Performance Metrics of Micro Heat Pumps Through Laboratory Testing

Final Report

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Executive Summary

This project collected comprehensive heating and cooling performance data on commercially available micro heat pumps in a Nationally Recognized Testing Laboratory, expanding on the performance data collection efforts from completed CalNEXT project ET23SWE0034. Micro heat pumps are self-contained units that plug into standard 110/120-volt National Electrical Manufacturers Association 5-15 outlets—without requiring field-installed refrigerant lines. They come with inverter-driven, variable-speed compressors that can provide space cooling and heating in both single-family and multifamily buildings. Additionally, these units can operate in ambient temperatures from 115^{0}F to below 5^{0}F, ensuring reliable cooling and heating performance in all 16 California climate zones for spaces up to 1,000 square feet. This new generation of technology has the potential to rapidly displace in-unit gas-fired furnaces, window air conditioners, and electric resistance space heaters by avoiding many of the cost barriers associated with the design, installation, and permitting requirements of traditional heat pumps.

Testing focused on heating and cooling performance of micro heat pumps, with specific focus on capacity and efficiency, as well as dehumidification performance. Several industry organizations have evaluated technology capabilities and developed specifications for energy efficient products; a Nationally Recognized Testing Laboratory tested four micro heat pump units with various form factors—including saddle, window, and through-the-wall—and followed the test plan based on some of those specifications, further detailed in Appendix A.

A summary of the project's key findings and recommendations is below, and the project team encourages interested parties to pursue additional field and laboratory evaluations to validate this project's findings:

1. **Cooling performance:** The average decrease in performance across all tested MHP samples was 8 percent for the Combined Energy Efficiency Ratio and 3 percent for the Energy Efficiency Ratio, at adjusted evaporator inlet temperatures of 75°F dry-bulb and 63°F wet-bulb. With these results in mind, the California Electronic Technical Reference Manual could slightly increase the rated Combined Energy Efficiency Ratio criteria to help offset the observed performance decrease at California-specific indoor temperatures. Results from this testing could also be used to support Energy Efficiency Ratio as a requirement for other space conditioning products to mitigate peak demand.

2. **Heating performance:** Two of the four tested micro heat pumps were able to satisfy most criteria prescribed in the draft or final specifications issued by the Consortium for Energy Efficiency or US Environmental Protection Agency. However, one high efficiency system did not meet the Environmental Protection Agency's Version 7.0, Draft 1 criterion on the Heating Energy Efficiency Ratio. The project team recommends program administrators consider heating performance levels that appropriately balance both energy savings and affordability.

3. **Dehumidification performance:** Although several California climate zones are predominantly driven by sensible cooling loads, the warm marine region—which contains approximately 28 percent of California's zip codes—requires significant latent cooling in single-family buildings. The Sensible Heat Ratio and standard cubic feet per minute per ton are well established metrics in other industry test procedures; this presents program administrators with an

opportunity to prioritize dehumidification performance for consumers without unduly increasing test burden on the industry.

4. **Test chamber:** The Environmental Protection Agency's room heat pump and packaged terminal heat pump test methods provide manufacturers with the option to choose between calorimetric or psychrometric chambers. Appendix F to Subpart B of Part 430, Title 1 of the Code of Federal Regulations currently requires room heat pumps to be tested in a calorimeter chamber, so a manufacturer attempting to test, rate and certify Combined Energy Efficiency Ratio and Heating Energy Efficiency Ratio metrics will likely test the product in both chamber types. Industry and interested parties should consider approaches to help reduce test burden.

This project and other data collection efforts are crucial in developing energy modeling performance maps of micro heat pumps across multiple form factors and could support the development of a deemed measure in subsequent projects. Ultimately, this project aims to lay out the technical groundwork needed for California investor-owned utilities to provide incentives for this rapidly emerging technology.

Abbreviations and Acronyms

Abbreviation/Acronym	Meaning
ACEEE	American Council for an Energy-Efficient Economy
AHAM	Association of Home Appliance Manufacturers
AHRI	Air-Conditioning. Heating, and Refrigeration Institute
Btu/hr	British thermal units per hour
CAC/HP	Central air conditioners and heat pumps
CFR	Code of Federal Regulations
CalMTA	California Market Transformation Administrator
CEC	California Energy Commission
CEE	Consortium for Energy Efficiency
CEER	Combined Energy Efficiency Ratio
CH4A	Clean Heat for All
COP	Coefficient of Performance
CVP	Controls verification procedures
DAC	Disadvantaged community
DOE	US Department of Energy
EER	Energy Efficiency Ratio
EPA	US Environmental Protection Agency
eTRM	Electronic Technical Reference Manual
GWP	Global warming potential

Abbreviation/Acronym	Meaning
HEER	Heating Energy Efficiency Ratio
HP	Heat pump
HSPF2	Heating Seasonal Performance Factor 2
HVAC	Heating, ventilation, and air conditioning
IOUs	Investor-owned utilities
kWh	Kilowatt-hour
LADWP	Los Angeles Department of Water and Power
L/kWh	Liters per kilowatt-hour
MHP	Micro heat pump
NCLC	National Consumer Law Center
NEEA	Northwest Energy Efficiency Alliance
NEMA	National Electrical Manufacturers Association
NRTL	Nationally Recognized Testing Laboratory
NYCHA	New York City Housing Authority
NYPA	New York Power Authority
NYSERDA	New York State Energy Research and Development Authority
PAC	Portable air conditioner
RAC	Room air conditioner
SACC	Seasonally Adjusted Cooling Capacity
SCFM	Standard cubic feet per minute
SEER2	Seasonal Energy Efficiency Ratio 2

Abbreviation/Acronym	Meaning
SERC	Super-efficient room conditioner
SHR	Sensible Heat Ratio
T20	Title 20 of the California Energy Code
V	Volt

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Introduction

Micro heat pumps (MHPs) offer significant potential to rapidly electrify space heating and simultaneously replace existing space heaters and/or less efficient room air conditioners (RACs) with more efficient heat pumps (HPs). The overall objectives of this project are to collect comprehensive laboratory test data on the heating and cooling performance and investigate the dehumidification performance of MHPs. This effort builds on the data collected through the completed CalNEXT project ET23SWE0034, "Emerging 'Micro' Heat Pumps: Modeling, Testing, and Space-Conditioning Performance Metrics." Future efforts may leverage data from this project to inform relevant standards and specifications, and to support the development of a measure package in the California Electronic Technical Reference Manual (eTRM) that enables incentives and rebate programs in California.

In pursuit of California's ambitious goal of installing six million HPs by 2030, MHPs can revolutionize the building electrification space. MHPs are self-contained units that plug into standard 110/120-volt (V) National Electrical Manufacturers Association (NEMA) 5-15 outlets—without requiring field-installed refrigerant lines. They come with inverter-driven, variable-speed compressors that can provide space cooling and heating in both single-family and multifamily buildings. Additionally, these units can operate in ambient temperatures from 115^{0}F to below 5^{0}F, ensuring reliable cooling and heating performance in all 16 California climate zones for spaces up to 1,000 square feet. They are available in various form factors, including saddlebag, through-the-wall, window, and portable.

MHPs can be installed by the owner or renter without the need for a contractor, and cost significantly less than traditional heating, ventilation, and air conditioning (HVAC) retrofit systems. They can address similar heating loads satisfied by decarbonizing gas-fired heating appliances and electric resistance space heaters across California; additionally, MHPs could be particularly impactful in disadvantaged communities (DACs) by providing a lower-cost pathway to electrification. Among other benefits, they also offer the potential for improved thermal comfort and indoor air quality.

While some cooling data is available for constant-speed window HP systems, performance data on variable-capacity MHPs for both heating and cooling metrics is largely missing from product literature, and the limited HP offerings relative to air conditioner models make it challenging for consumers to distinguish between reverse cycle models and models with auxiliary heating components.[1] The completed CalNEXT project ET23SWE0034 was the first of its kind to conduct laboratory performance testing of MHP units in a Nationally Recognized Testing Laboratory (NRTL). Due to the emerging nature of this product and many unknowns, the ET23SWE0034 project faced significant challenges in data collection. The project team tested one saddle-form MHP prototype, one commercially available portable HP, one constant-speed window unit, and two through-the-wall MHPs using the US Environmental Protection Agency (EPA) room HP heating test method. This project expands on the performance data collection efforts from CalNEXT project ET23SWE0034,

[1] The project team's review of the US Department of Energy's Compliance Certification Database and overall industry shipments suggests that only 1 percent to 2 percent of current basic models distributed in commerce are reverse-cycle MHPs.

focusing on heating and cooling performance—specifically capacity and efficiency—while following the previously developed test plan and addressing dehumidification performance.

The current effort to collect additional laboratory performance data on MHPs will be crucial to developing energy modeling performance maps of MHPs across multiple form factors and could support the development of a deemed measure in subsequent projects. Ultimately, this project aims to lay the technical groundwork needed for California investor-owned utilities (IOUs) to provide incentives for this rapidly emerging technology.

Background

MHPs entering the US market could potentially address critical barriers, including the high costs of electrification, the lack of skilled labor, limited electrical capacity within existing electric panels, and the split-incentive challenge—and many of these barriers are especially significant for people in DACs. This new generation of technology has the potential to rapidly displace in-unit gas-fired furnaces, window air conditioners, and electric resistance space heaters by avoiding many of the cost barriers associated with the design, installation, and permitting requirements of traditional HPs.

MHPs represent a new pathway that could support initiatives addressing whole-building electrification. Until recently, most commercially available room air conditioners (RACs) and portable air conditioners (PACs) were cooling-only models, with a small selection providing heating through electric resistance. However, HP options without auxiliary electric resistance heaters are increasingly emerging in the market.

The California market for MHPs in single-family and multifamily residences is unique, driven by technological advancements and increased consumer comfort. Fortunately, HVAC is a well-established industry with deep expertise across manufacturers, distributors, designers, retailers, installers, contractors, technicians, and other professionals. While MHP is an emerging technology, several manufacturers are entering the market for this equipment type.

