2024 HVAC Technology Priority Map

Final Report

ET24SWE0006

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July 30, 2024

Acknowledgements

This Heating, Ventilation, and Air Conditioning (HVAC) Technology Priority Map (TPM) was developed by the HVAC Subject Matter Expert (SME) Team of the CalNEXT Program, which is responsible for the production of this document, background research, stakeholder engagement of the Technical Advisory Committee, and management of the TPM development process. We thank the HVAC SME team members and our facilitation team for their contributions in this process:

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Abbreviations, Acronyms, and Glossary of Terms

Acronym	Meaning
ADU	Accessory Dwelling Units
BAS	Building Automation Systems
BUILD	Building Initiative for Low-Emissions Development
CARB	California Air Resources Board
CEC	California Energy Commission
Cx	Building Commissioning
DAC	Disadvantaged Communities
DOAS	Dedicated Outdoor Air System
EBCx	Existing Building Commissioning
EE	Energy Efficiency
ERV	Energy Recovery Ventilator
ET	Emerging Technology
eTRM	Electronic Technical Reference Manual (CA)
FDD	Fault Detection Diagnostics
GHG	Greenhouse Gas Emissions
GWP	Global Warming Potential
HP	Heat Pump
HTR	Hard-to-Reach
HVAC	Heating, Ventilation, and Air Conditioning
IOU	Investor-Owned Utility
LEED	Leadership in Energy and Environmental Design
MHP	Micro Heat Pump

Acronym	Meaning
NEMA	National Electrical Manufacturers
PNNL	Pacific Northwest National Laboratory
RTU	Roof top unit
SCE	Southern California Edison
SGIP	Self-Generation Incentive Program
SME	Subject Matter Expert
TECH	Technology and Equipment for Clean Heating
TPM	Technology Priority Map
VRF	Variable Refrigerant Flow
VS	Variable Speed
WH	Water Heating

Glossary	Meaning
Technology Category	One of six broad technology categories (e.g. Whole Buildings, HVAC, Water Heating (WH), Plug Loads, Lighting, Process Loads).
Technology Family	Functional grouping that provides description of program role, opportunities, barriers.
Research Initiatives	New 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, research in progress, immediate needs, or future research needs.
High Understanding	Projects have run in this technology category, overall, the market is comfortable with this technology category, and it is well known.
Research In Progress	CalNEXT projects are currently running regarding this technology category.
Immediate Needs	There is a need to learn about this technology and there may not be any CalNEXT projects taking place at this time.
Future Research Needs	If the technology is not on the immediate horizon and requires further understanding and research before being fully developed.
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 Role	Describes general level of engagement by CalNEXT SMEs. *Note: Roles will change as research is completed.*
Lead Collaborate Observe	"Lead" - CalNEXT expects to take on most or all of the work and cost burden. "Collaborate" – CalNEXT is interested in collaborating and co-funding projects. "Observe" – CalNEXT will track progress but encourage external programs to take lead in unlocking these opportunities.
CALNEXT Priority	Communicates expected level of focus by CalNEXT SMEs. *Note: Priorities will change as research is completed.*
High Medium Low	"High" - CalNEXT SME team has highlighted this technology family as having high impacts within the Technology Category. "Medium" - CalNEXT SME team determined this technology family has moderate overall impacts within the Technology Category. "Low" - CalNEXT SME team has highlighted this technology family as having low relative impacts within the Technology Category.

Introduction

The Technology Priority Maps (TPMs) provide the CalNEXT Program a framework to externally communicate priorities of the program, clearly define the central focus areas of the program, and assist with project screening. They will document the impact potential, programmatic research needs, and market readiness of all technology families across each of the end-use technology areas. The TPMs will drive product ideation and inform project selection. This Final Report covers the revision process for the 2024 HVAC TPM.

2024 TPM Key Changes

Table 1 shows how content from the 2023 TPM technology families appears under new technology family headings in this 2024 revision. There are instances where several 2023 technology families have been dispersed into various 2024 technology families, as shown below by the number of arrow pathways.

Table 1: Technology Priority Mapping

2023 TPM Technology Families	2024 TPM Technology Families
High Efficiency Heat Pumps	Micro Heat Pumps
Scalable HVAC Controls	Residential Air-to-Air HPs and Controls
Hybrid or Fully Compressor-less HVAC	Commercial Air-to-Air Heat Pumps
Heat Pump Market Development	Large Commercial Decarbonization Designs
HVAC Design for Decarbonization	Commercial Scalable Thermal Storage
Scalable Thermal Storage	Commercial HVAC Equipment Installation, Operations, and Maintenance
110V/120V Heat Pumps	Residential Multifunction Heat Pumps
Installation, Operations, & Maintenance	Commercial Hydronic Heat Pumps
Refrigerant Management / Low-GWP Transition	

The HVAC category has seen significant changes relative to that of other technology areas. Notable drivers for these changes include the passage of the Inflation Reduction Act (IRA) of 2022, which continues to provide additional market support over the next decade in the form of tax credits and state-administered incentive programs targeting the heat pump market. In addition, research conducted by California's Investor-owned utility (IOU) Codes and Standards Enhancement (CASE) Team related to multiple technology families (Scalable HVAC Controls Deployment, HVAC Design for

Decarbonization, Scalable Thermal Storage) have impacted the state of knowledge to varying degrees. Finally, the continued need for programs to transition to the Total System Benefit metric has implications for both demand flexibility and low global warming potential (GWP) refrigerants. These changes were reflected in different ways in the 2023 TPM update.

