Micro Heat Pumps, Are they ready for Prime Time?

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ABSTRACT

California aims to install six million heat pumps by 2030, but the diversity of building applications and ownership, complexity of installations, and affordability of clean heating and cooling solutions pose obstacles to achieve this ambitious goal. There are increasingly high demands for air conditioning systems across the United States alongside decarbonization goals that will require innovative solutions. Emerging packaged "micro" heat pump technologies offer an alternative solution and could be a game changer for owners and renters living in older single-family and multifamily buildings. Micro heat pumps are self-contained, packaged, plug-in 120-volt consumer products that provide more efficient heating and cooling via variable speed operations for spaces smaller than 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 cost barriers associated with the design, installation, and required permitting for traditional heat pumps. This paper focuses on the emergence of packaged window heat pumps, discusses innovative market transformation strategies to spur development and deployment, and provides a summary of different ongoing research activities critical to their support in the market.

Introduction

In July 2022, California Governor Gavin Newsom set an ambitious goal to deploy six million heat pumps statewide by 2030, with new programs planned specifically to address disadvantaged communities (Newsom 2022). This heat pump goal builds upon existing goals established under the 2018 California Senate Bill 100 and its pathway to transition the grid to 100% zero-emissions sources by 2045 (California Senate 2018). Given the high penetration of natural gas space heating in California's existing residential building stock, increasing the rate of conversion to electric heat pumps is a major challenge to meeting this goal. The 2019 California Residential Appliance Saturation Study (RASS) estimates the number of California households with gas space heating to be 77% and gas water heating to be 86% (DNV 2021). This is significantly higher than the United States national average of 52% for gas space heating, and 48% for gas water heating (EIA 2020).

The market transformation strategy has relied on a combination of incentives for traditional central and split heat pumps as replacements for existing gas heating equipment, alongside efforts to conduct performance testing on these products to provide technical validation and inform future incentive program offerings. This approach, most often practiced at the state level, is described by the U.S. Department of Energy (DOE) as a method to support market transformation (DOE 2024).

Transforming this market is no small feat and requires significant investment from the full breadth of stakeholders. California's flagship heat pump market transformation program TECH Clean California launched in December 2021 with a budget to support over $72 million in incentives. Due to extremely high demand, this fund was exhausted just five months later in May 2022 (TECH Clean California 2023). The program was replenished with another round of funding that was quickly consumed, while total installed costs for heat pumps remain high, with no indication that the costs will decrease in the immediate future. Based on publicly reported data, the total project cost for an HVAC heat pump in California has been over $17,000 (TECH Clean California 2024). This represents a huge up-front investment barrier for homeowners and a costly proposition for traditional utility and state programs to support affordability through traditional incentive programs. Simultaneously, there is a growing need for more skilled labor to meet all this demand. A 2019 study from UCLA's Luskin Center for Innovation estimated "that California would need 22,900–35,700 full-time construction industry workers per year from 2020–2045 to electrify California's homes" (UCLA Luskin Center for Innovation 2019).

New heat pump products are entering the U.S. market that could potentially address critical barriers including the high costs to electrify, the skilled labor challenge, and other challenges in the market such as limited electrical capacity within existing electric panels or the split-incentive challenge. Emerging packaged micro heat pump (MHP) technologies represent a new electrification pathway that could be a game changer to rapidly enable incremental or whole building electrification. As a replacement or displacement option for space heating equipment, MHPs can reduce indoor air-quality issues associated with in-unit gas-fired furnaces, inefficiencies of electric resistance heating, or be part of a whole building strategy to replace a large hydronic boiler used for space heating. In addition to space heating, MHPs can replace inefficient room air conditioners or serve as an efficient solution to support the increasing need for cooling in California due to climate change. Many of these MHPs can be deployed relatively quickly, plugging into a standard 120 V wall outlet, but the biggest advancement has been the introduction of inverter-driven, cold-climate units that can perform below 0°F, eliminating the need for backup heating sources in many North American climates.

These MHPs come in a variety of form factors to match the wide range of existing space conditioning designs and needs in residential buildings as further detailed in Table 1 on the following page. While some window MHP models look like variations of room air conditioners or packaged terminal heat pumps, the industry has also recently introduced more novel form factors including "saddle-bag" designs. However, all of the in-unit MHPs are alike in being self-contained and packaged designs.