California IOUs are well positioned to offer rebates and incentives that could accelerate the uptake of energy efficient HVAC systems, including MHPs. These programs would help offset the initial cost—which is often a barrier for homeowners especially those within DACs—and make these systems more accessible.

MHP Form Factors

MHPs support a wide range of existing space conditioning designs and needs in residential buildings, as detailed in Table 1. All in-unit MHPs currently available for sale in the United States are single-package systems.

Table 1: Summary of MHP form factors.

MHP Form Factor	Installation Details	Notable Characteristics	Image†
Saddle Window HP	This unit straddles the windowsill, with an evaporator and fan sitting on the inside of the building and the compressor sitting on the outside of the building.	• Offers a high Coefficient of Performance (COP) in lower ambient temperatures • Quiet design • Low profile	
Portable HP	This portable, encased assembly includes ducted configurations to discharge heat rejected by the condenser coil during cooling mode, while the condenser coil absorbs heat from the unconditioned space air during heating mode.	• Already popular in California • Lower upfront cost • Easy to move from one room to another • Takes up floor space • Often noisy while running	
Through-the-Wall HP	Manufacturers rate this product as a single-package central HP (other than space-constrained).	• More intensive installation that requires professional installers • Easier to install than a central system • Ideal for saving space in any area with open walls • Quiet design	
Window HP (Room HP)	This unit is installed directly inside the window frame. It provides both cooling and heating.	• Simple installation, but risk of falling if not secured properly • Low upfront cost • Obstructs part of the window while installed • Inner wall and insulation, vibration isolation, or optimized air duct designs mitigate operating noise	

†Photos: Gradient, Friedrich and Ephoca.

MHP Types

In July 2024, the EPA published the Final Test Method to determine RAC heating mode performance, which categorizes room HPs into following types:

- **Type 1 HP:** A room HP that does not have active defrost, or for which the specified compressor cut-in and cut-out temperatures are both no less than 40°F.
- **Type 2 HP:** A room HP that has active defrost, and for which the specified compressor cut-in and cut-out temperatures are both less than 40°F but both no less than 17°F.
- **Type 3 HP:** A room HP that has active defrost, and for which the specified compressor cut-in and cut-out temperatures are both less than 17°F but both no less than 5°F.
- **Type 4 HP:** A room HP that has active defrost, and for which the specified compressor cut-in and cut-out temperatures are both less than 5°F.

As discussed in completed CalNEXT project ET23SWE0034, MHPs with variable-speed compressors that provide heating at lower temperatures were typically available in Type 4, although Type 3 models have been introduced into commerce since the publication of the report in late 2024. Type 1 MHPs are typically single-speed air conditioners, while Type 2 MHPs were not commercially available at that time.

In 2024, the ET23SWE0034 project team selected Type 1 and Type 4 units for project testing to compare the performance of variable-speed units with a baseline single-speed unit. For ET23SWE0034, the project team tested products using the ENERGY STAR® test method for RAC heating mode performance and calculated region-specific heating performance values using a combination of laboratory testing results and energy modeling for California-based climate zones and property types. The report summarized cooling capacities; cooling energy efficiency ratios; heating capacities and heating Coefficients of Performance (COP) at certain outdoor test conditions; calculated seasonal metrics, such as Heating Energy Efficiency Ratio (HEER), Heating Seasonal Performance Factor 2 (HSPF2), and Combined Energy Efficiency Ratio (CEER); and the installed HEER and installed HSPF2 values based on the California-specific climate zone.

For this phase of testing, the project team selected one Type 1 unit, one Type 3 unit, and two Type 4 units from various manufacturers to investigate the heating, cooling, and dehumidification performance, the results of which are detailed in the Results section of this report.

Published Specifications and Testing Initiatives

The MHP market has been developing quickly over the past decade and especially in the last few years. While cooling potential remains an important factor, there have been advancements in technology that allow for greater heating potential than initially expected for this product class, and more products across a variety of form factors have come into the market. Stakeholders across the industry—including the US Department of Energy (DOE), the EPA, New York State Energy Research and Development Authority (NYSERDA), California Market Transformation Administrator (CalMTA), manufacturers, and energy efficiency advocates—have been involved in assessing the state of the market for specifications and energy savings potential. The section below details specification development, notable advancements, and the applicable federal standards for MHPs.

New York Clean Heat for All (CH4A) Challenge

In December 2021, the New York City Housing Authority (NYCHA)—in collaboration with New York Power Authority (NYPA) and NYSERDA—launched their Clean Heat for All (CH4A) global innovation challenge to engage manufacturers in developing novel HP technologies to further progress on the NYCHA Sustainability Agenda. The agenda aims to decarbonize NYCHA buildings and reduce emissions from buildings by 40 percent by 2030 as a steppingstone to 80 percent greenhouse gas emissions reductions by 2050.

For this challenge, NYCHA sought standalone room HPs that can be installed in occupied apartments with limited tenant disruption, no field-installed refrigerant piping, no major electrical upgrades, and no skilled labor required for installation. The units would have to provide adequate heating for buildings in Climate Zones 4 and 5, the coldest regions within most of the continental United States.

Following an initial performance validation, NYCHA committed an initial $70 million through this innovation challenge to conduct scaled deployments for the chosen units (NYPA 2022b). In February 2022, NYCHA released their request for proposal to industry, which detailed several requirements, all aimed to rapidly decarbonize their multifamily housing stock at-scale. Table 2 provides a summary of CH4A key product requirements; the high potential retail price remains a barrier, as the low-cost models previously available did not provide enough heating to meet NYCHA's requirements—for example, some of these low-cost models use electric resistance, while others cannot heat below 40°F.

Table 2: CH4A key product requirements.

Attribute	Specification
Retail Price	$3,000 per unit maximum
Electrical Requirements	120 VAC, standard 3-prong (NEMA 5-15), 15A outlet
Cooling Capacity	9,000 BTU/h at 95°F OAT
Heating Capacity	9,000 BTU/h at 17°F OAT
Heating Efficiency	1.85 COP at 17°F OAT
Heating Operating Range	Shall operate down to 0°F or below (shall not use electric resistance)
Compressor Type	Shall have variable speed compressor
Noise	Shall not exceed 50dB on low fan mode
Installation Requirements for: Condensate Management,	Drainage for condensate (meltwater) shall not require a plumber.

Attribute	Specification
Refrigerant, Install Procedure, & Install Time	All refrigerant piping shall be hermetically sealed to minimize risk of refrigerant leaks.
	Shall not require drilling through exterior wall
	Installation must not exceed 2 hours.

Note: Identical requirements were incorporated into the CEE SERC initiative. *Source:* (NJYPA (New York Power Authority) 2022)

CH4A received six entries and chose one product from Midea America, alongside one product from Gradient Comfort for field demonstration. Both units deliver a nominal capacity of 9,000 British thermal units per hour (Btu/hr) down to 17°F, provide low ambient heating operation down to manufacturer-claimed -13°F, include integrated condensate removal mechanisms, and use R-32 refrigerant. Thirty-six units from each manufacturer—72 total—were installed in 12 typical NYCHA apartments, which were distributed throughout two buildings with identical layouts in Woodside, Queens, New York City. Prior to the installation of the room HPs, a central gas-fired steam boiler plant supplied heat to each building. During installation, the team disconnected and removed radiators in each apartment and shut off the steam risers, which were previously used to heat the bathrooms.

As a result of CH4A's project (the results of which are detailed below in Table 3), NYCHA concluded that the existing electrical infrastructure of these apartments adequately supported the installation of room HPs; additionally, the site's realized peak loads were lower than NYCHA's initial design calculation predictions. Additionally, per-unit demand peaks were lower in cooling mode, with overall power consumption significantly lower in cooling season than during the heating season.

Overall, the CH4A project provided a field study that indicates room HPs are a viable heating solution for residential apartments, with NYCHA stating, "…[Room heat pumps] offer a promising approach for electrifying NYCHA's housing. Although beyond the scope of this specific project, we believe these results also suggest broader viability in non-NYCHA multifamily, residential, and certain commercial buildings." Room HPs can reliably maintain comfortable indoor temperatures in the field during both heating and cooling seasons. Lab and field testing indicates that the units meet their efficiency targets, and residents surveyed as part of this study expressed a strong preference for room HPs over the previous steam system.

Table 3: CH4A heating and cooling performance data.

Performance Metric	Midea	Gradient
Heating Performance Data, *October 15, 2023 - April 26, 2024*		
Average Indoor Temperature	75.6°F	73.4°F
Min Indoor Temperature	64.3°F (unused near bedroom)	58.4°F (unused near bedroom)
Apartment Heating Power Consumption	Max: 4,343 kWh	Max: 2,714 kWh
	Avg: 1,465 kWh	Avg: 1,804 kWh
	Min: 283 kWh	Min: 1,177 kWh
Maximum Peak Power Draw	1.79 kW/UNIT (3.99 kW/apt)	1.31 kW/PWHP (2.94 kW/apt)
Average Peak Power Draw	1.08 kW/UNIT (2.46 kW/apt)	0.92 kW/UNIT (2.05 kW/apt)
Cooling Performance Data, *May 28 - July 31, 2024*		
Average Indoor Temperature	77.5F	75.2F
Apartment Heating Power Consumption	Max: 765 kWh	Max: 1,212 kWh
	Avg: 434 kWh	Avg: 615 kWh
	Min: 114 kWh	Min: 83 kWh
Maximum Peak Power Draw	1.29 kW/UNIT (2.88 kW/apt)	0.94 kW/UNIT (2.15 kW/apt)
Average Peak Power Draw	0.66 kW/UNIT (1.50 kW/apt)	0.73 kW/UNIT (1.74 kW/apt)
General Performance Data, *October 15, 2023 – July 31, 2024*		
Air Leakage Change (CFM@75 Pa, pre-post install)	-52 to +26	-26 to +36
Noise Levels (heating/cooling, high fan, dB)	48.3 +/- 1.5	54.2 +/- 0.6

Performance Metric	Midea	Gradient
Installation Time (2-person crew) - Unboxing	5–10 minutes	5–10 minutes
- Remove existing, clean area	15-20 minutes	15–20 minutes
- Mount Bracket	5 minutes	5–10 minutes
- Mount HP	5–10 minutes	20–30 minutes
- Air seal install	15 minutes	--
Total Installation Time	45–60 minutes	45–70 minutes

Consortium for Energy Efficiency Initiatives

SUPER-EFFICIENT ROOM CONDITIONER (SERC) INITIATIVE

In February 2022, the Consortium for Energy Efficiency (CEE) released their Super-Efficient Room Conditioner (SERC) Initiative, which defined the opportunities of this new class of products and brought broader exposure to the efforts from New York's CH4A. CEE is a consortium of utility program administrators in North America, with a long track record of collaboration among its members and a mission to help program administrators meet their energy savings targets. The SERC Initiative was developed with support from NYPA and mirrored the requirements of the CH4A Specification, with the intent to support future incentive programs. With the passage of the Inflation Reduction Act of 2022, CEE's standard initiatives were given added market importance by connecting the CEE-defined efficiency tiers to an expanded Residential Energy Efficiency Tax Credit that included high efficiency HPs (CEE (Consortium for Energy Efficiency) 2024) (CEE (Consortium for Energy Efficiency) n.d.) (IRS 2024).