As for the 2024 TPM update, the CalNEXT Program Team established a robust process for this initial phase of the TPM development and revisions. This year, the project team incorporated a stronger outreach push to ensure feedback, directly targeting deemed measure stakeholders from the California Public Utilities Commission (CPUC), San Diego Gas & Electric (SDG&E), DNV, CLEAResult, California Market Transformation Administrator (CalMTA), and the California Technical Forum (CalTF). The process this year started with the reformation of the HVAC Technology Priority Map (TPM) Subject Matter Expert (SME) Team, with representatives from each of the program team partners: VEIC, AESC, TRC, UC Davis, and Energy Solutions. The HVAC SME team represents members that collectively support an array of energy efficiency (EE) programs, using technologies covered by the HVAC TPM, as well as members who support the California Investor-Owned Utilities (IOUs') Codes and Standards (C&S) program. These emerging products are then contextualized into the priority maps through a markets and solutions lens. The team met four times between February and March of 2024 to revise this draft HVAC TPM. The SME team worked through a number of visual changes at the start of this revision process which can be seen below in the narratives of the Final Report. These visual changes will serve for submitters and viewers to see what topics are of most interest in a given technology family and those most important to progress within the portfolio, with an end goal of a simplified view for easier use and better connectedness across domains. For example, the Micro Heat Pumps table has an initiative named, "portable HPs," within this deliverable. There are additional icons under each of the overhead criteria. The first two criteria, Performance Validation & Market Analysis are technology-driven, and the next two, Measure Development & Program Development are market driven. These icons serve to show if the research initiative is at the stage of high understanding, research in progress, immediate needs, or future research needs. When a submitter or viewer views the table, the icons and their aided descriptions will help depict the categories where projects are needed the most and what stages those initiatives are at. The changes provide a visual summary of what topics are of most interest within a given technology family and to record the current state of progress. The end goal of these visual summaries is to have a clear representation of where the technology family stands in the portfolio and what remaining research is needed. The Research Initiatives table has a goal of describing what the three to five most important technology areas should be focused on, with subsequent versions providing a simplified icon view of where the HVAC portfolio stands for easier use and external understanding. To date, the majority of research projects take place within a handful of technology families, which was a large driver in how the technology families were chosen in 2024.

Table 2. Icons and their meanings

Icon	Meaning
	High Understanding
	Research In Progress
	Immediate Needs
	Future Research Need

One additional feature specific to this HVAC TPM (and the water heating TPM) is the development of two cross-listed technology families. This development was made to better orient and provide consistency between the two TPM categories and address an emergent system and design need: air-to-water heat pumps which can be deployed to address both space conditioning demand under normal conditions under HVAC, and domestic and service water heating demand needs under the Water Heating TPM. The structure of these cross-listed topics was developed to ensure strong coordination among CalNEXT activities. Those two technology families are named: (1) residential multifunction heat pumps and (2) commercial hydronic heat pumps. They can be found at the end of the HVAC technology families. These two technology families are structured slightly differently to account for the differing needs by market. As these systems grow in size, so does the complexity. Residential multifunction heat pumps are anticipated to be sold as a package of features (e.g. thermal storage, hydronic heating, cooling, hot water). That is in contrast with commercial systems, which appear heavily custom-engineered as a collection of components (heat recovery chillers, air-to-water heat pumps, service water controls, thermal storage), all of which need to be sized, integrated, and controlled together to support large-scale building electrification.

Overall, the changes made in this 2024 TPM aim to focus on increased 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. These changes should put greater focus on shorter-term activities, like measure packages to support expansion of the existing resource acquisition programs. Even for longer-term investments, as mentioned above, the new visual format of the Research Initiatives table will provide more tactical guidance as to what type of research is needed to better encourage the progress of different technologies towards the ultimate goal of portfolio savings.

Stakeholder Feedback

TPM Advisory Committee Outreach

The TPM Advisory Committee outreach began in April 2024, when stakeholders feedback was requested via email, which resulted in the Word document of the technology family narratives that are listed below in Table 2. Any further stakeholder feedback conducted is incorporated in this Final Report.

Table 3: TPM Advisory Committee Outreach

Organization
2050 Partners
CalMTA
CalTF
CLEAResult
CPUC
DNV
SCE
SDG&E

This outreach allowed advisory members to provide candid feedback, with the opportunity to provide written comments and suggestions via a collaborative Word document hosted on Microsoft SharePoint. Suggestions were reviewed by the TPM coordinator, the HVAC SME team, and incorporated into the Revised 2024 HVAC TPM section below. A detailed table of the changes made can be found in the Appendix of this report labeled, “Advisory Committee Feedback & Resolution Matrix.”

Micro Heat Pumps

CalNEXT Role: Lead | CalNEXT Priority: High

Definition

Efficient, rapidly deployable HPs that require minimal professional installation and are suitable for compact spaces where HPs can replace electric space heaters or where traditional split-systems are too costly or onerous to deploy. They should connect with standard 110V/120V NEMA 5-15 outlets, without any field-installed refrigerant lines. They can appear in the market in several form factors such as saddle, portable, and through-the-wall. The saddle units are generally do-it-yourself (DIY), while others may require infrastructure costs. Typical uses include single-family, ADUs, multifamily, mobile homes, hospitality, assisted living facilities, and schools. The condensate in these units is managed via either drip-free melt water atomization and/or water dispersion into the internal air or outside air.

Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Window HPs (Room Heat Pumps)	Research In Progress	High Understanding	Immediate Needs	Future Research Need
Portable HPs	Research In Progress	High Understanding	Immediate Needs	Future Research Need
Through- the-wall HPs (PTHPs/SPVHP)	Research In Progress	High Understanding	Immediate Needs	Future Research Need

KEY High Understanding Research In Progress Immediate Needs Future Research Need

Opportunities

Mass deployment of Micro HPs has the potential to rapidly electrify space heating and simultaneously replace existing portable space heaters and older, less efficient room air conditioners with more efficient HPs. Advancements in this technology family may be especially important for DAC and HTR customers since they are a majority renter group with limited options to improve their HVAC infrastructure. These products have the potential to provide a low up-front cost alternative, compared with traditional central heat pump systems, that are significantly more efficient than current systems (portable electric resistance heaters and gas-fired heaters). The adoption of new MHPs will bring in tangible real-world benefits, when compared with single-speed products. Prospective ET studies should investigate deployment costs of 110V/120V HPs when compared with more traditional HVAC solutions and investigate in-field heating performance of these products, to ensure they can fully displace existing electric resistance heaters, since these products have historically been optimized for their cooling performance, rather than their heating performance. Studies investigating customer usage patterns may also help inform the real-world efficiency and electrification potential of these products. Other considerations may include in-field performance of the units to validate any noise, defrost and/or dehumidification, ventilation and/or air-filtration issues, and consumer research detailing the usage patterns, ease of self-installation and customer satisfaction, as these products start to become more widely available. The research opportunities may be "inclusive" of any variant or form factors of these units.

Barriers

Most MHP products are adaptations of familiar products, such as room air conditioners or portable air conditioners. CalNEXT has made initial investments in this technology family to better understand product costs, product availability, and validate performance. Additional research can inform product usage patterns, customer sentiment, and understand overall market awareness, as these are all anticipated to be early implementation barriers. Installation practices are likely to vary on this product, but much of the appeal is that installation could be performed by end-users. Identifying common installation challenges, in turn, for different product types is needed. For example, these challenges might include the setting of the outdoor air damper position, sealing around the unit, practices related to decommissioning existing equipment, or thermostat control setting.

One major challenge has been the lack of heating performance testing and metrics. It is, however, an area that is quickly evolving as ENERGYSTAR® is continuing to develop a test procedure for window heat pumps that is expected to be released in 2024. The new standard(s) will attempt to capture the benefits of variable speed equipment and other advanced features that are not appropriately captured under current metrics. This new standard may be a template for test procedures of other equipment types. This may be particularly important for the predominately mild heating needs of California and common oversizing practices.

Related CalNEXT Projects

- ET22SWE0035 - Multifamily In-Unit Heat Pump (published November 2023)
- ET23SWE0034 - Emerging "Micro" Heat Pumps: Testing and Heating Performance Metrics (expected December 2024)
- ET23SWE0038 - Double Duct Packaged Terminal Heat Pump Field Demonstration (expected March 2025)

Resources & Links

- CalMTA Portable/Window Heat Pumps, Market Transformation Advancement Plan- Draft, 2023
- 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

Commercial Air-to-Air Heat Pumps

CalNEXT Role: Lead | CalNEXT Priority: High

Definition

Commercial air-to-air heat pump equipment with over 65,000 btu/h cooling capacity (5.4 tons) or smaller capacity roof top units (RTUs), serving commercial space, capable of providing both space cooling and heating. Commercial air-to-air heat pump equipment includes unitary split and packaged units. Common examples include variable refrigerant flow (VRF) and heat pump RTUs. Other technologies that are considered part of this technology family includes those that complement heat pump systems, such as heat recovery; innovative market interventions that lead to increased heat pump adoption; and strategies to reduce the need for additional electrical service.

Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Heat Pump RTUs	Immediate Needs	Research In Progress	Immediate Needs	Future Research Need
Efficient Ventilation (DOAS/HRV/ERV)	High Understanding	High Understanding	Future Research Need	Future Research Need
VRF: transitioning to low-leak and sub-750 GWP refrigerants	Immediate Needs	Immediate Needs	Future Research Need	Future Research Need

Note: The VRF refrigerant topic may end up being relocated into the "Installation, Operations, and Maintenance" Technology Family pending feedback.

KEY High Understanding | Research In Progress | Immediate Needs | Future Research Need

Opportunities

The increased adoption of commercial air-to-air heat pumps systems represent a significant opportunity for energy efficiency and decarbonization of the HVAC energy end use in commercial buildings. While technically mature, the commercial market for high efficiency packaged equipment is still relatively new. Rooftop units represent the most common commercial HVAC equipment in California, yet the large replacement market has been largely driven by minimum-efficiency products with like-for-like replacements, continuing the use of AC-units with gas-fired furnaces, despite higher efficiency alternatives. While California ET programs have historically supported high-efficiency decoupled designs such as VRF, persistent challenges of refrigerant leakage continue and VRF systems will need to both reduce leaks and transition to refrigerants below 750 GWP to remain viable under CARB's new regulations. Finally, efficient ventilation and, specifically, the use of heat recovery remains an underutilized opportunity in California, particularly for the growing population centers in the more extreme Central Valley. This is even more obvious when considering the different value of energy under the TSB metric, which assigns greater value to energy savings associated with winter and summer peak conditions.

