAC SME team includes members who support an array of energy efficiency programs using technologies covered by the HVAC TPM, as well as members who support the California investor-owned utilities' (IOUs) Codes and Standards program. These emerging technology products are then contextualized into priority maps through markets and solutions lens.

In 2025, the team revised research initiatives as needed based off any market changes that have occurred since the 2024 HVAC TPM revision. In 2026, the HVAC SME team focused on revising and cleaning up the technology families based on energy efficiency and affordability standards, among annual revisions considering market changes and CalNEXT program priorities. Research initiatives should be at a higher level than project- or proposal-specific details, with the intent to provide guidance for project submitters rather than specific examples.

The end goal of these visual summaries is to have a clear representation of where the technology family stands in the portfolio, as well as what remaining research is needed. The research initiatives tables describe the two to five most important technology areas, with the current version providing a

simplified ranking view of where the HVAC portfolio stands for easier use and external understanding. To date, most research projects take place within a handful of technology families across HVAC, which was a large driver in how the technology families were chosen in 2026.

Table 1: Rankings and their meanings.

Icon	Meaning
Future Needs	Covers items that are not yet ready for consideration due to having high needs in validation, market analysis, measure development, or program development. Programs should not be discouraged from submitting proposals for research initiatives with a "Future Needs" classification but instead focus on making a strong argument for how the project outcomes can help fill in the missing gaps for validation or market analysis.
Low	Covers items that have lower industry interest and/or uncertain impacts for energy efficiency due to having an expansive data set or information readily available or not being pertinent to the research initiative.
Medium	Covers items that are an evolution or offer promise to existing and common technologies for energy efficiency. This can be in the form of needs that are currently being addressed with existing projects or needs that may exist but are not critical to the objectives of meeting efficiency metrics.
High	Covers items that have high industry interest and high impacts for energy efficiency.

One additional feature specific to the HVAC and Water Heating TPMs is a cross-listed technology family, Residential Multifunction Heat Pumps. This development was made to better orient and provide consistency between the two TPM end uses, as well as to address an emergent system and design need: air-to-water heat pumps that can be deployed to address space conditioning demand under normal conditions with HVAC. This technology family also has ties to the Integrated Systems technology family of the Whole Buildings TPM.

The CalNEXT team designed the cross-listed topic to ensure strong coordination across CalNEXT. As systems serving non-residential spaces grow, so does their complexity. Residential multifunction heat pumps are anticipated to be sold as a package of features, including thermal storage, hydronic heating, cooling, and hot water. This is in contrast with commercial systems, which appear to be heavily custom-engineered as a collection of components—such as heat recovery chillers, air-to-water heat pumps, service water controls, and thermal storage—all of which need to be sized, integrated, and controlled together to support large-scale building electrification.

Overall, the changes made in the 2026 TPM aim to increase technology transfers broadly across the portfolio, allowing the CalNEXT team to define new measures of interest and illustrate its efforts to bring them to the portfolio. Even for longer-term investments, the visual format of the research

initiatives tables will provide more tactical guidance as to what type of research is needed to better encourage the progress of different technologies toward the goal of portfolio savings.

Stakeholder Feedback

TPM Advisory Committee Outreach

The TPM Advisory Committee outreach began in April 2026. The team requested stakeholder feedback via email, through survey questions targeted for the HVAC TPM, which resulted in updates to the Word document of the technology family narratives based on that feedback. The stakeholders are listed below in Table 2.

Table 2: Advisory committee outreach.

Organization
California Market Transformation Administrator (CalMTA)
California Technical Forum (CalTF)
California Public Utilities Commission (CPUC)
Pacific Gas & Electric (PG&E)
Southern California Edison (SCE)
San Diego Gas & Electric (SDG&E)

This outreach allowed advisory committee members to provide candidly written comments and suggestions, which were reviewed by the TPM coordinator and the 2026 HVAC TPM SME team before being incorporated into the Revised 2026 HVAC TPM section. A detailed table of changes can be found in Appendix A.

Room Heat Pumps

CalNEXT Priority: High

Definition

Room heat pumps are efficient, rapidly deployable heat pumps (HPs) that can be installed without the need for professional HVAC and electrical skills. They are suitable for compact spaces where HPs can replace electric space heaters or where traditional split systems are costly or onerous to deploy. They should connect with standard 110V/120V National Electrical Manufacturers Association 5-15 outlets, without any field-installed refrigerant lines. They can appear in the market in several form factors such as saddle (also referred to as U-shaped), window box units, portable, and through-the-wall. Saddle, window, and portable units are generally do-it-yourself, while others—including through-the-wall—may require infrastructure costs. Typical uses include single-family, accessory dwelling units, multifamily situations, mobile homes, hospitality spaces, assisted living facilities, and schools. Unit condensate is managed through drip-free meltwater atomization or water dispersion into air, inside or outside, and drip pan systems for portable units.

Research Initiatives

Table 3: Room heat pump research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Window/Saddle HPs	High	Medium	High	Medium
Portable HPs	Medium	Medium	High	Medium
Through- the-wall HPs (PTHPs/SPVHP)	Medium	Low	Medium	Low

KEY High Needs | Medium Needs | Low Needs | Future Needs

Opportunities

Room HPs have the potential to rapidly electrify space heating, replacing existing portable space heaters and older, less efficient room air conditioners with more efficient HPs. As these products become more widely available, they offer various opportunities. For example:

- Room HPs can provide options for energy efficient cooling to customers who do not currently have air conditioning.
- This technology family may be especially important for disadvantaged communities and hard-to-reach customers, where the majority of households are renters with limited options to improve their electrical or HVAC infrastructure by way of 120V plug-in options.

- Customer usage patterns can help inform the real-world efficiency and electrification potential of these products:
    - Ease of self-installation and customer satisfaction.
    - Cost and performance compared to central HPs.
    - Value-add to residential space when changing tenants and portability if moving is required.
    - In-field performance testing of the units may be of particular interest to validate issues such as noise, defrost and dehumidification, and ventilation and air-filtration.
    - Verify value to consumer in sell ownership and portability when moving.