CEE SPECIFICATIONS FOR CENTRAL AIR CONDITIONERS AND HEAT PUMPS

The CEE announced key updates to the residential electric HVAC specifications, with the aim of making energy efficient options more accessible. They collaborated with the DOE and industry, including the Association of Home Appliance Manufacturers (AHAM), to validate models and develop specifications. The CEE simplified the specification structure to make the process easier for both contractors and consumers, offer flexibility to cater to unique building and climate needs, encourage market transformation, and create a foundation for future demand flexibility.

These specifications became effective on January 1, 2025, and are detailed in Table 4 below. The 25C Home Energy Efficiency Improvement Tax credit was available through December 31, 2025 (Air Source Heat Pump Collaborative 2025).

Table 4: CEE air-source heat pumps specifications.

	CEE Level	SEER2	EER2	HSPF2	COP at 5°F	Capacity Ratio
2025 CEE Split ASHP Specification	CEE Tier 1 – Path A	≥16	≥9.8	≥8.5	≥1.75	≥ 60% at 5F/47°F
	CEE Tier 1 – Path B	≥16	≥11	≥8.0	≥1.75	≥ 45% at 65F/47°F
	CEE Advanced Tier			Refer to the DOE Cold Climate Heat Pump Challenge Specification		
2025 CEE Packaged ASHP Specification	CEE Tier 1	≥ 15.2	≥ 10.0	≥7.2	≥1.75	≥ 45% at 5F/47°F

DOE Energy Conservation Standards

ROOM AIR CONDITIONERS

The most recent DOE standard for RACs was adopted in 2023, with compliance required on and after May 26, 2026. Covered products include consumer products—other than packaged terminal air conditioners—that are powered by a single-phase electric current and designed as an encased unit for mounting in a window or through the wall with a prime cooling source; some products also include heating.

RACs' efficiency and capacity must be tested in accordance with the DOE test method specified in the Code of Federal Regulations (CFR), Appendix F, Subpart B of Part 430, Title 10. RAC efficiency is rated using a CEER, which is expressed in British thermal units per watt-hour. Table 5 shows the current energy conservation standards for RACs with a reversing cycle—also referred to as room heat pumps.

Table 5: DOE energy conservation standards for RACs.*

Equipment Class	CEER (Btu/Wh)
With Reverse Cycle, with Louvered Sides, and Less Than 20,000 Btu/h	14.4
With Reverse Cycle, Without Louvered Sides, and Less Than 14,000 Btu/h	13.7
With Reverse Cycle, with Louvered Sides, and 20,000 Btu/h or More	13.7
With Reverse Cycle, Without Louvered Sides, and 14,000 Btu/h or More	12.8

Equipment Class	CEER (Btu/Wh)
Casement-Only†	13.9
Casement-Slider	15.3

*The DOE established 18 total equipment classes for this standard. The above table does not include equipment without reverse cycles, which are not within the scope of this lab testing.

†As of June 25, 2026, the project team's review of available basic models in comments suggests that no casement-only and casement-slider reverse-cycle basic models are currently being distributed into commerce in the United States.

PORTABLE AIR CONDITIONERS

In 2020, the DOE adopted the first energy conservation standard—which establishes minimum allowable CEER standards (DOE 2020)—for all PACs, including single-duct and dual-duct. The adopted standards are shown in Table 6 and are dependent on the product's seasonally adjusted cooling capacity (SACC). As of January 10, 2025, manufacturers must follow the test procedure (detailed in Title 10 CFR 430, Subpart B, Appendix CC) to determine a unit's CEER and SACC values.

During the rulemaking, the Appliance Standard Awareness Project (ASAP), the Alliance to Save Energy, the American Council for an Energy-Efficient Economy (ACEEE), the Consumers Union, and the Northwest Energy Efficiency Alliance (NEEA) supported development of the standard and test procedure, working to address manufacturer concerns and advocating for more data collection (ASAP et. al. 2015). Industry stakeholders—including ASAP, ACEEE, the National Consumer Law Center (NCLC), Natural Resources Defense Council (NRDC), the Northeast Energy Efficiency Partnerships, and NEEA—advocated that the DOE adopt more stringent efficiency levels for the standard. Meanwhile, due to concerns around technical feasibility and asserted lack of economic justification, AHAM advocated for less stringent efficiency levels. Overall, stakeholders agreed that more test data would be beneficial to determining standard efficiency levels (ASAP et. al. 2016) (AHAM 2016).

On May 16, 2025, the DOE published a Federal Register notice proposing to withdraw prior determination that PACs qualify as covered products (DOE 2025). As of the time of this report's writing in July 2026, there has been no resolution to this proposed withdrawal of determination.

Table 6: DOE energy conservation standards for PACs.

Portable Air Conditioner Product Class	Minimum CEER (Btu/Wh)
Single-Duct and Dual-Duct PACs	$1.04 \times \frac{SACC}{(3.7117 \times SACC^{0.6384})}$

The SACC equation below is established in Title 10 of the CFR (DOE 2016); the test method measures cooling capacities and losses, assuming two different outdoor air conditions of 83°F dry bulb and 95°F dry bulb.

$$SACC = (ACC_{95} \times 0.2) + (ACC_{83} \times 0.8)$$

ACC_{95}= Adjusted cooling capacity of tests using 95F outdoor air (Btu/hr)
ACC_{83}= Adjusted cooling capacity of tests using 83F outdoor air (Btu/hr)

CONSUMER CENTRAL AIR CONDITIONERS AND HEAT PUMPS

This DOE rulemaking covers split-system central air conditioners and heat pumps (CAC/HP), single-package central air conditioners and HPs, small-duct high-velocity products, and space-constrained products. The scope includes systems with and without ducts for distributing air to multiple rooms; mini- and multi-splits are included in the CAC/HP scope rather than the RAC scope due to their configuration as split systems. The current CAC and HP standards were published in 2017, with compliance required in January 2023 (DOE 2017). In 2025, the DOE published a final rule amending the test procedure for CAC/HPs to incorporate the latest and most relevant industry consensus test standard, Air-Conditioning, Heating, and Refrigeration Institute (AHRI) 210/240-2025 (I-P) (DOE 2025). After manufacturers and other stakeholders expressed concern about market readiness for relevant products, the DOE amended the final rule for the test procedure and pushed the compliance date by a year to July 7, 2026. Table 7 and Table 8 detail the CAC/HP energy conservation standards; note that for cooling performance, the standard is expressed in Seasonal Energy Efficiency Ratio 2 (SEER2), rather than the CEER used to measure efficiency for smaller products, and heating performance is rated using the Heating Seasonal Performance Factor 2 (HSPF2).

Table 7: DOE energy conservation standards for CAC and HP for products manufactured on or after January 1, 2023.

Product Class	SEER2	HSPF2
Split-System Air Conditioners with a Certified Cooling Capacity <45,000 Btu/h	13.4	
Split-System Air Conditioners with a Certified Cooling Capacity ≥45,000 Btu/h	13.4	
Split-System Heat Pumps	14.3	7.5
Single-Package Air Conditioner	13.4	
Single-Package Heat Pumps	13.4	6.7
Space-Constrained Air Conditioners	12	6.1
Space-Constrained Heat Pumps	11.7	
Small-Duct High-Velocity Systems	11.9	6.3

Table 8: Additional DOE energy conservation standards for CAC and HP in southeast* and southwest regions.**

Product Class	Southeast *	Southwest **	
	SEER2	SEER2	EER2***
Split-System Air Conditioners with a Certified Cooling Capacity <45,000 Btu/h	14.3	14.3	11.7/9.8
Split-System Air Conditioners with a Certified Cooling Capacity ≥45,000 Btu/h	13.8	13.8	11.2/9.8
Single-Package Air Conditioners			10.6

* Southeast: Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, Texas, Virginia, the District of Columbia, and the US territories.

** Southwest: Arizona, California, Nevada, and New Mexico.

***The 11.7 EER2 standard applies to products with a certified SEER2 less than 15.2. The 9.8 EER2 standard applies to products with a certified SEER2 greater than or equal to 15.2. The 11.2 EER2 standard applies to products with a certified SEER2 less than 15.2. The 9.8 EER2 standard applies to products with a certified SEER2 greater than or equal to 15.2.

ENERGY STAR® Specifications

ROOM AIR CONDITIONERS

The current specification for room air conditioners is version 5.0 (v5.0), published in February 2023 (EPA 2024d). This specification and corresponding test method only covers cooling mode performance. Since the release of v5.0, the covered product market has advanced, and the most recent DOE energy conservation standards established more stringent energy efficiency levels. In November 2024, the EPA simultaneously released v6.0 and v7.0 RAC Draft 1 Specifications. Version 6.0 aims to address heating mode efficiency for room HPs in addition to the savings from cooling, while version 7.0 proposes to update all requirements; the final determination for these specifications is still under review. The project team further details use of these specifications in Table 14 of this report.

PORTABLE AIR CONDITIONERS

There is no current specification for portable room air conditioners. In June 2025, ENERGY STAR® stated that they would determine whether to add PACs to the program after the federal standard was finalized (EPA 2025b).