Table 1. Summary of common micro heat pump form factors

MHP Form Factor	Installation Details	Notable Characteristics
"Saddle" window HP	The unit straddles the windowsill with evaporator and fan sitting on the inside, compressor on the outside of the building	- Well-known across the industry - Relatively quiet design - Low profile
Portable HP unit	This design option can come with an exhaust hose to vent air outdoors, or rest on the windowsill like standard window air conditioners	- Already popular in California - Lower upfront cost - Easy to move from one building or room to another - Takes up floor space - Often noisy while running
Through-the-wall HP	This is a variation of the single packaged (vertical) heat pump that can be mounted high or low, connected directly to the outdoor unit rather than through refrigerant and electrical lines.	- More intensive installation than other types but still possible for unskilled workers to drill the holes required - Still less difficult than installation of a central system - Ideal for saving space in any area with open walls - Relatively quiet
Room air conditioners (Room Heat Pumps)	These are typical AC units that are installed directly inside the window frame. In climates with cooler winters, occupants might remove the unit	- Simple installation requiring no building modifications - Low upfront cost - Risk of unit falling out of window if not secured properly - Obstructs part of the window while installed
Packaged terminal HP	DOE defines these units as a wall sleeve and a separate combination of heating and cooling assemblies mounted to an exterior wall.	- Not used as widely for residential purposes, most often for buildings like schools and hospitals - Covered units are those in the U.S. that can run on 110-volt and 120-volt in residential settings

While these different forms each have different advantages, associated market barriers, and technical performance characteristics, the majority of this paper focuses on packaged window heat pumps (PWHPs) with the first four form factors listed above. Until recently, these did not have an approved appropriate test procedure or efficiency metric for their heating operation. Despite that challenge, these PWHPs have garnered immense interest in the U.S. since the announcement of New York's Clean Heat for All Innovation Challenge (CH4A) in late 2021 (NYPA 2021). There are active studies in New York, California, the Pacific Northwest, and on the national level that are currently investigating multifamily market applications, test procedure development, field and lab performance validation, tenant behavior research, and additional factors. This paper summarizes several projects to date, the collaboration of manufacturers to rapidly develop test procedures, and the extensive stakeholder coordination between multiple energy efficiency organizations, manufacturers, and standards and regulatory bodies all working together to accelerate market viability of these products.

Packaged Window Heat Pump Research Review

In just over two years PWHPs have seen a tremendous level of activity including technology development, field and lab evaluations, as well as product definitions, performance specifications, standards and test procedures as described in further detail below. These simultaneous efforts aim to support and validate PWHPs as a viable replacement for existing gas equipment in California, New York, and nationally. Increasing urgency for utility electric demand reduction and decarbonization of space heating is driving accelerated manufacturer investments and accompanying federal, state, and utility incentive programs, both necessary to support rapid technology development and deployment efforts.

Table 1 shows several key research activities focused on bringing these new heat pumps to market but also to coordinate the necessary technical validation to support future incentive programs and tax credits. These initiatives are further described below.

Table 1. Key research activities for PWHP

Initiative / Activity	Organization(s)	Date
Clean Heat for All (CH4A) Innovation Challenge	New York Housing Authority (NYCHA), New York Power Authority (NYPA), New York State Energy Research and Development Authority (NYSERDA)	December 2021
CH4A: Declaration of Design Specifications	NYCHA, NYPA, NYSERDA	February 2022
CEE Super-Efficient Room Conditioner	Consortium for Energy Efficiency (CEE)	February 2022
CH4A: Awardees announced	NYCHA, NYPA, NYSERDA	August 2022
Industry Working Group formed (Test Development)	(6) Manufacturers, (9) Energy Efficiency Organizations, (2) Testing Labs	June 2023
Consumer Field Testing	Northwest Energy Efficiency Alliance (NEEA)	July 2023
CH4A: Prototype Installation	NYCHA, NYPA, NYSERDA	September 2023
Industry Working Group presents its findings to CEE	(6) Manufacturers & CEE	September 2023
Multifamily market potential study	CalNEXT	November 2023
ENERGY STAR ® FINAL Test Method	Environmental Protection Agency (EPA)	April 2024
Laboratory Performance Testing	CalNEXT	May-August 2024
CH4A: Scaled Deployment (30,000 units)	NYCHA, NYPA, NYSERDA	Planned: September 2024
Super-Efficient Room Conditioner (SERC) Initiative update resulting in 25C tax credits	CEE	Future: TBD

New York's Clean Heat For All Innovation Challenge

In December 2021, the New York City Housing Authority (NYCHA) in collaboration with New York Power Authority (NYPA) and New York State Energy and Development Authority (NYSERDA) launched their Clean Heat for All (CH4A) global innovation challenge to engage manufacturers to develop novel heat pump technologies to decarbonize NYCHA buildings and to reduce emissions from buildings by 40% by 2030 as a steppingstone to 80% greenhouse gas (GHG) emissions reductions by 2050. Space and water heating and cooling currently produce the majority of NYCHA emissions, and 53% of total U.S. residential emissions (EIA 2018).