Barriers

While the commercial HVAC market is very mature, there has been a limited uptake of commercial heat pumps, even with the general growth of heat pumps from other HVAC markets. One of the key barriers is supply chain product availability. While many high-efficiency heat pumps have been developed in multiple HVAC product lines, they commonly need to be custom ordered, a significant challenge in terms of bringing a level playing field for heat pumps to compete with air conditioners. There also needs to be a better understanding of the installation process around the need for electrical upgrades and whether the weight of heat pump equipment would trigger a structural review. In addition, several of the "high efficiency" features are either not well-defined or not mature within the incentive ecosystem, which currently only has an IEER-rating based calculations and is unable to properly account for the performance benefits of variable-speed equipment and does not have a simple way to incentivize heat recovery. CalNEXT should continue its focus on these market barriers and look to coordinate with efforts such as CalMTA's Efficient RTU (ERTU) market transformation initiative.

Related CalNEXT Projects

- https://calnext.com/approved-projects/#ET23SWE0069
- https://calnext.com/approved-projects/#ET23SWE0054
- https://calnext.com/approved-projects/#ET23SWE0028
- https://calnext.com/approved-projects/#ET23SWE0073
- https://calnext.com/approved-projects/#ET22SWE0034
- https://calnext.com/approved-projects/#ET22SWE0023
- https://calnext.com/approved-projects/#ET22SWE0020
- https://calnext.com/approved-projects/#ET24SWE0012

Resources & 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

Large Commercial Decarbonized Designs

CalNEXT Role: Lead | CalNEXT Priority: High

Definition

A holistic design that is aimed at achieving a high-efficiency, low-emissions HVAC system in both new and existing buildings.

Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Large building all-electric design (new construction)	Research In Progress	Research In Progress	Immediate Needs	Immediate Needs
Large building all-electric design (existing buildings)	Immediate Needs	Immediate Needs	Future Research Need	Future Research Need
Standardization and interoperability of component systems (e.g. heat recovery chillers, thermal storage, and air-to-water heat pumps)	Immediate Needs	Research In Progress	Future Research Need	Future Research Need
Standardized and scalable control for all-electric and hybrid central plant operation	Immediate Needs	Research In Progress	Future Research Need	Future Research Need

KEY High Understanding | Research In Progress | Immediate Needs | Future Research Need

Opportunities

Emerging technology (ET) research in this technology family will yield strong energy efficiency (EE) savings potential and decarbonization by electrifying space heating, enabling energy recovery, or removing design barriers to future decarbonization in large commercial buildings. Prospective research should focus on:

1. Field demonstrations studies to validate the performance and cost-effectiveness in electrifying “difficult” existing building HVAC systems, such as systems using large boilers for hydronic space heating.
2. Assessment of electrical infrastructure impacts, especially for retrofit applications.
3. Technoeconomic assessment of benefits (floor area, operating cost, total cost of ownership, and TSB) relative to decarbonization solutions that rely on separate heat pumps for DHW, cooling, and heating.

4. Development of design guides (and eventually design tools) to support market actors to electrify new and existing buildings most cost effectively.
5. Data collection to support development of AWHP performance maps (could support future programs and building codes infrastructure).
6. Development of program strategies for overcoming technical and market barriers.
7. Introduction of hydronic heat pumps that can provide multiple hydronic services to a building to address efficiency and decarbonization market needs across the California multifamily and non-residential sectors.

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 research to overcome considerable technical and market barriers in transitioning these complex systems. Research is needed on cost-effectively retrofitting and electrifying HVAC systems in the existing building market, as well as understanding the appropriate program designs and deployment mechanisms to address these 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

Resources & Links

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

Commercial HVAC Equipment Installation, Operation, and Maintenance

CalNEXT Role: Lead | CalNEXT Priority: High

Definition

This technology family is focused on advancements in commissioning tools, techniques, and practices that improve the installation, operations, and maintenance of HVAC equipment. The goal is to optimize the performance and efficiency of HVAC equipment at the time of installation through quality installation practices, commissioning, and sustaining the optimal performance through continuous commissioning and maintenance.

Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Scalable technologies and approaches for quality installation and continuous commissioning	Immediate Needs	Immediate Needs	High Understanding	Immediate Needs
Tools for continuous commissioning in small to medium buildings	Immediate Needs	Research In Progress	Future Research Need	Future Research Need
Refrigerant leak mitigation	Research In Progress	Research In Progress	Immediate Needs	Future Research Need
Guideline 36 Advancement	High Understanding	Research In Progress	Immediate Needs	Immediate Needs

KEY High Understanding Research In Progress Immediate Needs Future Research Need

Opportunities

Improvements in installation, operations, and maintenance have a moderate potential for energy savings, demand flexibility, and reduction in refrigerant-related emissions. Under a 2020 Lawerence Berkely National Lab (LBNL) study, research found median simple payback time for existing building commissioning (EBCx) to be less than two years. The continued advancements within the Normalized Metered Energy Consumption (NMEC) programs means there is the potential for program delivery improvements within this technology family.

Prospective research should focus on: (1) the demonstration of low-cost approaches to existing building commissioning, continuous commissioning, and quality installation programs; (2) the demonstration of tools to help operators incorporate sophisticated asset monitoring; and (3) improvements to existing program models to improve the quality of installations, maintenance practices, and ultimately the persistence of energy efficiency measures.

Barriers

Technical understanding of installation, operations, and maintenance is mature. To date, adoption of commissioning has been mostly driven by mandatory building code requirements or voluntary code requirements such as California Green Building Standards (Title 24, Part 11) (CALGreen) or Leadership in Energy and Environmental Design (LEED) ratings. While research indicates that existing buildings still have significant cost-effective energy savings opportunities through proper installation, operations, and maintenance, deployment across building types needs to be tailored to the unique needs of each market. Initial cost also remains a significant barrier, especially for small to medium buildings. Utility incentive-based approaches may continue to be important to develop the market capabilities, while California's policy makers further assess systematic existing building policy approaches, such as the development of building performance standards.