CENTRAL AIR CONDITIONERS AND HEAT PUMPS

As of February 1, 2026, the ENERGY STAR® specification for CAC sunsetted. The majority of stakeholders that commented on the proposal supported the sunset, asserting that the decision aligns with the market trend of consumers purchasing HPs over CAC (EPA 2024c).

The latest specification for HP equipment, v6.2, includes criteria for residential HPs, including cold climate use cases. Table 9 and Table 10 detail the minimum energy efficiency requirements for ENERGY STAR® certification; note that gas/electric package HPs are not eligible for the "cold climate" designation.

Table 9: ENERGY STAR® criteria for certified residential heat pumps.

Product Type	SEER2	EER2	HSPF2
HP Split Systems	≥15.2	≥11.0	≥7.8
HP Single Package Equipment	≥15.2	≥10.0	≥7.2

Table 10: ENERGY STAR® Criteria for certified residential cold climate heat pumps.

Product Type	SEER2	HSPF2
HP Split Systems (Non-Ducted)	≥ 15.2	≥8.5
HP Split Systems (Ducted)	≥ 15.2	≥8.1
HP Single Package Equipment	≥ 15.2	≥8.1

In addition to the criteria in Table 10, cold climate HPs must also demonstrate low ambient performance (EPA 2024b).

California eTRM Measure Packages

ROOM AIR CONDITIONER, RESIDENTIAL

San Diego Gas and Electric (SDG&E) led development for a 2026 eTRM measure package for residential RACs and HPs.[2] To qualify for the measure, equipment must meet or exceed the following two efficiency tiers:

1. **ENERGY STAR® Basic Tier:** The unit meets the ENERGY STAR® v7.0 eligibility criteria specified in Table 11.
2. **ENERGY STAR® Connected Tier:** The connected model offers advanced controls and increased functionality, such as the ability to turn off the unit remotely without using the manufacturer-specific operating system when the user is not at home and provides feedback on the energy use of the product. ENERGY STAR® Connected Tier offerings must be noted as "connected capable" in ENERGY STAR®.

[2] Statewide Measure ID SWAP007-05.

The equipment must also use a California Air Resources Board–listed refrigerant and have a 100-year global warming potential (GWP)—i.e, AR4—of less than 750. RHPs are within the scope of this measure and are considered as RACs with reverse cycle under federal and state code, as well as under ENERGY STAR®. However, the measure does account for the heating HEER metric.[3]

Table 11: California eTRM measure case description for RACs and RHPs.

Product Class	Louvered Sides?	Cooling Capacity (Btu/hr)	Minimum CEER
Room AC	Yes	<6,000	14.4
		6,000–7,999	15.1
		8,000–13,999	17.6
		14,000–19,999	17.6
		20,000–27,999	15.2
		≥ 28,000	14.5
Room AC	No	<6,000	14.1
		6,000–7,999	14.1
		8,000–10,999	15.5
		11,000–13,999	15.3
		14,000–19,999	15.1
		≥ 20,000	15.2
Room HP (i.e., Room AC with reverse Cycle)	Yes	<20,000	15.1
		≥ 20,000	14.4
Room HP (i.e.,	No	<14,000	14.4

[3] The eTRM provided the following rationale for excluding HEER levels: Although ENERGY STAR® v7.0 requires HEER as well, the federal code does not require reporting of HEER or a minimum HEER value; therefore, HEER values may not be broadly published by manufacturers. Since the energy savings are based only on cooling savings, eligible products are not required to meet any minimum HEER value.

Product Class	Louvered Sides?	Cooling Capacity (Btu/hr)	Minimum CEER
Room AC with reverse Cycle)		≥ 14,000	13.4
Casement-Only Room AC	Either	Any	15.3
Casement-Slider Room AC	Either	Any	16.8

PORTABLE AIR CONDITIONERS AND HEAT PUMPS, RESIDENTIAL

The Los Angeles Department of Water and Power (LADWP) led development for a 2023 eTRM measure package for residential portable air conditioners (PAC) and HPs. To qualify for the measure, equipment must exceed the California Energy Code's Title 20 (T20) efficiency by 5 percent or more, and use a Significant New Alternatives Policy–listed refrigerant with a GWP equal to or less than 1,000; some offerings also require connected controls. T20 requires that the CEER for all PACs must exceed the value calculated from the equation based on the SACC in Btu/hr—which was established in the most recent DOE test procedure and energy conservation standards for PACs and is available in Table 6 earlier in this report. Meanwhile, Table 12 below details the California eTRM measure offerings for both new construction and normal replacement options (CalTF 2023).

Table 12: California eTRM measure offerings.

Measure Case Equipment	Measure Offering Description	Existing Case Description
Portable Air Conditioners (NC*)	Efficient portable air conditioner, CEER 5% greater than T20 standard	New construction—home with no HVAC
Portable Air Conditioners (NR*)	Efficient portable air conditioner, CEER 5% greater than T20 standard	Standard portable air conditioner, T20 CEER
Portable Air Conditioners with Connected Controls (NC)	Efficient portable air conditioner with connected controls, CEER 5% greater than T20 standard	New construction—home with no HVAC

Measure Case Equipment	Measure Offering Description	Existing Case Description
Portable Air Conditioners with Connected Controls (NR)	Efficient portable air conditioner with connected controls, CEER 5% greater than T20 standard	Standard portable air conditioner, T20 CEER
Portable Heat Pumps with Connected Controls (NC)	Efficient portable HP, CEER 5% greater than T20 standard	New construction—home with no HVAC
Portable Heat Pumps with Connected Controls (NR)	Efficient portable HP, CEER 5% greater than T20 standard	Standard portable HP, T20 CEER
Portable Heat Pumps Connected Controls (NC)	Efficient portable HP with connected controls, CEER 5% greater than T20 standard	New construction—home with no HVAC
Portable Heat Pumps with Connected Controls (NR)	Efficient portable HP with connected controls, CEER 5% greater than T20 standard	Standard portable HP, T20 CEER

*The California eTRM abbreviates new construction as "NC" and normal replacement as "NR."

CalMTA Room HPs Lab Testing Report

CalMTA pursued testing of five MHP units—including four room HPs—at an NRTL. Participating manufacturers included Midea, Gradient, Gree, and GE Appliances, and CalMTA was able to verify manufacturers' ENERGY STAR® ratings. Three of the units met classification for Type 4 RAC with active defrost and operation below 5°F, one met the classification for Type 3 with active defrost and operation down to 17°F, and the fifth was a 120V plug-in HP product "split system" that can be installed through a window opening but that does not meet the EPA definition of an RAC. All five units were able to achieve a COP higher than 2 at 17°F, and two of the Type 4 units achieved a COP above 2 at 5°F. Fixed-speed tests validated manufacturer-claimed efficiency ratings: Units tested with manufacturer-provided HEER test targets all came within 5 percent below their rated capacities and within 1 percent below target COP.

After completing the ENERGY STAR® tests, the CalMTA team completed load-based testing using a target virtual load approach, per Appendix I of AHRI Standard 210/240-2024 and CSA Group SPE-07:23. There were similar efficiencies during fixed-speed and load-based testing at and near full-load operation; COP generally increases as outdoor air temperature increases, but there is no shown correlation between the target building load and the MHP COP. Further testing would be needed for definitive load-based testing conclusions, as lack of convergence and variability in the results led the

team to conclude that load-based testing is not suitable for compliance or enforcement testing without further refinement of the test procedure (McFadden and Meinrath 2025).

Stakeholder Outreach

The project team continued to collaborate with participants in the Room Heat Pump Collaborative meetings organized by CalMTA, NEEA, and CEE℠. Interested parties who regularly attended these meetings included MHP manufacturers, utilities, program administrators, energy efficiency organizations, state agencies like NYSERDA, and government agencies like DOE. The project team attended the 2025 CEE℠ Industry Partners meeting to summarize the findings of the ET23SWE0034 project report in 2024, as well as to gather additional laboratory test plan ideas from interested parties. In January 2026, the project team attended the ASHRAE winter conference and AHR Expo and met with various MHP manufacturers to socialize the laboratory test plan published in the 2024 ET23SWE0034 project report. Finally, in March 2026, the project team presented the findings of the 2024 ET23SWE0034 project at the ACEEE Hot Air and Hot Water Conference and gathered feedback from interested parties on laboratory testing opportunities. Stakeholder feedback resulted in the project team streamlining its laboratory test plan to prioritize non-duplicative performance tests, and complement the work of other interested parties pursuing parallel MHP laboratory tests. This approach was also supported by the manufacturers partnering on this project.

The project team also met one-on-one with several organizations over the entire duration of this project; we greatly appreciate the contributions of the following organizations toward the successful completion of this project:

- Manufacturers, such as Friedrich/Rheem, GD Midea, GE Appliances, Gradient, Gree, and LG Electronics USA, Inc.
- Interested parties, such as the California IOUs, CalMTA, CEE, DOE, EPA, EPRI, NEEA, and NYSERDA.

Performance Data Collection

Objectives

Beyond the data collected through completed CalNEXT project ET23SWE0034, this effort has resulted in comprehensive performance data on commercially available MHPs pertaining to cooling, heating, and dehumidification features. This project focused on the development of performance maps and measure development, informing potential updates on test procedures and standards development at the federal level, and assisting the EPA's ongoing product specification development. The following tasks were performed as part of this project:

- Collected comprehensive heating performance data on commercially available MHP models in an NRTL using the air enthalpy method. Data collection included heating capacities, power consumption, temperatures at selected test conditions, and airflows.
- Extended data collection opportunities, using the air enthalpy method, to cooling and dehumidification performance—particularly cooling sensible capacities, cooling total capacities, power consumption, temperatures at selected test conditions, and airflows.

This project provides a comprehensive set of data resulting in comparative performance that may assist entities—including the DOE, the EPA, the California Energy Commission (CEC), and the CEE—by providing data and insights with updating relevant standards or specifications; it is also intended to facilitate the uptake of MHPs. The target market includes residential, single-family, multifamily, hard-to-reach customers, DACs, accessory dwelling units, mobile homes, hospitality, assisted living facilities, and schools.