As of early 2022, 100% of NYCHA cooling was provided by resident-owned window air conditioners. The United States market has a massive presence in this space, with NYPA estimating the presence of over 50 million room air conditioners in the U.S. (NYPA 2022a). For this challenge, NYCHA sought standalone unitary PWHPs 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. Aesthetics and volume of operating equipment were considered as additional non-energy, quality of life impacts.

NYCHA committed another $70 million through this innovation challenge to conduct scaled deployments for the winners, following initial performance validation (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 those 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 requirement; 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 • Refrigerant • Install Procedure • Install Time	Drainage for condensate (meltwater) shall not require a plumber.
	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

Identical requirements were incorporated into the CEE SERC initiative. *Source*: NYPA (New York Power Authority). 2022. *Specifications for Clean Heat for All Challenge Cold Climate Packaged Heat Pump Solution.* Request for Proposal, New York: NYPA.

Additional design options were considered by a technical evaluation panel to score the proposed products. These technologies further support energy efficiency as well as ease of installation and service. The design targets included: minimal window light obstruction, avoiding use of electric resistance, low indoor sound levels, support for lower global warming potential (GWP) refrigerants, building management system integration capability, estimated useful life of at least 20 years, removability from the window, and short lead times for delivery schedules.

In response to the global innovation challenge, two manufacturers—Gradient and Midea America—were selected to produce and install 72 prototype units in NYCHA apartments beginning September 2023. These units are currently undergoing in-field validation with a scaled deployment expected in September 2024 before the program moves forward with the staged installation of 30,000 total units (NYSERDA 2023).

Consortium For Energy Efficiency (CEE): Super-Efficient Room Conditioner Initiative

In February 2022, coinciding with the release of New York's CH4A specification, CEE released their Super-Efficient Room Conditioner (SERC) Initiative, which defined the opportunities of this new class of products bringing binational exposure to the efforts from New York's CH4A effort (CEE 2022). 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 as those under the CH4A Specification. The initiative was developed to help define future incentive programs that could be enacted by its members. This process has been completed for many other products over decades, including clothes washers and dishwashers (CEE 2024).

With the passage of the Inflation Reduction Act (IRA) of 2022, CEE's standard initiatives were given added market importance by connecting the efficiency tiers defined within CEE's initiatives to an expanded Residential Energy Efficiency Tax Credit that included high efficiency heat pumps (Senate of the United States 2022) (IRS 2024). This means that when future performance tiers are defined within CEE's SERC initiative, it would not only define utility incentive program parameters but could qualify participants for the Residential Energy Efficiency Tax Credit, which can account for up to a 30% federal tax credit. CEE performance standards currently include specifications for split ducted heat pumps, ductless heat pumps, and PTHPs. CEE is in the process of collaborating with DOE and the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) alongside individual manufacturers to validate models likely to meet IRA criteria for the 25C tax credit (CEE n.d.).

Industry Working Group on SERC Performance Testing Harmonization

In June 2023, following the development of the CEE SERC Initiative, manufacturers including Midea, Gradient, and Gree self-organized and led a working group to develop an interim heating performance test procedure. Additional working group participants included DOE, EPA, and testing labs such as Intertek. While there were performance requirements specified under the CH4A innovation challenge, these were adapted from tests intended for other product types since there was no applicable DOE or other industry-approved test procedure for measuring the heating performance of these units at the time of the program. Under current federal requirements, PWHPs are classified as Room ACs and only had requirements to test and rate their cooling performance. A test procedure that evaluated heating performance needed to be

developed to access more robust market support through ENERGY STAR recognition and future IRA tax credits.

After several months of meetings, the group eventually converged on an interim heating test procedure for these products by specifying the acceptable measurement tolerances needed for repeatability and reproducibility to validate performance of the below-freezing temperatures these units would be tested under. The working group culminated with a presentation to the CEE Industry Partners meeting in September 2023. This interim test procedure formed the basis of the heating performance requirements that are were developed into EPA's Final Draft Test Method to Determine Room Air Conditioner Heating Mode Performance (2024).