Barriers

Barriers may include the following:

- Implementation barriers, including product usage patterns, customer sentiment, and understanding overall market awareness.
- Installation practices, including identifying common installation challenges. For example, the setting of the outdoor air damper position, sealing around the unit, decommissioning existing equipment, and thermostat control setting—especially to avoid conflict with controls of central systems—may be challenging.
- Evaluate the extent to which room HPs overcome the split-incentive issue in rental properties by allowing the technology to be owned by the tenant rather than the building owner; this would be a measure barrier, as there is an immediate need to account for equipment moving out of the IOU territories.
- A general lack of awareness, including uncertainty around reliability, performance, and long-term savings. There is also a related lack of strong local or community support and education.
- Room HPs are not currently included as standard measures in mainstream low-income programs, such as PG&E, SCE, and SDG&E's Energy Savings Assistance programs or the Low-Income Weatherization program.
- Room HP costs may still be a significant barrier when replacing regular window box air-conditioning-only units—especially for some more expensive types, such as saddle room heat pumps and cold climate versions.

Related CalNEXT Projects

- ET22SWE0035 – Multifamily In-Unit Heat Pump
- ET23SWE0034 – Emerging "Micro" Heat Pumps: Testing and Heating Performance Metrics
- ET23SWE0038 – Double Duct Packaged Terminal Heat Pump Field Demonstration

Resources and Links

- CalMTA Portable/Window Heat Pumps, Market Transformation Advancement Plan, MTI-Advancement-Plan-Portable-Heat-Pumps, February 2, 2024.
- CalMTA Room Heat Pumps MTI Plan, December 18, 2024
- CalMTA Room Heat Pumps Lab Testing Report, December 10, 2025
- Room Heat Pumps: Market Characterization Report - CalMTA

- CalMTA Draft Program Strategy Pilot, Portable/Window Heat Pump Self-Installation Practices, January 2024
- DNV 2021, 2021 California Residential Appliance Saturation Study (RASS), July 2021 | CEC-200-2021-005-ES
- ENERGY STAR Final Draft Heating Mode Test Procedure for Room Air Conditioners (Room Air Conditioner Specification Version 5.0) – (April 1, 2024)
- NEEA.org/img/documents/Micro-Heat-Pump-Field-Study-Presentation-Product-Council.pdf
- NYSERDA Clean Heat for All: Taitem Measurement and Verification, October 2025

Commercial Air-to-Air Heat Pumps in Existing Buildings

CalNEXT Priority: High

Definition

This category includes commercial air-to-air heat pump equipment with over 65,000 British thermal units per hour (Btu/h) cooling capacity (5.4 tons) or smaller-capacity rooftop units (RTUs), serving commercial spaces and capable of providing both space cooling and heating. Commercial air-to-air heat pump equipment includes split and packaged units. Common examples of air-to-air heat pumps include variable refrigerant flow (VRF), dedicated outdoor air systems, and heat pump RTUs. Other technologies that are considered part of this technology family include those that complement heat pump systems, such as improved control systems.

Research Initiatives

Table 4: Commercial air-to-air heat pump research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Heat pump RTU: Controls and infrastructure	High	High	High	Medium
Efficient mechanical ventilation strategies	Medium	Medium	Medium	Medium
VRF: System optimization for efficiency	High	High	High	Medium
Strategies for reducing reliance on supplementary electric resistance heat[1]	High	High	High	Medium

KEY High Needs | Medium Needs | Low Needs | Future Needs

Note: The heat pump refrigerant maintenance topic is noted in the "Commercial HVAC Equipment Installation, Operation, and Maintenance" technology family.

[1] As heat pumps have become more prevalent, over-reliance on supplementary electric resistance heat is a known issue: e.g., contractor switchover temperatures set too high, especially with newer heat pumps maintaining better efficiency and capacity at lower temperatures.

Opportunities

The increased adoption of commercial air-to-air HP equipment represents a significant opportunity for energy efficiency and decarbonization of the HVAC energy end use in commercial buildings. Opportunities for increased system efficiency and decarbonization include:

- Tailoring intervention strategies for the different market types; for example, planned capital improvements vs. emergency replacements.
- Understanding air-source heat pump equipment retrofit feasibility by region, building type, baseline system, and market type.
- Optimizing operation and control strategies of packaged equipment.
- Reducing reliance on supplemental heating systems.
- Modeling and evaluating HVAC systems in-field on efficiency and performance, including readily available system equipment and components.

Barriers

Addressing barriers to HP adoption will increase uptake of HPs in the commercial HVAC market. Examples of barriers to increased adoption include:

- Distributor stocking practices focused on minimally compliant standard efficiency equipment, resulting in long lead times for high efficiency units.
- Contractor preferences for standard efficiency equipment due to easier procurement and service familiarity.
- Refrigerant leakage, charge management, and a transition to low-GWP options.
- A retrofit focus on equipment efficiency ratings over system optimization for efficiency.
- Existing infrastructure limits.
- Limited understanding of the scope of options, costs, and timelines associated with electrical infrastructure upgrades.
- Low customer tolerance for downtime resulting from longer lead times for high efficiency equipment and electrical service upgrade timelines that may be required.