Related CalNEXT Projects

- ET22SWE0020 – Variable Refrigerant Flow (VRF) Refrigerant Management Market Assessment

Resources & 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

Commercial Hydronic Heat Pumps

CalNEXT Role: Lead | 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

Key Research Topics	Performance Validation	Market Analysis	Measure Development	Program Development
Heat Recovery Chiller	Immediate Needs	Research In Progress	Research In Progress	Future Research Need
Air-to-Water Heat Pumps	Immediate Needs	Research In Progress	Research In Progress	Future Research Need
Software tool development to support product specification	Immediate Needs	Research In Progress	Immediate Needs	Future Research Need
Test Method Development & Validation	Immediate Needs	Research In Progress	Immediate Needs	Future Research Need

KEY High Understanding Research In Progress Immediate Needs Future Research Need

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:

1. Laboratory applications testing and field demonstration of various multifunction AWHP systems in new construction and existing buildings.
2. Measure development for heat recovery chillers and AWHPs to support partial or complete fuel substitution in large buildings.

3. Conducting cost benefit analysis of retrofitting existing buildings with VRF with hydronic systems.

Barriers

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

1. 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.
2. Load flexibility of multifunction AWHPs has not been explored. Controls that incorporate function switching, thermal energy storage (dedicated or DHW volume), and load up/shed all require data, modeling, development, and testing.
3. Early adopter approaches are often custom-engineered, site-built systems. Packaged designs are needed for design, equipment, installation, and commissioning cost compression.

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

Resources & 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 Role: Lead | CalNEXT Priority: Medium

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.

Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
2-function: Water Heating & Space Heating	Research In Progress	Research In Progress	High Understanding	Immediate Needs
3-function: Hot Water, Space Heating & Space Cooling[2]	Immediate Needs	Immediate Needs	High Understanding	Immediate Needs
Selection Guidelines	Immediate Needs	Immediate Needs	Future Research Need	Future Research Need

KEY High Understanding | Research In Progress | Immediate Needs | Future Research Need

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 (HPWH 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 lower overall refrigerants than current heat pump practices.

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:

1. Laboratory testing of MFHPs to evaluate system performance in various applications.

[2] This research initiative is not in the eTRM at this time, leading to the ranking seen.

2. Field demonstration / performance validation of MFHP in new construction and existing building applications.
3. Market assessment of MFHP for California homes, including cost and requirements associated with MFHP installation in new construction and existing buildings.
4. Assessment of the potential TSB value of MFHPs (energy performance, demand flexibility, fuel substitution, and refrigerant emissions) compared with the efficiency of single-function separate heat pump, HVAC, and water heating equipment.
5. Assessment of the bill impacts and customer economics of MFHPs (total costs of operation, operating costs under current rate structures, increased value of load shed, etc.) compared with the efficiency of single-function separate heat pump, HVAC, and water heating equipment.
6. Development of modeling tools to compare various MFHP types and guide program development and/or support early adopting market actors.
7. Understanding workforce needs related to upselling practices to customers, comfort level of installation, and maintenance needs.
8. Validation of customer amenity and confirmation that proper hot water temperature and space temperatures can be met.

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:

1. Absence of standardized testing procedures for MFHP evaluation.
2. Lack of MFHP product offerings compared to international markets, particularly those where hydronic heating is common.
3. Limited understanding of the capabilities of the MFHP system in managing occupant thermal comfort.
4. Absence of a standardized installation procedure and contractor/installer knowledge.
5. Absence of understanding of the efficiency of MFHPs compared to independent systems.
6. Need for market assessment of MFHP for California homes, including cost and requirements associated with new construction and retrofits.
7. Absence of MFHP modeling/design tools.
8. Lack of performance standards.

Related CalNEXT Projects

- ET22SWE0021 - Residential multi-function heat pumps: Product search
- Field assessment of residential three function heat pump performance
- ET22SWE0051 - Residential multi-function heat pump - heat exchanger improvement project
- ET23SWE0047 - 2023 Residential Multi-Function Heat Pump - Laboratory Testing

- ET23SWE0066 - 2023 Multi-Function Heat Pump - Lab Test Variable Speed
- ET24SWE0020 - Demonstration of “Combi” Air-To-Water Heat Pump
- ET22SWE0050 - Tech Evaluation of Air-to-Water Heat Pumps

Resources & Links

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

Residential Air-to-Air HPs and Controls

CalNEXT Role: Collaborate | CalNEXT Priority: Medium

Definition

Advancement of 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 and 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

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Connected Controls/Commissioning	Immediate Needs	Immediate Needs	Immediate Needs	Immediate Needs
Smart Thermostats	Immediate Needs	High Understanding	High Understanding	Immediate Needs
Systems and Services for Coil Cleaning	Future Research Need	Future Research Need	Future Research Need	Future Research Need

KEY High Understanding   Research In Progress   Immediate Needs   Future Research Need

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, in order to maximize their overall impact, continued efforts are needed to ensure that they are energy efficient and deployed with demand flexible capabilities. The Inflation Reduction Act's (IRA) 25C tax credit provides market support to encourage higher-efficiency products. Aside from the equipment, additional CalNEXT research should focus on ways to improve high-performing systems from itself, by validating new digital tools in support of quality installations, and by supporting deployment of quality controls to ensure systems have demand flexible capabilities and are properly compatible with the higher-efficiency variable-speed systems.