EPA ENERGY STAR Test Method, Product Classes, Efficiency Metrics

In December 2023, the EPA released their Draft 1 Test Method to Determine Room Air Conditioner Heating Mode Performance (EPA 2023). This specification defined the procedure for a new method of test, defined a new performance metric Heating Energy Efficiency Ratio (HEER), and defined three new classes of products based on their outdoor temperature operating limitations. While most products to-date are either a fixed speed mild climate heat pump or an inverter-driven cold climate heat pump that meets the CH4A innovation challenge, EPA also defined a cool climate heat pump anticipating varying product specifications to meet varying regional climate needs.

In April 2024, the EPA released "Final Draft Test Method to Determine Room Air Conditioner Heating Mode Performance" (EPA 2024). Changes from the Draft 1 Test Method to the Final Draft Test Method include:

- Updated definitions of room heat pumps to Types 1-4 rather than the classes defined by their outdoor temperature operating limitations
- Removal of capacity ratios and efficiency requirements
- Addition of a simulated cut-out
- Added test conditions for single-speed and variable-speed units
- The $H_{2,int}$ test is now optional for all units
- Requirement for meltwater to be drained using a drain port during testing if possible

The nomenclature for defining heat pump types was changed in response to stakeholder concerns that a refrigeration system may be able to operate at certain temperatures but less efficiently in some clients; the change allows ENERGYSTAR ® and other efficiency specifications to properly evaluate factors such as efficiency and capacity ratio instead of depending on the narrowly focused test method definitions.

While stakeholders have submitted comments seeking further clarification on some parts of the test procedure and recommendations for future changes, all submitted and published comments are supportive of EPA and DOE efforts to provide an accurate test method and accompanying potential for incentives to various stakeholders for energy efficiency improvements. The Room Air Conditioner Test Method showcases the potential for innovation through collaboration between stakeholders all along the supply chain from the pre-test method working group to EPA's responsiveness to docketed comments on the procedure.

Consumer Insights from NEEA Micro Heat Pump Field Study

In July 2023, the Northwest Energy Efficiency Alliance (NEEA), an alliance of more than 140 utilities and energy efficiency organizations in the Pacific Northwest, commissioned a consumer research study to assess consumer use and experience with these new products. Three popular MHP form factors were chosen: “saddle”, portable units, and classic room AC. The research was intended to obtain insights on customer experience with this new class of products, to guide the future of utility programs and voluntary programs like EPA, and to provide input to manufacturers to improve overall customer experience (NEEA 2023).

The study had two components. The first phase was a set of detailed interviews with a diverse set of 36 consumers in Oregon and Washington State which found that the concept of plug-in conditioning units was familiar to the participants and that there was perceived value associated with energy savings. Under Phase 2, a sample of 12 participants were delivered units to better understand the customer experiences of both installing and operating parameters of the units within their homes. Key findings from the study indicated that the saddle-type units were viewed very favorably and that most customers were satisfied with the ease of use and performance. Of the 36 Phase 1 participants, eight raised issues with the mechanical noise level of the portable and room AC form factor. However, follow up survey responses indicated that the noise was not actually bothersome but rather any volume equipment would be louder than the completely silent electric resistance alternative. 10 out of the 12 Phase 2 participants were pleased with their product experience including noise and aesthetics to the point of recommending purchasing the product.

While there is likely to be significant variation in consumer sentiment towards energy efficiency and levels of skepticism for the technologies based on the region, the general premise is that consumers are accustomed to and enjoy using electric plug-in comfort devices such as space heaters. More consumer research is needed as these heat-pump products become more available to landlords, contractors, and building occupants – but the initial study is promising.

CalNEXT Research: Market Study, Technical Potential Study, and Laboratory Validation

CalNEXT is a utility-funded research program on behalf of the three electric investor-owned utilities in California: Southern California Edison, Pacific Gas & Electric, and San Diego Gas & Electric (CalNEXT 2024). The mission of CalNEXT is to identify emerging technology trends, validate promising technologies, and to transfer commercially available technologies to the utility program portfolio. As a part of that vision CalNEXT funded the following two projects related to MHPs. The first, to assess the state of the market of MHPs, the related building stock for multifamily buildings, and to estimate energy savings and GHG reduction potentials. The second study, related to performance validation, is currently underway conducting laboratory performance evaluations of MHPs with the aim to support future implementation of related utility incentive programs. CalNEXT is using a nationally recognized testing laboratory to test the selected sample units for the heating mode following the EPA test method. Tests for heating load points most relevant to California’s mild climate are of specific interest. Both studies are detailed further below.