Related CalNEXT Projects

- ET24SWE0066 – High Efficiency Rooftop Unit (HE RTU) Focused Pilot
- ET23SWE0037 – Integrated HVAC RTU Remote Monitoring System
- ET23SWE0069 – Light Commercial Variable Speed Heat Pump Performance Map
- ET23SWE0054 – Heat Pump Rooftop Unit Demonstration
- ET23SWE0028 – Market Characterization of Ultra-Low GWP Space Conditioning Heat Pumps for Commercial Buildings
- ET23SWE0073 – Supply Chain Engagement for Increasing Packaged Unitary Heat Pump System Adoption
- ET22SWE0034 – Hybrid Heat Pump and Indirect Evaporative Cooling Packaged Unit (Hybrid RTU)
- ET22SWE0023 – Occupancy-based Thermostats for Commercial Offices
- ET22SWE0020 – Variable Refrigerant Flow (VRF) Refrigerant Management Market Assessment
- ET24SWE0012 – Controllers for Inverter-driven Compressors

- ET26SWE0037 – Drop-In Rooftop VRF Retrofit Field Demonstration
- (In Development) – Hybrid RTU Measure Development

Resources and Links

- CARB SNAP Regulations: CCR 17 Section 95374
- Statewide IOUs Program: Comfortably California
- CalMTA ERTU Advancement plan
- Applicable eTRM measures:
- Unitary Air-Cooled Air Conditioner or Heat Pump, Under 65 kBtu/hr, Commercial
- Multiple Capacity Unitary Air-Cooled Commercial Air Conditioners Between 65 and 240 kBtu/hr
- Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution

Decarbonized Designs for Complex HVAC Systems

CalNEXT Priority: High

Definition

These complex HVAC systems feature a holistic design, aimed at achieving high energy efficiency and low emissions in both new and existing buildings.

Research Initiatives

Table 5: Decarbonized complex HVAC systems research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
All-electric design for new construction	High Needs	High Needs	High Needs	High Needs
All-electric design for existing buildings	High Needs	High Needs	Medium Needs	Medium Needs
Standardization for interoperability of component systems	High Needs	High Needs	Medium Needs	Medium Needs

KEY High Needs | Medium Needs | Low Needs | Future Needs

Opportunities

Emerging research in this technology family will yield strong energy efficiency savings potential and decarbonization by electrifying space heating, enabling energy recovery, and/or removing design barriers to decarbonization in large commercial buildings. Example opportunities include:

- Field validation of the performance and cost effectiveness of electrifying "difficult" existing building HVAC systems, such as those using large boilers for hydronic space heating.
- Assessment of electrical infrastructure impacts, especially in retrofit applications, including owner decision frameworks and phased retrofit pathways.
- Technoeconomic assessment of benefits—such as floor area, operating cost, and total cost of ownership—relative to energy efficient and decarbonization solutions.
- Development of design guides and tools that incorporate guidance on electrical upgrades, building envelopes, controls, and resilience to support market actors in electrifying new and existing buildings cost effectively.
- Development of program strategies for overcoming technical and market barriers.

Barriers

HVAC designs have been evolving to meet the needs of a decarbonized building future. While technical understanding is growing, particularly in the new construction market, the existing building sector needs to overcome considerable technical and market barriers in transitioning these complex systems, such as:

- The difficulty of cost-effectively retrofitting and electrifying HVAC systems in the existing building market.
- Lack of understanding the appropriate program designs and deployment mechanisms to address technical and market barriers.

Related CalNEXT Projects

- ET23SWE0028 – Market Characterization of Ultra-Low GWP Space Conditioning Heat Pumps for Commercial Buildings
- ET23SWE0048 – Commercial Air-to-Water HP Market Study
- ET23SWE0073 – Supply Chain Engagement for Increasing Packaged Unitary Heat Pump System Adoption
- ET23SWE0041 – Propane Air to Water Heat Pump Market Study
- ET24SWE0036 – Nonresidential Heat Recovery Chiller and Air-to-Water Heat Pump Measure Package Development

Resources and Links

- https://www.energy.ca.gov/data-reports/reports/building-decarbonization-assessment

Commercial HVAC Equipment Installation, Operation, and Maintenance

CalNEXT Priority: High

Definition

This technology family is focused on tools, techniques, and practices that improve the installation, operations and maintenance, and commissioning of HVAC systems, particularly for small- to medium-sized commercial buildings. The goals are to optimize the operational performance and efficiency of HVAC equipment at the time of installation through quality installation practices and commissioning, and to sustain optimal performance through continuous commissioning and maintenance.

Research Initiatives

Table 6: Commercial HVAC equipment installation, operation, and maintenance research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Scalable technologies and approaches for quality installation, FDD, and continuous commissioning				
Tools for continuous commissioning in small to medium buildings without BMS				

KEY  High Needs  Medium Needs  Low Needs  Future Needs

Opportunities

Improvements in installation practices, operations, and maintenance will result in energy savings, demand flexibility, and a reduction in refrigerant release emissions. A 2020 Lawrence Berkeley National Lab study found the median simple payback for existing building commissioning is less than two years. The continued advancements within the various normalized metered energy consumption programs mean there is the potential for program delivery improvements within this technology family.

Example opportunities for improving installation, operations, and maintenance of HVAC equipment include:

- Low-cost approaches to existing building commissioning, continuous commissioning, and quality installation.
- Tools to help facility managers and operators incorporate quality installation, operation, and maintenance of HVAC equipment into practice.
- Tools and methods for identifying and mitigating refrigerant leaks.

- Program design that helps improve the quality of installations, maintenance practices, and persistence of energy efficiency measures, which may include workforce development and technician training.

Barriers

To date, commissioning practice has been mostly driven by mandatory building code requirements or voluntary code requirements, such as California Green Building Standards (Title 24, Part 11) or Leadership in Energy and Environmental Design ratings. While research indicates that existing buildings still have significant cost-effective energy savings opportunities through proper installation and maintenance, some barriers have been identified that could hinder the adoption of the most efficient options, such as:

- Operation and maintenance practices, which need to be tailored to the unique needs of each building.
- High initial cost for small to medium buildings.
- Lack of dedicated building staff to manage and maintain the HVAC systems and energy.
- Lack of tools for buildings without building management systems, particularly for small- to medium-sized commercial buildings.