New thermostats optimized for variable capacity HVAC systems remain an untapped opportunity. To date, there has been limited performance data illustrating the performance differences, despite requests from EPA as part of the ENERGY STAR® Specification v2.0 update. New research should seek to validate the performance of variable-capacity smart thermostats to inform future product standards.

In addition, manufacturers are beginning to release tools that allow for easier commissioning, control, and troubleshooting of residential HVAC systems, often allowing a user or contractor to communicate directly with the HVAC system, even when not physically present. The use of such systems can allow for more seamless commissioning at time of installation and troubleshooting of future problems.

Barriers

Air-to-Air HPs constitute a well-researched field with mature ratings systems and testing methods. While new ratings and metrics took effect last year for a transition to EER2/SEER2/HSPF2, 2024 will continue to see additional changes, as equipment in the residential market begins to comply with CARB regulations and transition to refrigerants below 750 GWP, such as R-32 and R-454B. These new standards may continue to under-represent the benefits of variable speed equipment and other advanced features that are poorly captured under current metrics. This may be particularly important for the California market, given its predominately mild climate and low heating needs and the common oversizing practices. This can lead to uncertainty as to the real-world benefits of these products, when compared with single-speed products. Continued research will be helpful to ensure the right-sizing of products and may help programs fully account for the known benefits of high-efficiency, variable-speed products.

First cost continues to be a key driver in the residential market. Impactful new product features, such as smart thermostats and connected controls, continue to be seen as premium features. CalNEXT research validating the performance benefits may be important to support faster transfer to programs such as TECH Clean California, as well as statewide IOU programs such as Comfortably California or the Statewide Quality Residential HVAC Services program.

Related CalNEXT Projects

- https://calnext.com/approved-projects/#ET22SWE0022
- https://calnext.com/approved-projects/#ET23SWE0024
- https://calnext.com/approved-projects/#ET23SWE0063
- https://calnext.com/approved-projects/#ET23SWE0053

Resources & 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
- 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

Commercial Scalable Thermal Storage

CalNEXT Role: Collaborate | CalNEXT Priority: Medium

Definition

Heat energy-based systems in commercial buildings capable of decoupling the coincident time of HVAC loads and HVAC energy input. Commercial, scalable thermal storage systems can reduce peak demand and shift energy inputs to a time period when electric grid power is lower cost and less GHG-intensive, with either greater or lesser energy efficiency. Scalable systems have been implemented in commercial or residential building applications, could be implemented in larger sizes and higher percentages of building projects, and have the potential for innovative improvements in terms of load shift, efficiency, and cost-effectiveness.

Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Hot Water hydronic thermal storage	Research In Progress	Immediate Needs	Future Research Need	Future Research Need
Cold water/ ice hydronic thermal storage	High Understanding	Research In Progress	Immediate Needs	Future Research Need
Building mass thermal storage	Immediate Needs	Immediate Needs	Future Research Need	Future Research Need

KEY High Understanding Research In Progress Immediate Needs Future Research Need

Opportunities

Incorporating thermal storage into HVAC systems has the potential for significant demand flexibility and can reduce the energy consumption, by shifting the HVAC cooling and heating loads to periods with a lower energy cost and less GHG-intensive energy supply. Thermal storage can reduce peak demand by spreading heating and cooling loads over longer periods of time and by shifting to non-peak hours. Commercial thermal energy storage can also support decarbonization by allowing electric heat extraction and heat rejection systems (e.g., air-to-water HPs, heat recovery chillers, etc.) to serve the non-simultaneous heating and cooling loads commonly found in larger HVAC systems. Prospective emerging technology studies should build upon the ongoing research of the CA IOU CASE Team on this topic, as well as pursue lab and field demonstrations with a viable path to scalability. As this is an emerging technological space, there is a need for new market studies to characterize different emerging product types and their uses for commercial building types and HVAC system typologies.

Barriers

Significant technical and market barriers exist, including a higher capital cost, an added complexity of design and controls, additional space requirements for equipment, added risk of equipment failure, and the need for additional cross-trade coordination. Technical and market barriers can be addressed with packaged product solutions and application guidance for designs, installers, and operators. Thermal storage ideas and projects should identify barriers and provide strategies for mitigating or removing such barriers.

Related CalNEXT Projects

- https://calnext.com/approved-projects/#ET23SWE0059 (Water Heating)
- https://calnext.com/approved-projects/#ET23SWE0041
- https://calnext.com/approved-projects/#ET23SWE0022
- https://calnext.com/approved-projects/#ET23SWE0071
- https://calnext.com/approved-projects/#ET22SWE0050

Resources & Links

- https://title24stakeholders.com/measures/cycle-2025/nonresidential-hvac-space-heating/

Discussion

Following submittal of the 2024 HVAC TPM, the Program Team will do the following:

- Update CalNEXT website with new 2024 HVAC TPM and this Final Report.
- Launch email announcement through email outreach.
- Develop and submit Distribution Report.