Targeted project outcomes included the following:

- Used the collected MHP performance data to update existing information and improve estimates of energy savings, market potential, and strategies for statewide adoption.
- Laid technical groundwork to support IOUs with providing incentives for this rapidly emerging market.
- Provided background to encourage market adoption and replacement of existing gas heating equipment and central heating systems with this emerging MHP technology.

Background on Testing Methodology

The project team prioritized the most novel and untested attributes of the core tests identified in the test plan for the ET23SWE0034 project, summarized in Appendix A's Table 22. The following section covers the products tested and the testing methodology.

Products to Be Tested

The project team considered equipment selection approaches taken in the field and determined that they can vary by the type of consumer product. For CAC/HP, California's 2025 Building Energy Efficiency Standards mandate equipment selection based on the Air Conditioning Contractors of America Manual S-2023, after the building cooling loads, heating loads, and design conditions are

determined.[4] The selected central HP is also required to have a heating capacity meeting the minimum requirements of the California Building Code, not including any supplementary heating.[5] In comparison, the EPA's ENERGY STAR® program specifies a square-footage chart for RACs that accounts for the factors for RAC selection: room size, room shape, shading, occupancy, and the room's utility (e.g., kitchen); this chart currently addresses only cooling modes for RACs.

Additionally, the project team conducted a market survey to understand the nascent products being developed and sold in this equipment category. The initial survey led to manufacturer coordination and procurement of products for testing, which are listed in Table 13; the project team tested four units across three form factors.

Table 13: Tested MHP samples.

Sample Compressor Type (Number of Samples)	Technical Attributes	Notes
Variable-Speed (2)	120V, 15A, R32, 38-42 dBA, atomization of meltwater and condensate or automatic drainage	Operate from -13^{0}F (heating) to 115^{0}F or 120^{0}F (cooling) Cooling capacities are at 9.3 kBtu/h Heating capacities are up to ~10kBtu/h
Single-Speed (2)	115V, 9.1–10.5A, R32, and reduced operating noise via use of inner wall and insulation, and vibration isolation	Operate from 14^{0}F (heating) to 115^{0}F (cooling) Cooling capacities range between 10–12kBtu/h Heating capacities range between 8.5–8.7 kBtu/h

MHP Performance Testing in an NRTL

CalNEXT project ET23SWE0034 collected data on prototypes rather than commercially available models, and focused on updating existing equipment information to improve estimates of energy savings, their market potential, and strategies for their statewide adoption. The project team collected comprehensive laboratory performance test data on heating, cooling, and dehumidification. This project differs from ET23SWE0034 in that the team collected performance

[4] Per Sections 150.0(h)1, 150.0(h)(2) and 150.0(h)(5) of the 2025 Edition of Title 24, Part 6.

[5] Per Section 150.0(h)(5)B.iii.a of the 2025 Edition of Title 24, Part 6.

testing data on commercially available MHPs—particularly with the saddlebag form factor—that are of specific interest to single-family and multifamily buildings in California.

We performed all cooling, heating, and dehumidification tests in a psychrometric chamber.

Cooling Performance Methodology

One of the project's objectives was to investigate the effect of representative indoor temperatures on product cooling performance. The following federal test procedures are most applicable to MHPs and prescribe evaporator inlet temperatures of 80°F dry-bulb and 67°F wet-bulb within the indoor test chamber:

- Appendix F to Subpart B of Title 10 CFR Part 430 ("Appendix F") for room HPs that include casement-only, casement-slider, window-mounted or through-the-wall mounted encased assembly.
- Appendices CC and CC1 to Subpart B of Title 10 CFR Part 430 ("Appendix CC" and "Appendix CC1") for portable HPs.
- Appendix M1 to Subpart B of Title 10 CFR Part 430 ("Appendix M1") for single-package central HPs (other than space-constrained) Title 10 CFR 431.96(g) for single-phase packaged terminal HP equipment.

The project team considered the following sources of information prior to the execution of cooling mode tests with adjusted evaporator inlet temperatures of 75°F dry-bulb and 63°F wet-bulb within the indoor test chamber:

- California's 2025 building energy efficiency standards—set forth in Energy Code Title 24, Part 6—require design conditions for space-conditioning equipment to satisfy an indoor temperature of 75°F in cooling mode in single-family residential and multifamily buildings.[6]
- 2020 Residential Energy Consumption Survey data with the following approximations were deemed to be most applicable to US housing units that use air conditioning: a) only 5 percent of housing units have an indoor daytime temperature of 80°F or more in the summer when someone is home, and b) only 15 percent of housing units have an indoor daytime temperature of 80°F or more in the summer when no one is home.[7]
- An Oak Ridge National Laboratory study made the following assumption, which resulted in the current Appendix M1 heating load line: a design cooling load at the 75°F indoor setpoint condition and 50 percent relative humidity.[8]
- American National Standards Institute/Residential Energy Services Network /International Code Council 301 requires the temperature in cooling mode to be 75°F for an energy rating reference home and a rated home. The required cooling mode temperature influences the resultant Energy Rating Index–based compliance provisions, as set forth in section R406.5 of the Residential Energy Efficiency Chapter of the International Energy Conservation Code;[9] this

[6] Per section 150.0(h)2 for single-family residential buildings and 160.3(b)2 for multifamily buildings.

[7] Per Table HC7.1 of RECS 2020: https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%207.1.pdf

[8] https://info.ornl.gov/sites/publications/files/Pub68338.pdf

[9] https://www.resnet.us/wp-content/uploads/ANSIRESNETICC301-2022_resnetpblshd.pdf

can influence energy codes in states who adopt or adapt their respective energy codes based on the International Energy Conservation Code's actions.

The project team collaborated with a testing laboratory with a psychrometric test chamber to maximize the investigative testing opportunity within the framework of the allotted project budget, and noted that MHPs falling within the scope of the Appendix F test procedure are required to be tested in a calorimeter test chamber.

Heating Performance Methodology

The project team's review of manufacturer literature concluded that, prior to the issuance of the ENERGY STAR® room HPs test method, a variety of heating performance claims in product literature were made to highlight the full spectrum of available features to consumers. Some examples of claims included heating capacities and COPs at specific outdoor temperatures, HSPF2 ratings, heating operation based on hose installation type, and HEER ratings based on the draft version of the ENERGY STAR® room HPs test method.

Table 14 summarizes the performance criteria within published final or draft specifications issued by CEE℠ and/or the EPA. Unlike cooling, there are no mandatory federal test procedures or metrics for heating performance or dehumidification. The specifications accounted for the heating performance metrics prescribed in the ENERGY STAR® room HPs test method issued in November 2024. In response to the EPA draft specification, the California IOUs recommended that the EPA consider adjusting the heating performance levels in the Version 6.0 and 7.0 specifications, allowing non-variable speed products to qualify. The IOUs' recommendation was based on their support of the development of more affordably priced room heat pumps.[10]

[10] The California IOUs' letter to the EPA can be accessed here for reference.

Table 14: Performance in published draft or final specifications.

Specification and Status (Publication Date)	CEER Criteria	HEER Criteria	COP 17°F Criteria	COP 5°F Criteria†	Heating Capacity Ratio Criteria
CEE℠ RHP Draft* (05/14/2026)	14.4 (Tier 1) 15.1 (Advanced)	7.0 (Tier 1) 8.5 (Advanced)	1.75 (Tier 2)	1.75 (Advanced)	70% at 17°F/47°F (Tier 1) 70% at 5°F/47°F (Advanced)†
CEE℠ RHP Final** (1/1/2025)	13.2 (Tier 1) 14.4 (Tier 2) 15.1 (Advanced)	5.8 (Tier 1) 7.0 (Tier 2) 8.5 (Advanced)	1.75 (Tier 2)	1.75 (Advanced)	70% at 17°F/47°F (Tier 2) 70% at 5°F/47°F (Advanced)†
EPA RHP V6.0 Draft 1 (11/26/2024)	11.7-14.7 across 16 product classes	5.1 (Types 1&2) 6.8 (Types 3&4)	1.5 (Type 3)	1.5 (Type 4)†	70% at 17°F/47°F (Type 3) 70% at 5°F/47°F (Type 4)†
EPA RHP V7.0 Draft 1 (11/26/2024)	13.4-17.6 across 16 product classes	5.8 (Types 1&2) 8.3 (Types 3&4)	1.75 (Type 3)	1.75 (Type 4)†	70% at 17°F/47°F (Type 3) 70% at 5°F/47°F (Type 4)†

*Active defrost (Tier 2 and Advanced)

**Passive defrost (Tier 1) or active defrost (Tier 2 and Advanced)

†For information only: 5°F criteria are inapplicable to all 16 climate zones in California based on weather data previously considered in the ET23SWE0034 project.

Dehumidification Performance Methodology

The project team's review of manufacturer literature concluded that a variety of dehumidification performance claims were made to highlight the full spectrum of available features to consumers. Some examples of energy-consuming claims included moisture removal in pints per day, pints per hour, or a dry-run mode feature.

The project team considered approaches to dehumidification performance using current industry test procedures, including the following:

1. **Appendix X1 to Subpart B of Part 430 for dehumidifiers:** The ET23SWE0034 project previously identified this test method as a basis to determine dehumidification capacity in pints per day and an integrated energy factor in liters per kilowatt-hour (L/kWh).
2. **Sensible Heat Ratio (SHR) calculations set forth in Section 4.5 of Appendix M1 to Subpart B of 10 CFR Part 430 (dated November 25, 2022):** Test method prescribes SHR calculations using the sensible cooling capacity and total cooling capacity results from the B test conditions for products with various compressor types.
3. **AHRI Standard 1230-2023:** Specifies SHR limits such that the SHR for the 100-percent load test point and the 75-percent part-load test point shall not be higher than 0.82 and 0.85, respectively.
4. **AHRI Standard 1600-2024:** Specifies airflow limits to address dehumidification needs for consumers. A 450 standard cubic feet per minute (SCFM) per ton (or 37.5 SCFM per 1,000 Btu/hr) limit is applicable to the "Cooling Full Airflow" provisions set forth in section 6.1.5.2 of the test method, and a 600 SCFM per ton (or 50 SCFM per 1,000 Btu/hr) limit is applicable to "Cooling Low Airflow" and "Cooling Intermediate Airflow" provisions set forth in sections 6.1.5.3 and 6.1.5.4, respectively. The test method requires a reduction in airflow during the test if the SCFM per ton limit is exceeded.