Related CalNEXT Projects

- ET22SWE0020 – Variable Refrigerant Flow (VRF) Refrigerant Management Market Assessment
- ET22SWE0039 – ASHRAE Guideline 36 Open-Source Supervisory Control Technology Development and Demonstration
- ET23SWE0060 – PG&E HVAC Tool Validation
- ET24SWE0019 – Automated Guideline 36 Validation
- ET25SWE0013 – Simplified HVAC Control Retrofits (ASHRAE G36 Lite)
- ET25SWE0036 – Improving HVAC Refrigerant Charge Value Estimates for Residential Systems
- ET25SWE0037 – Improving HVAC Refrigerant Charge Value Estimates for Commercial Systems
- ET25SWE0064 – Remote Retro-Commissioning (RRCx) Study

Resources and Links

- https://eta-publications.lbl.gov/sites/default/files/crowe_building_commissioning_costs_and_savings_.pdf
- CA IOUs NMEC studies: ET17SCE1130, ET17SCE7050, ET17SCE1080, ET17SDG1061, ET18PGE1211, ET19SCE7010
- https://www.energycodes.gov/BPS

Hydronic Heat Pumps for HVAC

CalNEXT Priority: High

Definition

Commercial hydronic heat pumps serve space conditioning and service water needs for multifamily or non-residential buildings with large heating needs, such as a commercial kitchen or a large office building. These may be air-to-water heat pumps (AWHP) designed as boiler replacements or water-to-water heat pumps, such as heat recovery chillers, which can provide partial heating and cooling for facilities with simultaneous loads. This technology family is focused on advancements of the product itself.

Note: This technology family will not focus on the holistic system design or interoperability with other large components, which are spread across several technology families.

Research Initiatives

Table 7: Hydronic heat pumps for HVAC research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Heat recovery chiller	High	Medium	High	Medium
Low-GWP air-to-water heat pumps	High	Medium	High	High
Software tool development to support product specification	High	Medium	Medium	Medium
Test method development and validation	High	Medium	Medium	Medium

KEY: High Needs; Medium Needs; Low Needs; Future Needs

Opportunities

Hydronic heat pumps can provide multiple hydronic services to a building to address efficiency and decarbonization market needs across the California multifamily and non-residential sectors. Opportunities for emerging technology research include:

- Conducting a performance validation through laboratory applications testing and field demonstration of hydronic heat pump systems in new construction and existing buildings to address building owners' performance risk concerns
- Collecting data to support the development of AWHP performance maps—and possibly future programs and building codes infrastructure.

- Measure development for heat recovery chillers and AWHPs to support partial or complete fuel substitution in large buildings.
- Conducting a cost-benefit analysis for retrofitting existing buildings with VRF with hydronic systems.
- Developing multiple standardized system designs for optimal performance in selected applications.
- Focusing on the development of drop-in packaged systems vs. custom-engineered solutions.
- Creating specification templates and design guides to inform market actor procurement decisions.

Barriers

There are several barriers to hydronic heat pumps that could be addressed through emerging technology efforts:

- While manufacturers have developed test procedures under AHRI 550/590, this test procedure has not been adopted by mandatory standards or voluntary standards, which limits the broad reach needed for this market adoption.
- Load flexibility of multifunction AWHPs has not been explored. Controls that incorporate function switching, thermal energy storage (dedicated or domestic hot water volume), and load up/shed all require data, modeling, development, and testing.
- Early adopter approaches are often custom-engineered, site-built systems. Packaged designs are needed for design, equipment, installation, and commissioning cost compression.
- Building owner aversion to performance risks associated with newer technologies.

Related CalNEXT Projects

- ET23SWE0028 – Market Characterization of Ultra-Low GWP Space Conditioning Heat Pumps for Commercial Buildings
- ET23SWE0048 – Commercial Air-to-Water HP Market Study
- ET24SWE0020 – Demonstration of "Combi" Air-To-Water Heat Pump
- ET24SWE0036 – Nonresidential Heat Recovery Chiller and Air-to-Water Heat Pump Measure Package Development
- ET24SWE0042 – Multipurpose Hydronic CO_2 Heat Pump for Commercial Buildings

Resources and Links

- AHRI 550/590: 2023 Standard for Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle

Residential Multifunction Heat Pumps

CalNEXT Priority: High

Definition

Residential multifunction heat pumps (MFHPs) use an efficient compressor system to serve both space conditioning and water heating requirements of a household, typically configured as a primarily hydronic system. MFHPs can come in multiple formats. Two-function (or combination) heat pump systems serve space heating and water heating demands. Three-function MFHPs provide space cooling in addition.

Note: This technology family is cross-listed with the Water Heating TPM[2].

Research Initiatives

Table 8: Residential multifunction heat pump research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Two-function: water heating and space heating	High	High	High	Medium
Three-function: hot water, space heating, space cooling[3]	High	Medium	High	Medium
Selection guidelines	High	High	Medium	Medium

KEY High Needs | Medium Needs | Low Needs | Future Needs

Opportunities

Residential MFHPs offer a novel pathway to decarbonization, providing an efficient alternative to existing gas-fired equipment or the current approach of multiple heat pumps (heat pump water heaters and a packaged central heat pump). MFHPs can potentially replace space heating, space cooling, and water heating with a single system, depending on the configuration and design. MFHPs have the potential to provide much higher total system benefits by extending the benefits of thermal storage to space heating (and potentially space cooling). In addition, the single heat pump may free up a home's electrical panel capacity for other electrification uses and could be deployed with less overall refrigerant charge than current heat pump practices.

[2] This technology family also cross-cuts with research initiatives 1 and 2 in the Integrated Systems technology family of the Whole Buildings TPM (https://calnext.com/resources/whole-buildings/).

[3] This research initiative is not in the Electronic Technical Reference Manual (eTRM) at this time, leading to the ranking seen.