Appendix A: Advisory Committee Feedback & Resolution Matrix (Incorporated in the Draft Report)

Table 4: Advisory Committee Feedback & Resolution Matrix

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Micro Heat Pumps	Definition	Suggest also investigating condensate management.	The manufacturers are using novel means to manage the condensate with a pump for drip-free melt water atomization and/or dispersion of water into the internal air or outside air. This enhances the relative humidity of the internal air, which is a welcome change in cold external ambient conditions.
Micro Heat Pumps	Research Initiatives	Will this research include single duct and dual duct systems?	The research should be "inclusive" of any variant or form factors.
Micro Heat Pumps	Opportunities	Suggest the deployment cost include infrastructure cost for a dedicated 120V receptacle/ circuit if required by code for these products.	The saddle units are Do-It-Yourself (DIY), while others may require infrastructure costs.
Micro Heat Pumps	Narrative	High priority technology family for CPUC.	Note received – these are indeed prime candidates.
Residential Air-to-Air HPs and Controls	Definition	Does this include onboard diagnostics/ FDD?	Yes, onboard diagnostics will be considered as part of connected controls.
Residential Air-to-Air HPs and Controls	Definition	Cost of these systems has precluded significant update, so suggest review of controls costs vs. benefits and alternatives, e.g. regular maintenance check-ups.	Noted, however maintenance checkups are already a best practice and may be something that many homeowners do. Would need to understand what current practice is in terms of maintenance frequency to conduct this analysis.
Residential Air-to-Air HPs and Controls	Narrative	Can you clarify if the compatible manufacturer thermostats "smart"/ connected?	Unclear what this question is asking and will connect with the stakeholder further.

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Residential Air-to-Air HPs and Controls	Research Initiatives	Is Low-GWP refrigerant research based on AHRI data sufficient for estimating performance and potential savings impacts? How can this research address any performance rating data shortcoming so these systems can be accurately and confidently included into the EE portfolio?	Residential systems are subject to the same test procedures and ratings regardless of refrigerant used, so savings impacts between different refrigerants can still be captured using existing frameworks. More research may be needed if functions like variable capacity operation are to be considered.
Commercial Air-to-Air HPs and Controls	Definition	It seems there is a significant need within this research topic to address the deficiency of prototype models to accurately simulate zones that benefit from VRF heat recovery.	Agree, for new construction specifying VRF that an energy model could inform the benefit of heat recovery module or optimal zone layout for simultaneous heating and cooling.
Commercial Air-to-Air HPs and Controls	Narrative	High priority technology family for CPUC.	Note received.
Commercial Air-to-Air HPs and Controls	Research Initiatives	Curious why Res Heat Pumps includes controls in the title, but this does not? According to LBNL/DOE "94% of commercial buildings are less than 50k sq. ft. and only 5% of those buildings have smart thermostats", so it seems like a big opportunity for commercial RTUs as well.https://betterbuildingssolutioncenter.energy.gov/sites/default/files/slides/The%20Next%20Big%20Thing%20-%20Slides.pdf In addition to thermostats, cutover/resistance backup and defrost controls for heat pump RTUs need more research and have potential for improvement.	Agree that this presents a good opportunity, however there may be overlap with the Commercial IOM TPM.

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Commercial Air-to-Air HPs and Controls	Definition	This is confusing because it says **over** 5.4 tons **or smaller**, so it sounds like you are referring both to equipment over 5 tons and under 5 tons — is that the intention? Or only over 5.4 tons? CalMTA is focused specifically on **single-zone** commercial RTUs, not as much on capacity as a defining factor.	"Or smaller roof top units." The intent was to differentiate between commercial air to air heat pump equipment and more residentially typical mini splits. Trying to exclude those from this family. Consider new wording.
Commercial Air-to-Air HPs and Controls	Definition	I don't know if this is where the prioritization occurs, but at some point, it seems like it's important to distinguish between VRF and HP RTUs in order of priority. I would suggest focusing on heat pump RTUs because it's so much easier to shift from mixed fuel RTU to heat pump RTU vs. VRF + DOAS, and that is setting aside concerns about refrigerant leakage from VRF. Dealing with that issue and/or fire safety from semi-flammable refrigerants makes it even harder to implement VRF right now. But I agree about E/HRV as a high priority alongside of and synergistic with HP RTUs.	RTUs are listed as the first Research Initiative and the priority on RTUs is also noted in the opportunities section.
Commercial Air-to-Air HPs and Controls	Definition	This sort of implies electrical service upgrades at the site, which is important to avoid/address. However, it seems like this should include strategies to avoid broader impacts to T&D (and eventually the grid) as more buildings electrify. Every service upgrade at the site level contributes to	Agree, that the infrastructure impact of electrifying heating loads needs to be evaluated on a site-by-site basis.

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
		the eventual need for T&D upgrades and grid impacts.	
Commercial Air-to-Air HPs and Controls	Opportunities	BAAQMD zero NOx rule 9-4. CARB zero NOx appliance rulemaking.	The rulemaking for furnaces takes effect in 2029 and may be considered in future TPMs.
Commercial Air-to-Air HPs and Controls	Opportunities	Maybe add "heat pump" here? The statement is probably true either way, but I think CalNEXT wants to focus on heat pump RTUs specifically, right? I think there are unique set of challenges in the market for heat pump RTUs, so it would be good to clarify that focus.	I think the intended comment was to add "roof top unit" to the first sentence of the opportunities section. This can be called out specifically if that is the intended focus.
Commercial Air-to-Air HPs and Controls	Opportunities	Refrigerant leak detectors will be required on A2L refrigerant systems according to my contact at HARDI. I think any such regulations are going to be much more challenging for VRF than RTUs, given the amount of refrigerant and opportunities for leakage with refrigerant lines running throughout the building. And reconciling CalFire concerns about mildly flammable refrigerants make it even harder. For now, it seems like focusing on how to improve RTUs (e.g. integrating ERV) is probably a better place to focus.	Noted and being executed following the 2024 HVAC TPM Final Report submittal as a dissemination strategy, to be incorporated in the 2025 HVAC TPM revision process.
Commercial Air-to-Air HPs and Controls	Opportunities	Even if we are successful in doing this, VRF + DOAS is really only practical for new construction or buildings that don't already have an RTU. Makes more	Building and existing building specific. This could be supported by research project.