Results

Cooling Performance Results

Table 15 summarizes the tested CEER, tested EER, tested adjusted CEER, and tested adjusted EER for the MHP samples under the framework of both this project and the ET23SWE0034 project. The team compared the performance metrics resulting from the tests with the products' rated performance. The tested CEERs at evaporator inlet temperatures of 80°F dry-bulb and 67°F wet-bulb either met or exceeded the model's rated CEERs; however, at adjusted evaporator inlet temperatures of 75°F dry-bulb and 63°F wet-bulb, the resultant CEER and EER values mostly decreased, as summarized in Table 16. The average decrease in performance across all samples was 8 percent for CEER and 3 percent for EER.

Table 15: Cooling performance for tested MHPs.

Sample #	Rated / Published CEER / EER*	Tested CEER† (80°F/67°F Evaporator Inlet)	Tested EER†, (80°F/67°F Evaporator Inlet)	Tested Adjusted CEER‡ (75°F/63°F Evaporator Inlet)	Tested Adjusted EER‡ (75°F/63°F Evaporator Inlet)
1	16.8 / 13.6	-	-	14.2	13.6
2	14.4 / -	16.1	13.5	14.2	12.2
3	7.4 / 10.6	6.7	7.0	6.6	6.9
4	10.8 / 10.9	12.0	12.1	11.7	11.8

*Cooling rating submitted to the DOE in accordance with all applicable federal certification and compliance requirements. Tests were performed in a calorimeter room. Applicable evaporator inlet test conditions are 80°F dry-bulb and 67°F wet-bulb. An EER specified as "-" means the manufacturer did not specify a value in published product literature.

**Cooling rating submitted to the DOE in accordance with all applicable federal certification and compliance requirements. Tests were performed in a calorimeter room. Applicable evaporator inlet test conditions are 80°F dry-bulb and 67°F wet-bulb.

†Tests were performed in a psychrometer room. The evaporator inlet dry-bulb and wet-bulb temperatures in the indoor room were held at 80°F and 67°F, respectively. During the EER test, the condenser inlet dry-bulb and wet-bulb temperatures in the outdoor room were held at 95°F and 75°F, respectively.

‡The adjusted CEER and EER tests were performed in a psychrometer room. The evaporator inlet dry-bulb and wet-bulb temperatures in the indoor room were held at 75°F and 63°F, respectively. During the EER test, the condenser inlet dry-bulb and wet-bulb temperatures in the outdoor room were held at 95°F and 75°F, respectively.

Table 16: Effect of adjusted evaporator inlet conditions from 80°F/67°F to 75°F/63°F on cooling performance.

Sample #	CEER Impact	EER Impact
1	15% decrease	No impact
2	12% decrease	10% decrease
3	1% decrease	1% decrease
4	3% decrease	2% decrease

The effect of indoor conditions can also have a significant impact on product cooling capacities (including the seasonal adjusted cooling capacity metric for portable HPs). The project team reviewed manufacturer literature for products with expanded rating—such as central air conditioners and HPs—and found significant differences between the rated nominal cooling capacities based on the 80°F dry-bulb and 67°F wet-bulb conditions, as well as the cooling capacities at the 75°F dry-bulb and 63°F wet-bulb conditions. Figure 1 summarizes the percentage differences between the cooling capacities at varying indoor conditions while holding the outdoor dry-bulb temperature constant at 95°F dry-bulb; the observed reduced cooling capacities ranged between 1 percent and 14 percent.

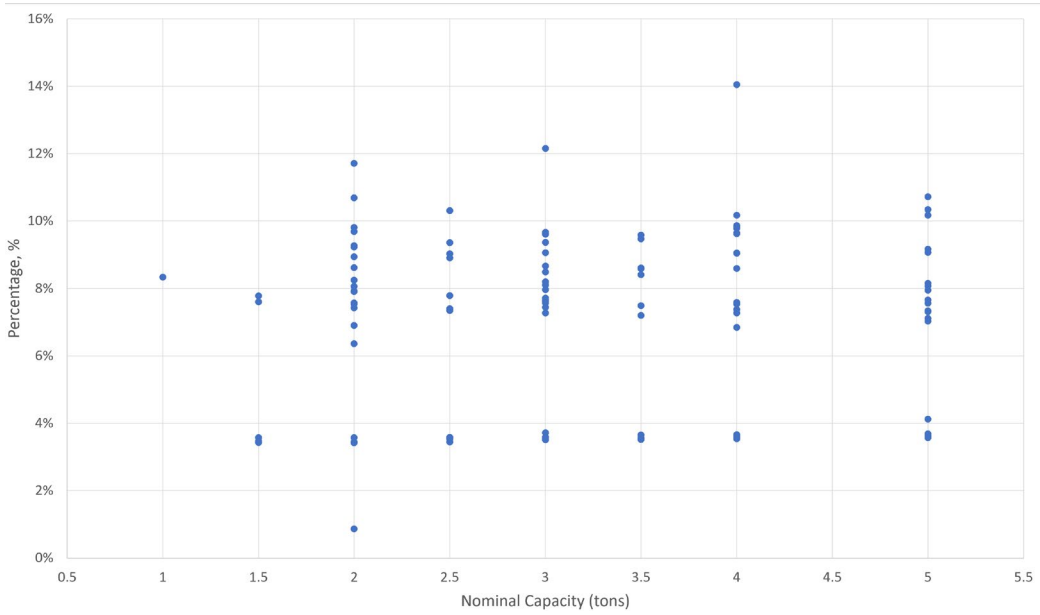

Figure 1: Percentage difference between rated cooling capacities and cooling capacities with indoor temperatures representative of real-world conditions.

The project team also ran the steady and cyclic dry coil test for each MHP sample and calculated the cooling degradation coefficients and cycling loss factors. We compared these values with those prescribed in the DOE's Appendix F and Appendix CC1 test procedures:

- **Appendix F** prescribes a cooling degradation coefficient of 0.38 and a cycling loss factor of 0.810, based on the DOE's load-based testing on two single-speed RACs; they used an outdoor temperature of 82°F and cooling loads between 47 and 57 percent of the full load, with a target of 52 percent.[11]
- **Appendix CC1** prescribes cycling loss factors of 0.82 for single-duct units and 0.77 for dual-duct units.

The DOE calculated the difference in efficiency for single-speed PACs when tested under full-load constant load conditions and part-load cycling load conditions, while focusing on just the cycling losses (and not fan operation) in the off-cycle mode. The DOE deemed load-based testing to be infeasible for PACs with the equipment and facilities used during their investigative testing process, and they instead performed cyclic tests to trigger single-speed PAC cycling by remotely adjusting the setpoint of the test unit in a cyclic pattern while it was in the test chamber. This simulated the unit's behavior when the room temperature reached the unit setpoint. The DOE tested multiple PACs in 10-minute and 30-minute increments to account for real-world variations in unit capacity and room size.[12]

Table 17 summarizes the calculated cooling degradation coefficients and cyclic loss factors for the four tested MHP samples. Unlike the DOE, the project team did not attempt load-based testing and did not attempt a 10-minute test length, but interested parties are encouraged to build upon the findings presented in this report to help develop representative values. The project team's observations are as follows:

- The cooling degradation coefficient for one of the tested MHP samples was lower than the 0.38 value presented by the DOE in the RAC final rule that led to the current Appendix F provisions. However, the project team believes that the lack of attempt at a load-based method—coupled with the reliance on a psychrometric chamber instead on a calorimetric chamber—may have contributed to the observed deviation in the calculated cooling degradation coefficient.
- The calculated cyclic loss factor for the dual-duct MHP was higher than the value in Appendix CC1 and would have likely increased or stayed flat if the project team had also pursued 10-minute test lengths.
- We compared the calculated cooling degradation coefficients for variable-capacity MHPs to the 0.25 default value prescribed in Appendix M1; the calculated results presented one MHP with an opportunity to use a lower value based on the tested results. We based the derivation of the cycling loss factors in the Appendix F test procedure on tests of single-speed RACs, so the results presented in this section may be considered by interested parties in ongoing or future test procedure discussions.

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[12] Page 34,950 of 87 FR 34,934

Table 17: Calculated cooling degradation coefficients and cycling loss factors.

Sample #	Cooling Degradation Coefficient	Cycling Loss Factor
1	0.07	0.965
2	0.62	0.690
3	0.16	0.920
4	0.28	0.860

Heating Performance Results

Table 18 summarizes the heating performance for the tested MHPs under this project and assesses the results against one finalized specification issued by the CEE on January 1, 2025, as well as two draft specifications issued by the EPA on November 26, 2024. Most samples tested had active defrost features. Samples 3 and 4 did not have published rated HEERs during the duration of this project, and the tested HEERs of samples 1 and 2 exceeded the rated HEERs. Sample 1 satisfied all published final or draft criteria, while Sample 2 satisfied CEE's Tier 2 criteria but did not meet EPA's Version 7.0 Draft 1 criterion on CEER and HEER. Samples 3 and 4 failed to meet all published final or draft criteria.

Table 18: Heating performance for tested MHPs (✓= meets criteria and x=does not meet criteria).

Sample #	HEER (Rated)*	Tested HEER	Tested COP at 47°F	Tested COP at 17°F	Tested Capacity Ratio 17°F /47°F	CEE RHP Final†	EPA RHP V6.0 Draft 1‡	EPA RHP V7.0 Draft 1‡
1	9.4	9.1	4.4	2.6	104%^	Tier 2 ✓	✓	✓
2	7.3	8.0	3.4	2.3	94%	Tier 2 ✓	✓	x
3	-	4.4	1.9	1.3	62.4%	Tier 1 x	x	x
4	-	3.7	3.1	-	-	Tier 1 x	x	x

Sample #	HEER (Rated)*	Tested HEER	Tested COP at 47°F	Tested COP at 17°F	Tested Capacity Ratio 17°F /47°F	CEE RHP Final†	EPA RHP V6.0 Draft 1‡	EPA RHP V7.0 Draft 1‡
5**	11	10.1	3.9	2.6	89%	Tier 2 ✓	✓	✓

*Heating rating submitted to the DOE n accordance with the ENERGY STAR® Version 1.0 Room Air Conditioner Heating Mode Performance test method. The test method allows tests to be conducted in a calorimeter or psychrometer room.