MFHPs are relatively new to the US market, and as a result, there are many opportunities to improve the understanding of their performance and impact on the residential sector. Opportunities for research include:

- Laboratory testing of MFHPs to evaluate system performance in various applications.
- Field demonstration or performance validation of MFHP in new construction and existing building applications across different climate zones.
- Market assessment of MFHP for California homes, including cost and requirements associated with MFHP installation in new construction and existing buildings.
- Assessment of the potential TSB value of MFHPs—including energy performance, demand flexibility, fuel substitution, and refrigerant emissions—compared with the efficiency of single-function separate HP, HVAC, and water heating equipment.
- Assessment of the bill impacts and customer economics of MFHPs—including total costs of operation, operating costs under current rate structures, increased value of load shed, etc.—compared with the efficiency of single-function separate HP, HVAC, and water heating equipment.
- Development of modeling tools to compare various MFHP types and guide program development, and/or support early adopting market actors.
- Understanding workforce needs related to upselling practices to customers, comfort level of installation, and maintenance needs.
- Validation of customer amenity and confirmation that proper hot water temperature and space temperatures can be met.
- Field demonstration and cost-saving or bill performance validation for disadvantaged communities and hard-to-reach residences in a fuel-switch scenario where electrical panel capacity is commonly limited.
- Market-assessment and field performance of “all-in-one" heat pumps and energy recovery ventilator products.

Barriers

As an emerging technology in the US market, there are many barriers to MFHP adoption that could be addressed. Understanding the performance of MFHPs in the context of US homes, the development of testing and installation standards, and the development of equipment selection guidelines are all necessary for understanding the efficacy of MFHPs in meeting California’s decarbonization goals and encouraging MFHP use in California. Specific barriers include:

- Absence of standardized testing procedures for MFHP evaluation include heat recovery and simultaneous modes of operation.
- Lack of MFHP product offerings compared to international markets, particularly those where hydronic heating is common.
- Limited understanding of how well MFHP systems manage occupant thermal comfort.
- Absence of a standardized installation procedure and contractor or installer knowledge.
- Lack of understanding of MFHP efficiency and decarbonization opportunities (compared to independent systems).
- Need for MFHP market assessment for California homes, including cost and requirements associated with new construction and retrofits.

- Absence of MFHP modeling and design tools.
- Lack of performance standards.
- Lack of awareness, knowledge of benefits, and understanding of sentiment within disadvantaged and hard-to-reach communities for this technology group.
- Retrofits may be constrained by the fact that water and space conditioning systems would rarely have to be replaced simultaneously for existing buildings.

Related CalNEXT Projects

- ET22SWE0021 – Residential Multi-Function Heat Pumps: Product Search
- ET22SWE0051 – Residential Multi-Function Heat Pump: Heat Exchanger Improvement
- ET23SWE0047 – Residential Multi-Function Heat Pump Laboratory Testing
- ET23SWE0066 – Lab Test of a Variable Speed Air-to-Air Multi-Function Heat Pump
- ET24SWE0020 – Demonstration of "Combi" Air-To-Water Heat Pump
- ET22SWE0050 – Tech Evaluation of Air-to-Water Heat Pumps with Thermal Storage
- ET25SWE0024 – Residential Multi-function Heat Pump Market Study
- ET24SWE0058 – Multi-Function Heat Pump Research Home Test – Variable Speed

Resources and Links

- CalFlexHub - Integrated Heat Pump for Residential HVAC and DHW with Hot Water Storage

Residential Air-to-Air Heat Pumps and Controls

CalNEXT Priority: Medium

Definition

These are advanced, high efficiency air-to-air HP units for use in the residential market, including ducted unitary HPs and ducted or ductless split systems. This technology family includes strategies to ensure adequate part-load performance (proper system sizing or use of variable-speed equipment); commissioning techniques; connected features that improve the installation, operation, and maintenance of residential systems; and deployment of smart thermostats to ensure proper control of variable speed systems and the ability to participate in demand response programs.

Research Initiatives

Table 9: Residential air-to-air heat pumps and controls research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Integrated or connected controls				
Variable capacity heat pumps				
Optimized design and quality installation				
Commissioning and continuous maintenance				

KEY  High Needs  Medium Needs  Low Needs  Future Needs

Opportunities

California's residential HP market has seen significant activity as the market continues to take shape through large market transformation efforts, such as TECH Clean California. However, to maximize the overall impact of HPs, there needs to be a continued effort to ensure they operate efficiently while satisfying heating and cooling needs—as well as assurance that this technology is capable of providing grid services through flexing electric demand.

Example opportunities for increased efficiency and performance in the residential air-to-air HP market include:

- Validating performance of variable capacity HPs.
- Validating new digital commissioning tools in support of quality installations.
- Supporting development of integrated, connected controls to optimize system efficiency, as well as energy cost and greenhouse gas savings.

- Development of standards for assessment and design of ductwork for centrally ducted heat pumps (retrofit and new applications).
- Development of smart thermostat technology that controls heat pump and auxiliary heating to optimize energy costs.

Barriers

Example barriers to increased adoption of residential air-to-air HPs include:

- Compatibility concerns, high costs to purchase and install integrated controls for ductless mini-splits, and unknown return on investment.
- Poor existing duct work that is not well suited for ducted heat pump retrofit applications.
- Lack of appropriate controls for variable-speed equipment.
- Lack of consumer awareness on availability of integrated controls.

Related CalNEXT Projects

- ET22SWE0022 – Residential Housing Characteristics Study
- ET23SWE0024 – eTRM Heat Pump Baseline Systems Assessment
- ET23SWE0063 – Residential Heat Pump Financing Solutions Analysis
- ET23SWE0053 – Insights from Innovative Programs on Barriers and Opportunities for Heat Pump Adoption
- ET25SWE0022 – Laboratory Testing of Variable Capacity Heat Pumps to Develop Building Energy Modeling Performance Maps

Resources and Links

- ENERGY STAR Version 2.0 Smart Thermostats Draft 1 Specification (July 21, 2022)
- TECH Clean California
- CARB SNAP Regulations: CCR 17 Section 95374
- Statewide IOUs Program: Quality Residential HVAC Services
- Statewide IOUs Program: Comfortably California
- NEEA Advanced HP Program: Residential Heat Pumps
- Applicable eTRM measures:
- Smart Thermostats
- Ductless HVAC, Residential, Fuel Substitution
- Heat Pump HVAC, Residential Fuel Substitution
- SEER Rated AC and HP HVAC Equipment
- Ductless Heat Pump, Residential

Thermal Energy Storage

CalNEXT Priority: Medium

Definition

Commercial scalable thermal energy storage (TES) systems encompass heat energy-based systems in commercial buildings, which are capable of decoupling the coincident time of HVAC loads and HVAC energy input. Commercial scalable TES systems can reduce peak demand and shift energy inputs to a period when electric grid power is lower cost and less greenhouse-gas-intensive; they should be designed and operated for higher energy efficiency, e.g. shifting cooling loads to time periods with lower ambient temperatures. Scalable systems have already been implemented in commercial or residential building applications and therefore, could be implemented in larger sizes and higher percentages of building projects. Additionally, they have the potential for innovative improvements in terms of load shift, efficiency, and cost-effectiveness.