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
		sense to invest in heat pump RTUs.	
Commercial Air-to-Air HPs and Controls	Opportunities	Strongly agree and this is proven out by the Code Readiness DOAS field studies, most of which had heat recovery DOAS and very flat load profiles. More research is needed on ERVs in RTUs to confirm the same load-flattening benefit, but the same idea generally applies.	Noted and being executed following the 2024 HVAC TPM Final Report submittal as a dissemination strategy, to be incorporated in the 2025 HVAC TPM revision process.
Commercial Air-to-Air HPs and Controls	Barriers	More extreme climate?	What is the suggestion related to climate? HVAC SME team is clarifying for the Final Report.
Commercial Air-to-Air HPs and Controls	Barriers	Cost? minimum code A2L systems may be 10-15% more expensive. If you want higher efficiency then expect even greater incremental cost. Also split incentives. If units are heavier, added weight may trigger structural engineering review. Agree that cost is a potential barrier but CalMTA still assessing the drivers of overall installed cost for efficient HP RTU. Weight may or may not be a factor. As mentioned in the intro paragraph electrical capacity at the site might be a bigger barrier that needs to be mitigated (and should probably be listed again in the barriers section).	Yes, efficient option will present an increased incremental cost over standard equipment. Agree that electrical infrastructure should be added as a potential barrier.
Commercial Air-to-Air HPs and Controls	Barriers	I believe a big barrier to long-term performance of efficient heat pump RTUs	Applies to all equipment. This concept is expanded upon in Commercial HVAC Equipment

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
		is related to installation and maintenance. More efficient equipment is generally more complex so more can go wrong during or after installation. We also don't really know how well heat pump RTUs are going to perform over the long term, especially how much they rely on backup heating, which is also a factor of how they are installed and maintained.	Installation, Operation, and Maintenance.
Commercial Air-to-Air HPs and Controls	Barriers	Possible point for collaboration on creating shared definitions to ensure we're pulling the market in the same direction.	Agree on need to collaborate with entities like CalMTA.
Commercial Air-to-Air HPs and Controls	Barriers	Do we see a pathway for this, or how are we accounting for this in our modeling?	Yes, CalMTA is modeling variable speed compressors separately from / in addition to EER/IEER, so they are able to model it, there just isn't a simple way for the market to differentiate the benefits.
Commercial Air-to-Air HPs and Controls	Barriers	CalNEXT — I think the new IVEC and IVHE metrics are supposed to do a better job of this but won't go into effect until 2029. Need to think about what can be done between now and then.	Noted and being executed following the 2024 HVAC TPM Final Report submittal as a dissemination strategy, to be incorporated in the 2025 HVAC TPM revision process.
Large Commercial Decarbonization Designs	Definition	Consider scoping a literature search…TES or other case studies?	Noted and being executed following the 2024 HVAC TPM Final Report submittal as a dissemination strategy, to be incorporated in the 2025 HVAC TPM revision process.
Large Commercial Decarbonization Designs	Narrative	Are there existing projects identified to study?	Three CalNEXT studies have been added to the narrative regarding this technology family.

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Large Commercial Decarbonization Designs	Research Initiatives	This seems most applicable to custom measures, less so towards deemed savings measures. Might be good to engage with the CPUC custom staff and DNV Group D staff as well on this.	Noted and being executed following the 2024 HVAC TPM Final Report submittal as a dissemination strategy, to be incorporated in the 2025 HVAC TPM revision process.
Commercial Scalable Thermal Storage	Narrative	Suggest coordinating with SGIP.	Noted and being executed following the 2024 HVAC TPM Final Report submittal as a dissemination strategy, to be incorporated in the 2025 HVAC TPM revision process.
Commercial Scalable Thermal Storage	Opportunities	I'm not sure if this is meant to include RTUs but would like to understand potential and whether integrated TES should be part of the long-term MT goal for HP RTUs. If so, it seems like a solution to shift load during both heating and cooling season is needed for HP RTUs.	The technology family is intended to include any technology and application with potential to perform at scale.
Commercial HVAC Equipment Installation, Operation, and Maintenance	Opportunities	Perhaps include the significant and well documented issues with economizers failing to perform as designed. https://www.etcc-ca.com/reports/code-readiness-rtueconomizer-analysis-and-field-assessment.	Specific RCx measures were not called out. Should this one be added specifically? It is assumed this one of the top obvious measures that is evaluated for operations.
Commercial HVAC Equipment Installation, Operation, and Maintenance	Definition	Suggesting investigating cost and savings, as prior commercial QM offerings have struggled with low saving relative to measure costs.	Agree and hope this would be addressed in a research initiative

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Residential Multifunction Heat Pumps	Opportunities	Wider potential for adoption of systems that provide space cooling as well vs. just space and DHW heating.	Agree but wanted there to be room in the program to look at combi systems (heating and DHW) as a potential area of interest for climates without cooling demand (i.e. CZ1)
Commercial Hydronic Heat Pumps	Definition	Suggest including a literature review of existing case studies.	Noted and being considered for the Final Report deliverable after further discussion with the SME team.
Commercial Hydronic Heat Pumps	Opportunities	Investigate potential given limited applications that have simultaneous heating and cooling loads that take advantage of heat recovery chillers.	Noted and being considered for the 2025 HVAC TPM revision update.