†CEE Residential Room Heat Pump Specification (Effective January 1, 2025). See here for details.

‡EPA issued the V6.0 and V7.0 Room Air Conditioner Draft 1 specifications in November 2024. The final versions are pending. See here for details.

^Some manufacturers implement a compressor modulation faster than the full compressor speed (e.g., boost mode) and it can result in an increased capacity ratio. The definition in section 3.2.80.1 in AHRI Standard 1600-2024 addresses this design approach.

**Sample 5 was tested under the completed ET23SWE0034 project within psychrometric chambers in accordance with the heating mode tests prescribed in Table 8 of the published report. The results are included here for comparative purposes.

Dehumidification Performance Results

Table 19 provides an overview of the SHR percentages and SCFM per ton values for each tested MHP sample, using a variety of test conditions. The condenser inlet temperatures have been excluded from the table to preserve the anonymity of the tested MHP form factors, and the values associated with sample 5 are based on prior testing efforts under the ET23SWE0034 project. The team observed that at least five calculated SHR values were above 85 percent, and all of them are associated with tests involving low or intermediate compressor speeds. Four of those tests also exceed the 600 SCFM per ton limit in AHRI Standard 1600-2024 for cooling low or intermediate airflows.

Table 19: Dehumidification performance of MHPs (✓=meets AHRI 1600-2024 airflow limit; x=does not meet AHRI 1600-2024 airflow limit).

Sample #	Test Conditions	SHR (%)	SCFM per Ton
1	Indoor 75°F DB/63°F WB at full compressor speed	80	597 to 598 x
	Indoor 75°F DB/63°F WB at intermediate or low compressor speeds	100	482 to 588 ✓
2	Indoor 75°F DB/63°F WB at full compressor speed	72	442 to 448 ✓

Sample #	Test Conditions	SHR (%)	SCFM per Ton
	Indoor 80°F DB/67°F WB at full compressor speed	68	403 to 408 ✓
	Indoor 75°F DB/63°F WB at intermediate compressor speed	77	496 ✓
	Indoor 80°F DB/67°F WB at intermediate compressor speed	74	454 ✓
	Indoor 75°F DB/63°F WB at low compressor speed	92	639 x
	Indoor 80°F DB/67°F WB at low compressor speed	86	710 x
3	Indoor 75°F DB/63°F WB at full compressor speed	67 to 69	298 to 326 ✓
	Indoor 80°F DB/67°F WB at full compressor speed	66 to 69	278 to 310 ✓
4	Indoor 75°F DB/63°F WB at full compressor speed	66	310 ✓
	Indoor 80°F DB/67°F WB at full compressor speed	71	-
5*	Indoor 80°F DB/67°F WB at full compressor speed	75	374 to 381 ✓
	Indoor 80°F DB/67°F WB at intermediate compressor speed	93	617 x
	Indoor 80°F DB/67°F WB at low compressor speed	102	890 x

*Sample 5 was tested under the ET23SWE0034 project within psychrometric chambers in accordance with the cooling mode tests prescribed in Table 8 of the published report. The results are included here for comparative purposes.

Table 20 summarizes the estimated SHR values in single-family buildings across various California climate zones, using energy modeling results summarized in Appendix A of the ET23SWE0034 project. While the results confirm that sensible cooling loads are predominant in California, latent

cooling loads at SHRs below 80 percent can be contributing factors in certain jurisdictions (e.g., up to 32 percent in warm marine regions). The project team also evaluated average sensible cooling loads across the total annual cooling loads in multifamily buildings across some California climate zones—the results of which are summarized in Table 21, and confirm that sensible cooling loads were predominant in some evaluated California climate zones. The project team recommends all interested parties pursuing energy modeling, laboratory testing, and field evaluations consider the results presented in this section and build upon these project findings.

Table 20: SHRs in single-family buildings based in California climate zones.

California Climate Zone	Thermal Climate Zone	SHR Range (%)	Weighting (%)
1	Mixed Marine	80–100	95
		<80	5
2, 3, 4, 5 & 6	Warm Marine	80–100	68
		<80	32
7, 8, 9, 10, 11, 12 & 13	Warm Dry	80–100	90
		<80	10
15	Hot Dry	80–100	85
		<80	15
14 & 16	Mixed Dry	80–100	90
		<80	10
16	Cool Dry	80–100	91

California Climate Zone	Thermal Climate Zone	SHR Range (%)	Weighting (%)
		<80	9
16	Cold Dry	80–100	97
		<80	3

Table 21: Average sensible cooling loads across total annual cooling loads in multifamily buildings based in some California climate zones.

California Climate Zone	Thermal Climate Zone	Average Sensible Cooling Load Across Total Annual Cooling Load (%)
1	Mixed Marine	91
2, 3, 4, 5 & 6	Warm Marine	86
7, 8, 9, 10, 11, 12 & 13	Warm Dry	95

Findings and Recommendations

The project team's findings for consideration by interested parties are as follows:

- **Coordinate on approaches to leverage laboratory test results towards energy savings estimations in measure packages and develop objects in energy modeling tools that are representative of MHP performance:** The previously published SWAP020-01 is an example of the CEER metric serving as the basis for product eligibility, so the higher calculated CEER values presented in Table 15 can be used to differentiate more efficient MHPs from baseline systems in cooling mode operation. The EER results presented in Table 15 also present program administrators with an option to consider EER-specific criteria to manage peak demand. The laboratory results could potentially aid the development of a new MHP object in DEER rather than measure package developers having to rely on PTAC and PTHP prototypes for savings estimates – the PTAC/PTHP approach was previously implemented in SWAP020-01 and is not adequately representative of MHP performance since the corresponding EER and COP metrics for these products are based on single outdoor temperature conditions in each cooling or heating mode. Regarding heating mode, the project team is not aware of any current measure incorporating the HEER metric in savings estimations, but program administrators could consider a heating mode energy savings approach analogous to the CEER-based approaches in previously-issued measure packages. Since California also experiences peak demand in the winter, the measure package development process could potentially consider COP requirements at 47°F or 17°F, depending on the region's specific climactic conditions.
- **Cooling performance:** All applicable federal and industry test procedures on MHPs specify test conditions at evaporator inlet temperatures of 80°F dry-bulb and 67°F wet-bulb. The average decrease in performance across all tested MHP samples was 8 percent for CEER and 3 percent for EER at adjusted evaporator inlet temperatures of 75°F dry-bulb and 63°F wet-bulb. Rather than unduly burdening the industry with performing additional laboratory tests, California's eTRMs could consider slightly increasing the rated CEER criteria, such that a modest increase appropriately helps offset the observed performance decrease at California-specific indoor temperatures. Program administrators have also historically considered EER for other space-conditioning products as a requirement to mitigate peak demand, so the results presented in this report could also be considered from the standpoint of a peak load mitigation opportunity. The project team recommends that interested parties continue pursuing additional investigative steady and cyclic dry-coil testing opportunities to potentially inform future test procedure revisions on cooling degradation coefficients and cycling loss factors.
- **Heating performance:** Two of the four tested MHPs were able to satisfy most criteria prescribed in the draft or final specifications issued by the CEE℠ or the EPA; however, one high efficiency system did not meet the EPA's Version 7.0 Draft 1 criterion on HEER. The project team recommends program administrators consider heating performance levels that appropriately balance both energy savings and affordability, so consumers have access to a broader range of choices across all possible MHP form factors.
- **Dehumidification performance:** The project team's review of manufacturer literature suggests that pints per day or pints per hour are being used as metrics to claim dehumidification performance. Although several California climate zones are predominantly driven by sensible cooling loads, the warm marine region—which contains about 28 percent of California's zip

codes[13]—requires significant latent cooling as well. The SHR and SCFM per ton are well established metrics in other industry test procedures and present program administrators with an opportunity to prioritize dehumidification performance for consumers without unduly increasing test burden on industry. The California IOUs previously conducted a survey that found approximately 79 percent and 73 percent of consumers consider dehumidification mode in purchasing decisions for PACs and RACs, respectively.[14]

- **Test chamber:** The EPA's room HPs test method and the packaged terminal HP test method in 10 CFR 431.96(g) provide manufacturers with the option to choose between calorimetric or psychrometric chambers. CFR's Appendix F currently requires room HPs to be tested in a calorimeter chamber, so a manufacturer attempting to test, rate, and certify CEER and HEER metrics will likely test the product in both chamber types. Industry and interested parties should consider approaches to help reduce test burden, ultimately allowing consumers to benefit from product features that are both innovative and affordable.

[13] Based on the project team's review of 756 zip codes in climate zones 2-6 out of a total 2,694 zip codes according to available data on the following CEC website: https://www.energy.ca.gov/media/3560

[14] https://www.regulations.gov/comment/EERE-2020-BT-TP-0029-0020

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Appendix A

Table 22: Testing metric of variable-speed MHPs.

Test Chamber	Test Mode	Test Description
Tests in psychometric chamber (air enthalpy method)	Heating mode tests	Perform all required and optional heating mode tests in Table 9 (applicable to Type 3 units) or Table 10 (applicable to Type 4 units) of ENERGY STAR® Final Test Method (EPA 2024f). For Type 4 units, perform the Hx,max test down to the lowest achievable outdoor temperature. Perform the following Controls Verification Procedures (CVP) if unit includes auxiliary electric resistance heater: Perform RH_CVP specified in the ENERGY STAR® Final Test Method; and Perform heating-specific CVP set forth in Appendix I (AHRI 2024a). Follow provisions of section 6.3 of the ENERGY STAR® Final Test Method on cut-in and cut-out temperatures. Record Ton, Toff, and calculate TL. Run the H1C1 and H22 tests following Table 14A of Appendix M1 to Subpart B of 10 CFR Part 430 (DOE 2023). Calculate Heating-Mode Cyclic-Degradation Coefficient using calculations in Section 3.8.1 of Appendix M1 using the results of the Appendix M1 H1C1 test, and the H1,FULL test from the ENERGY STAR® Final Test Method.