Research Initiatives

Table 10: Thermal energy storage research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Hot water hydronic thermal storage				
Cold water or ice hydronic thermal storage				
Phase change material thermal storage				
Building mass thermal storage				

KEY  High Needs  Medium Needs  Low Needs  Future Needs

Opportunities

Thermal energy storage systems have been in commercial use for decades and present an opportunity for an increased scale of application for higher efficiency and decarbonization. Example opportunities include:

- Storage to serve the non-coincident heating and cooling loads commonly found in larger HVAC systems with vapor compression heating and cooling equipment—e.g., air-to-water HPs, heat recovery chillers, etc.—that can support higher efficiency electrification.
- Integration of heating and cooling loops with high mass building structure to reduce peak loads, equipment cost, and energy consumption.

- Packaged product solutions and application guidance for designs, installers, and operators.
- Refined phase change material choices and control strategies for cooling and heating to maximize usable storage and performance across seasons.
- Storage to more efficiently and cost effectively serve water heating loads with HP water heating.
- Positive impacts on multifamily buildings with central systems—these projects could be paired with zonal or neighborhood electrification efforts.

Prospective emerging technology studies should build upon the California IOU CASE team's ongoing research on this topic, as well as pursue lab and field demonstrations with a viable path to scalability.

Barriers

Technical and market barriers for various TES technologies and system types include:

- Controls and interoperability challenges, especially in retrofit applications. For example, in retrofit applications, TES may be difficult to integrate with existing HVAC systems, limiting the ability to coordinate charging, discharging, and HVAC operation to maximize performance.
- Separate strategies required for heating vs. cooling load shifting. Heating and cooling loads often peak at different times and seasons, complicating TES control strategies and making it difficult to consistently optimize charging and discharging relative to time-of-use pricing. A different medium with a distinct solidification temperature may also be required.
- Physical constraints of technology. The size and weight of TES systems may limit deployment at sites with structural load or space constraints, reducing the number of feasible applications.
- Measurement and verification complexity for confirming savings. It can be complex to quantify bill savings and demand impacts, particularly for price-driven load shifting, which creates uncertainty for customers and utility programs.
- Smaller building operators may find some of the advanced TES controls challenging to manage.

Thermal energy storage ideas and projects should identify barriers and provide strategies for mitigating or removing such barriers.

Related CalNEXT Projects

- ET23SWE0059 – CHPWH Unpressurized Storage Design Optimization
- ET23SWE0041 – Propane Air to Water Heat Pump Market Study
- ET23SWE0022 – HVAC Thermal Energy Storage System (TESS) Field Evaluation
- ET23SWE0071 – Field Evaluation of Ultra-Efficient, Compressor-less, Packaged Rooftop Unit with Integral Energy Storage
- ET22SWE0050 – Comfort Impacts of Partial Coverage ASHPs
- ET25SWE0012 – PCM Enhanced Ceilings
- ET22SWE0028 – Packaged Central CO_2 Heat Pump Water Heater Multifamily Demonstration
- ET25SWE0065 – Modeling Distributed PCM CHPWH Systems
- ET25SWE0050 – Phase Change Material Applications in Residential Water Heating

- ET25SWE0043 – Multifamily Central Heat Pump Water Heater Storage and Control Strategies for Increasing TSB
- ET25SWE0029 – Field Demonstration of Atmospheric Storage Central Heat Pump Water Heater

Resources and Links

- https://title24stakeholders.com/measures/cycle-2025/nonresidential-hvac-space-heating/
- https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/ThermalEnergyStorage-REIteam.pdf

Next Steps

Following approval of the 2026 HVAC TPM, the program team will:

- Update the CalNEXT website with revised 2026 HVAC TPM and this final report.
- Launch an email announcement through email outreach.
- Develop and submit the distribution report.
- Highlight any technology families to reinvestigate for the 2026 Focused Pilot TPM, which will support the 2027 Focused Pilot projects.

Appendix A: HVAC Advisory Committee Feedback & Resolution Matrix

Table 11: Advisory committee feedback and resolution matrix.

HVAC TPM Technology Family	Section	Suggestion or Comment	Action Taken & Justification
General Recommendations	General Narrative	Which technologies that are not heat pump related, do you think would drive large electric energy savings for commercial systems? This question should ask about Total System Benefit as well, not just large electric energy savings.	The focus on electric energy savings was done at SCE's request.
General Recommendations	General Narrative	Every effort should be made to summarize the best-available data on both performance (savings potential), costs, and broad market potential for various technologies and research topics accessible from the literature, at least to give readers broad understanding of potential value of the research initiatives being proposed relative to the potential effort to address the research gaps and other barriers.	The overall intent of the ET program is to understand market potential of new technologies and collect data that was otherwise unavailable through literature review. The information included within the TPM includes all currently available data on the technology families outlined in the TPM.
Introduction	General Narrative	Is there a need to mention that prior "CalNEXT Role" is not being used this year within the TPM?	Yes, but at the website level, as this change impacts all TPMs.
General Recommendations	General Recommendations	Suggest refocusing 2026 TPM from primarily cataloging research needs to **driving implementable outcomes.** Each priority technology family should clearly state: 1. who must act next 2. what evidence or tools are still missing 3. how our investments will accelerate real customer adoption within the next program cycle.	This is already part of the tech transfer question in the project proposal form.

HVAC TPM Technology Family	Section	Suggestion or Comment	Action Taken & Justification
General Recommendations	General Narrative	Heat pumps will continue to play a central role in building decarbonization. But there are probably several adjacent technologies / operational strategies that could drive substantial electric energy savings. Areas could include (and I think probably some of these remain front and center): -Advanced building automation systems (BAS) and integrated controls -Fault detection diagnostics (FDD) - Low-cost remote monitoring and diagnostics for small and medium commercial buildings - Existing building commissioning and continuous commissioning - Occupancy-based controls and adaptive scheduling - High-efficiency fans, pumps, and motor/VFD optimization From a DAC/HTR market perspective, these technologies offer strong value because they can improve building performance, reduce operating costs, defer electrical infrastructure upgrades, and extend the effectiveness of existing systems without requiring full HVAC replacement. Also, operational optimization and controls strategies may represent some of the most scalable and cost-effective pathways for improving commercial building efficiency in underserved building sectors, particularly where older equipment, limited maintenance resources, constrained electrical infrastructure, or affordability concerns make full system replacement difficult.	This comment is being discussed by the SME team and will be addressed in the HVAC Final Report.

HVAC TPM Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Room Heat Pumps	Definition	In definitions paragraph: - When describing the installation needs of RHPs, we use the terminology “can be installed without the need for professional HVAC and electrical skills” - When discussing form factors, you do not mention U-shaped products or standard window box units which are both available as heat pumps - When discussing condensate management, the document does not mention portable units and their drip pan system. - We call what CalNEXT calls “saddle”, “saddlebag” - Under the Table titled “Research Initiatives” you have listed high needs for performance validation and measure development needs for Window/ Saddlebag HP. While this is true in terms of need, I wanted to make sure that much work on this is already happening or has happened. Please include links in the end of this section to show that some work has been done on these items. Like: Room Heat Pumps Lab Testing Report - CalMTA	Edited definition. Added window box units to form factors and clarified that saddle and U-shaped refer to same type of units. Added drip pan systems for portable units. Added CalMTA Room Heat Pumps Lab Testing Report link.
Room Heat Pumps	Opportunities	You should include the benefit gained to those that do not currently have AC. - “ease of self-installation and customer satisfaction” and “Cost and performance compared to central heat pumps” are listed twice. - Could add “customer usage patterns, might add cost and performance compared to mini-split HP systems.”	Added benefit to opportunities and removed duplicate bullet points. Added last bullet point to barriers section.
Room Heat Pumps	Barriers	CalMTA still sees costs as a significant barrier, especially for the saddlebag, colder climate versions, especially if we see them as a replacement for a regular box AC-only product.	Added this point to the barriers section.

HVAC TPM Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Room Heat Pumps	General	The report identifies awareness and installation barriers, but it would be more useful to also address post-installation behavior, maintenance responsibility, and pathways for inclusion in mainstream low-income and renter-serving programs. It'd be useful to: • Expand scope to explicitly address renter and low-income adoption realities. • Add guidance on post-installation behavior, persistence of use, maintenance responsibility, and equipment portability. • Explicitly position room HPs for mainstream low-income and renter programs, not only pilots.	This comment is being discussed by the SME team and will be addressed in the HVAC Final Report.
Room Heat Pumps	Opportunities and Barriers	The narrative could be more explicit about deployment pathways for low-income, renter, manufactured housing, and small multifamily applications. This is a technology that could represent a scalable electrification option for households that can't pursue/achieve panel upgrades or central HVAC replacement. Emphasis could also be placed on: -Electrical infrastructure avoidance value (avoided/reduced panel upgrades) -Tenant portability and split incentive mitigation -Climate resilience and backup heating/cooling applications -Indoor air quality and noise considerations in real-world occupied settings -Challenges associated with landlord restrictions and window configuration compatibility Lastly, there may also be an opportunity to distinguish more clearly between DIY-capable products and products requiring licensed installation/permitting.	This comment is being discussed by the SME team and will be addressed in the HVAC Final Report.

HVAC TPM Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Room Heat Pumps	Resources & Links	Please add the CalMTA MTI Plan itself dated Dec 2024. Room Heat Pumps MTI Plan - CalMTA. This report is more recent that the Advancement plan listed currently in the document and includes links to a number of additional reports on this technology. Like the lab testing report mentioned above, product assessment report and the market forecast work. Also might be good to acknowledge the work that NYSERDA has done on these product through listing one of their reports. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/About/Publications/Research-and-Technical-Reports/Clean-Heating-and-Cooling-Reports/Large-Scale-Thermal/PON-4614/25-21-Clean-Heat-for-All--Taitem-Measurement-and-Verification.pdf	Added CalMTA MTI Plan and NYSERDA report links.
Commercial Air-to-Air Heat Pumps	General	The report identifies like-for-like replacement and infrastructure limits, and it would be stronger if it distinguishes emergency replacement markets from planned capital improvement markets, because the intervention strategy is different for each. • Distinguish emergency replacement from planned retrofit markets and tailor strategies accordingly. • Add distributor stocking, lead times, contractor preferences, electrical service upgrade timelines, and customer tolerance for downtime. • Shift emphasis from equipment feasibility to replacement-cycle intervention strategies.	Added first and third bullet points to opportunities and added second bullet point to barriers.