Test Chamber	Test Mode	Test Description
Tests in psychometric chamber (air enthalpy method)	Cooling mode tests	For all MHPs, perform G1 and I1 tests in accordance with Table 8 of Appendix M1. Use G1 and I1 tests results to calculate Cooling-Mode Cyclic-Degradation following Section 3.5.3 of Appendix M1 to Subpart B of 10 CFR Part 430. For variable-speed single-duct PACs, run test configurations 2B and 2C in Table 2 of AHAM PAC-1-2022. Conduct the test following the ambient conditions for test configurations 2B and 2C, and measure cooling capacities (CapacitySD_Full and CapacitySD_Low) and input power values (PSD_Full and PSD_Low). For variable-speed dual-duct PACs, run test configurations 1C and 1E in Table 2 of AHAM PAC-1-2022 in accordance with Section 4 of Appendix CC1. For variable-speed dual-duct PACs, contractor shall also run modified test configurations 1C and 1E such that the applicable airflow and static pressure provisions outlined in AHAM PAC-1-2022 are reset to account for new return air temperature evaporator inlet (indoor) air temperature is at 75°F dry bulb and 63°F, and the condenser inlet temperature is at 95°F dry bulb and 75°F wet bulb. For PACs, run the off-cycle mode test in section 8.2 and standby and off mode tests in section 8.3 of AHAM PAC-1-2022. In accordance with section 4 of Appendix CC1, when conducting standby power testing using the sampling method described in section 5.3.2 of IEC 62301, if the standby mode is cyclic and irregular or unstable, collect 10 cycles or 30 minutes' worth of data, whichever is greater. As discussed in Paragraph 5.1, Note 1 of IEC 62301, allow sufficient time for the unit to reach the lowest power state before proceeding with the test measurement. For PACs, calculate SACC and AEER per Section 5 of Appendix CC1. Perform the following CVP for all MHPs: Perform cooling-specific CVP set forth in Appendix I to AHRI Standard 1600-2024 (AHRI 2024a); and Run the following cooling CVP if the manufacturer provides a remote controller or thermostat specific to this unit: Stabilize the indoor room at 80°F dry bulb/67°F wet bulb, and 82°F dry bulb/65°F wet bulb with unit running in cooling in the lowest stage thermostat setting for 10 minutes. Turn off the lowest stage thermostat setting and wait 5 minutes. Turn on the lowest stage thermostat signal. Wait for compressor to ramp up for up to 60 minutes, or when the compressor speed/power draw remains constant for over 15 minutes. Reduce indoor temperature to 78°F. Wait for compressor to ramp down for up to 60 minutes, or when the compressor speed/power draw remains constant for over 15 minutes. If unit does not ramp down, reduce indoor temperature to 76°F to see if it does. Pass criteria: If unit adjusts compressor speed/power up through step 3 and down through step 4 in more than 2 distinct steps, unit has load-based control. If unit does not adjust compressor speed/power, it does not have load-based control. Specify this in test report summary.

Test Chamber	Test Mode	Test Description
Tests in calorimetric chamber	Cooling mode tests	Perform required tests in Appendix F to Subpart B of 10 CFR 430 (DOE 2024a). In conjunction with bullet 1, also run all four test conditions in Table 1 of Appendix F at an evaporator inlet (indoor) air of 75° F dry bulb and 63° F wet bulb. For instance, after running "Test Condition 1" in accordance with Appendix F, leave the 95° F dry bulb and 75° F wet bulb outdoor room conditions fixed while adjusting the indoor room conditions from 80° F dry bulb and 67° F wet bulb to 75° F dry bulb and 63° F wet bulb.
Test room in accordance with AHAM DH-1-2022	Dehumidification tests	Follow these steps for MHPs that are not PACs: In cooling full airflow, measure and report the following in test report: a) measured full airflow; and b) measured indoor air-side total cooling capacity. In cooling low airflow, measure and report the following in test report: a) measured low airflow; and b) measured indoor air-side total cooling capacity. In cooling intermediate airflow, measure and report the following in test report: a) measured intermediate airflow; and b) measured indoor air-side total cooling capacity. Follow these steps for PACs: For variable-speed single-duct units, use results for test configuration 2C to calculate sensible heat ratio (SHR) using Section 4.5 of Appendix M1 to Subpart B of 10 CFR Part 430 (DOE 2023). For variable-speed dual-duct units, use results for test configuration 1E to calculate SHR using Section 4.5 of Appendix M1 to Subpart B of 10 CFR Part 430 (DOE 2023). Contractor shall use the following test procedures to determine dehumidification capacity in pints/day and an integrated energy factor in liters/kilowatt hour ("kWh") or suggest an alternate test method on dehumidification performance specified in Appendix X1 to Subpart B of Part 430 (DOE 2024b). In cooling full airflow, Contractor shall measure and report the following in the test report: Measured full airflow; and Measured indoor air-side total cooling capacity. In cooling low airflow, Contractor shall measure and report the following in the test report: Measured low airflow; and Measured indoor air-side total cooling capacity.
Reverberation room or free field over a reflecting pane	Sound	Test the MHP using ISO Standard 3741 if a reverberation room is used. Otherwise, test the MHP in a free field test room in accordance with ISO Standard 3744. Measure sound power of the indoor and outdoor portions of the unit per ISO 3741 in cooling mode high-speed and low-speed operation.

Table 23: Testing metric of single-speed RHPs.

Test Chamber	Test Mode	Test Description
Tests in psychometric chamber (air enthalpy method)	Heating mode tests	Perform all required and optional heating mode tests in Table 3 of ENERGY STAR® Final Test Method (EPA 2024f). Follow provisions of section 6.3 of ENERGY STAR® Final Test Method to record cut-out and cut-in temperatures. Record Ton and Toff. Record COP and heating capacity at each heating mode test. Calculate HEER using ENERGY STAR® Heating Mode Performance Test Reporting Template (EPA 2024). Run the H1C test in accordance with Table 11 of Appendix M1. Calculate Heating-Mode Cyclic-Degradation Coefficient using calculations in Section 3.8.1 of Appendix M1 using the results of the Appendix M1 H1C test, and the H1,FULL test from the ENERGY STAR® Final Test Method (EPA 2024f).
Tests in psychometric chamber (air enthalpy method)	Cooling mode tests	For all MHPs, run the C and D tests in accordance with Table 5 of Appendix M1. Use C and D test results to calculate Cooling-Mode Cyclic-Degradation in accordance with Section 3.5.3 of Appendix M1 to Subpart B of 10 CFR Part 430. For single-speed single-duct PACs, run test configuration 2A in Table 2 of AHAM PAC-1-2022. Conduct the test in accordance with the ambient conditions for test configuration 2A, and measure cooling capacity (CapacitySD) and input power (PSD). For single-speed dual-duct PACs, run test configurations 1A and 1B in Table 2 of AHAM PAC-1-2022. Conduct the test in accordance with the ambient conditions for test configuration 1A and 1B, and measure cooling capacity (CapacitySD) and input power (PSD). In addition to bullet 2, Contractor shall run modified test configurations 2A, 1A and 1B such that the applicable airflow and static pressure provisions set forth in AHAM PAC-1-2022 are reset to account for new return air temperature evaporator inlet (indoor) air temperature at 75°F dry bulb and 63°F, and the condenser inlet temperatures remain unchanged. Run the off-cycle mode test in section 8.2 and standby and off mode tests in section 8.3 of AHAM PAC-1-2022. In accordance with section 4 of Appendix CC1, when conducting standby power testing using the sampling method described in section 5.3.2 of IEC 62301, if the standby mode is cyclic and irregular or unstable, collect 10 cycles or 30 minutes' worth of data, whichever is greater. As discussed in Paragraph 5.1, Note 1 of IEC 62301, allow sufficient time for the unit to reach the lowest power state before proceeding with the test measurement. Calculate SACC and AEER per Section 5 of Appendix CC1. Run the C and D tests in accordance with Table 5 of Appendix M1. Use C and D test results to calculate Cooling-Mode Cyclic-Degradation in accordance with Section 3.5.3 of Appendix M1 to Subpart B of 10 CFR Part 430.
Test room in accordance with AHAM DH-1-2022	Cooling mode tests	Perform all required tests in Section 5.2.1.1 of AHAM RAC-1-2020 in accordance with the provisions of Section 3.1 of Appendix F. In conjunction with bullet 1, the Contractor shall also run the test conditions in Section 5.2.1.1 of AHAM RAC-1-2020 at an evaporator inlet (indoor) air of 75° F dry bulb and 63° F wet bulb. For instance, after running the test

Test Chamber	Test Mode	Test Description
		in bullet 1, the Contractor may choose to leave the 95° F dry bulb and 75° F wet bulb outdoor room conditions fixed while adjusting the indoor room conditions from 80° F dry bulb and 67° F wet bulb to 75° F dry bulb and 63 ° F wet bulb.
	Dehumidification mode tests	Contractor shall use the following test procedures to determine dehumidification capacity in pints/day and an integrated energy factor in liters/kilowatt hour on dehumidification performance specified in Appendix X1 to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Dehumidifiers (DOE 2024b). In cooling full airflow, Contractor shall measure and report the following in the test report: a) Measured full airflow; and b) Measured indoor air-side total cooling capacity.
Reverberation room or free field over a reflecting pane	Sound	Test the MHP using ISO Standard 3741 if reverberation room is used. Otherwise test the MHP in a free field test room in accordance with ISO Standard 3744. Measure sound power of the indoor and outdoor portions of the unit per ISO 3741 in cooling mode high-speed and low-speed operation.

Table 24: Load-based testing of MHPs.

Test Chamber	Test Mode	Test Description
Tests in psychometric chamber (air enthalpy method)	Load-based testing	Test description: perform load-based testing following Appendix I (starting from page 131) of AHRI 240/260 2024.