HVAC TPM Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Commercial Air-to-Air Heat Pumps	Research Initiative #4	As this is a new topic for this year, can you explain how the needs were already identified?	As heat pumps have become more prevalent, over-reliance on supplementary electric resistance heat is a known issue: e.g. contractor switchover temperatures set too high, especially with newer heat pumps maintaining better efficiency and capacity at lower temperatures.
Commercial Air-to-Air Heat Pumps	Related CalNEXT Projects	Any 2025 projects to include, even if in progress?	Added two completed projects from 2025.
Residential Multi-function Heat Pumps	Priority Ranking	Curious how/why this was updated from medium to high, but below research initiative needs remained the same. What is driving the increased priority rank?	This comment is being discussed by the SME team and will be addressed in the HVAC Final Report.
Residential Air-to-Air Heat Pumps	Opportunity #6	Shouldn't this be covered under Residential Multifunction Heat Pumps? Or how does this differ from MFHP?	Corrected.
Decarbonized Designs for Complex HVAC Systems	General	It'd be better to cover phased retrofit strategies, interoperability planning, resilience considerations, and sequencing guidance for complex buildings where electrification must be coordinated with envelope, controls, ventilation, and electrical upgrades. • Expand scope beyond system concepts to include owner decision frameworks and phased retrofit pathways. • Require sequencing guidance covering electrical upgrades, envelope, controls, and resilience. • Treat interoperability and future retrofit flexibility as core requirements, not secondary considerations.	First and second bullets incorporate in Opportunities. Interoperability is one of three research initiatives and not secondary consideration.

HVAC TPM Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Commercial HVAC Installation, Operation, and Maintenance	General	• Narrow focus to high-impact, scalable practices that improve persistence. • Explicitly define contractor workflows, service models, and operator capability requirements. • Prioritize low-touch commissioning and monitoring solutions for small and mid-sized buildings without BAS.	First and third bullets addressed by research initiatives. Second bullet incorporated in Opportunities.
Commercial HVAC Installation, Operation, and Maintenance	Opportunities	While not in the residential space, I'd recommend broadening this category to more explicitly include other DAC / HTR concerns, such as: - Workforce development and technician training - Remote diagnostics for underserved or rural markets	Included in Opportunities.
Commercial HVAC Installation, Operation, and Maintenance	General	Not clear if "Commercial HVAC Equipment Installation, Operation, and Maintenance" section includes central plant optimization measures, much of which include continuous commissioning and many controls-related measures but not exclusively so. Many of these measures have been demonstrated for decades in the field, so it is not clear why performance validation needs remain so high when we have more tools than ever for measuring and validating performance of such measures right where they are implemented in the field. Why are the measure development needs higher here, given how much TSB potential can be unlocked relative to prior years when annual energy savings were the main benefit metric? What research is needed on state-of-the-art energy management and information systems to support ongoing Cx and O&M? What role does machine learning and AI play to support and realize savings and TSB?	The TPM does not exclude central plant optimization if there is innovation there, but the primary focus is small to medium commercial buildings, as indicated in research initiatives. Included an edit under definition.

HVAC TPM Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Hydronic Heat Pumps for HVAC	General	• Shift emphasis from custom engineering toward packaged and semi-packaged solutions. • Add specification templates, design assistance tools, and procurement models. • Clearly identify who bears design and performance risk and what evidence owners require to proceed.	Added first and second bullet points to opportunities and third bullet point to barriers.
Residential Multifunction Heat Pumps	General	• Sharpen the customer value proposition relative to simpler system combinations. • Identify lead adoption segments and the conditions under which MFHPs clearly outperform alternatives. • Prioritize installer readiness, service pathways, and maintenance clarity over additional conceptual analysis.	Captured under opportunities and barriers; recommended prioritization may unnecessarily constrain or focus proposals; immediate impacts and program impacts are already assessed for the proposals which takes into account implicitly installer readiness and operational realities over concepts.
Residential Multifunction Heat Pumps	Opportunities and Barriers	Recommend expanding the discussion around: - Applicability in low-income and DAC/HTR households with constrained electrical capacity - Potential role in “good enough electrification” or phased electrification strategies - Contractor workforce readiness and training limitations - Long-term maintenance/serviceability concerns in underserved communities	Captured under opportunities and barriers; some of the proposed opportunities may be more applicable for the Whole Buildings TPM.

HVAC TPM Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Residential Multifunction Heat Pumps	Barriers	Barriers: • Relating to retrofits, is this a technology that is practical for replacements / retrofits given both water and space conditioning systems would have to be replaced at the same time and that rarely occurs other than major remodel?	Excellent point, added.
Residential Multifunction Heat Pumps	Opportunities	Opportunities for research: • Applications, operating modes and climate zones incl. cold-weather performance. • How does space heating in cold weather (not just cold climates) impact water heating performance (e.g., impact of defrost cycles). • HW recovery times / recharge performance in various space conditioning modes. • Impacts of thermal energy storage on performance	Excellent additions, have refined some of the opportunities.
Thermal Energy Storage	General	• Recenter the narrative on controls, tariffs, usability, and savings verification. • Require clearly defined bill savings logic and M&V approaches as a condition for prioritization. • Treat controls integration as the primary barrier, not storage media performance.	Excellent suggestions, but program setup for proposals already require solid logic and defined plans for M&V.

HVAC TPM Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Thermal Energy Storage	Opportunities	The TPM should include stronger discussion of: - Multifamily and affordable housing applications - Pairing TES with zonal or neighborhood electrification efforts Additionally, the barriers section should acknowledge that many smaller building operators lack the operational sophistication or staffing needed to manage advanced TES controls.	Excellent suggestions; added.
Thermal Energy Storage	General	The Thermal Energy Storage category seemed to be limited to the commercial sector. Given that a major OEM like Carrier is also deploying battery energy storage with residential HVAC units, an additional research initiative around the benefits of HVAC demand flexibility with battery storage across both commercial and residential sectors.	Added references to multifamily units in opportunities.
Thermal Energy Storage	General	• CalMTA stage 2 scoring for a submitted TES idea indicated C/E challenges, well less than 1.0. Recommend early research into cost-effectiveness. • Indication of TRL for each technology type would be very helpful • To what extent is grid storage (batteries) complementary to, overlapping with or redundant with TES? I.e., if grid batteres become ubiquitous, does TES still over the same magnitude of benefits?	TES would still have a positive impact for the end user; grid batteries can benefit the grid and provide more reliable service to the end user, but TES can help reduce kWh use.