CalNEXT Market and Technical Evaluation of Multifamily In-Unit Heat Pumps[1]

This CalNEXT project conducted a market study to characterize the MHP products available as well as investigating building-stock data in California to determine what the relative impact potential for these products is. The study also included a building stock impact modeling assessment and conducted building energy modeling assessments based on the National Renewable Energy Laboratory (NREL) Building Energy Optimization Tool (BEopt)[2] and the OpenStudio Parametric Analysis Tool (PAT).

The study's findings indicated that the current disaggregated standard ratings environment between existing AC/furnace efficiency metrics, traditional heat pump solutions (central heat pumps), and the numerous types of novel MHPs complicate comparisons for consumers and future programs. The study highlighted the growing opportunity presented in southern coastal regions of California where many buildings may only have space heating but are expecting needs for space cooling to adapt to increased heat storms. The wide range of building types in California suggests the need to innovate and develop a diverse set of heat pump solutions and to consider continuing complexity to fit into the widening range of heating performance metrics from heating seasonal performance factor (HSPF), HEER and coefficient of performance (COP). While the modelling results predicted energy savings of up to 40% and 20% in cold climate regions and mild climate locations respectively, operating costs did not universally decrease with today's rates. It remains to be seen how future rates may change the cost effectiveness for end users. The study highlighted that field performance evaluation of MHPs, as well as independent laboratory testing is critical for the ongoing product improvements, customer satisfaction and support incentives through national, state and utility incentive programs.

CalNEXT Emerging Micro Heat Pumps: Testing and Heating Performance Metrics[3]

Building upon the preceding study, this CalNEXT project is focused on delivering laboratory performance validation testing of MHP products both to validate the effectiveness of the 2024 test procedure developed by EPA for the heating mode of PWHPs, as well as to understand the relative performance across products with different attributes and form factors to inform the broader market and program design. To further this understanding, the project team worked collaboratively with key manufacturer stakeholders, regional efficiency research partners, and voluntary standards organizations to review the heating performance test standard for PWHPs.

After conducting an initial series of interviews with manufacturers, the research team found that as many as three manufacturers can meet the PWHP requirements from CH4A/SERC listed above in Table 2, with multiple manufacturers claiming they are able to provide heat below 0°F in laboratory tests without backup heating.

CalNEXT is using a nationally recognized testing laboratory to test a number of units for the heating mode following the EPA test method, with an emphasis on results for heating performance at different representative outdoor temperatures and load conditions. The laboratory test plan includes running the following tests for applicable units and comparing results to expected values:

[1] calnext.com/wp-content/uploads/2023/10/ET22SWE0035_Multifamily-In-Unit-Heat-Pumps_Final-Report.pdf
[2] www.nrel.gov/buildings/beopt.html
[3] calnext.com/approved-projects/#ET23SWE0034

- Cooling performance testing under RAC- DOE test procedure at 10 Code of 6 Federal Regulations (CFR) 430, Subpart B, Appendix F or in 10 CFR 430.2.
- ENERGYSTAR ® Heating Mode Test Method (2024) – Table 3, Table 9, or Table 10
- Defrost – EPA's $H_{2,int}$ test to be performed down to lowest achievable outdoor temperature.
- Sound test – basic assessment of noise while unit functions.
- Controls verification through performing RH CVP specified in the ENERGYSTAR ® test method (2024), and heating-specific CVP set forth in Appendix I to AHRI Standard 1600-2024.

Table 3 provides a more detailed description for each unit that is planned for testing including approximate values for the expected (rated) heating and cooling values. The team initially considered equipment that fit the specifications of 120 V, 60hz, 15A, and able to heat down to 35°F. The team selected units that represented a variety of ENERGYSTAR ® heat pump types from the 2024 test procedure, with emphasis on the most efficient (Type 4) units to gain a better understanding of the technologies that are being developed for this emerging market.

Table 3. Product configurations and information for units planned for CalNEXT laboratory testing

(Anonymized) Unit Number	Product Configuration	Compressor speed	Heat Pump Type	Cooling Rating (BTU/h)	Heating Rating (BTU/h)	Refrigerant
1	"Saddle" window HP	Variable	Type 4	9,000	9,000	R-32
2	Portable HP Unit	Variable	Type 3	12,000	9,500	R-32
3	Room air conditioners (HP)	Variable	Type 4	9,000	9,000	R-32
4	Room Heat Pump (Baseline)	Single-speed	Type 1	10,000	9,000	R-32
5	Through-the-wall HP	Variable	Type 4	11,600	10,500	R-32
6	"Saddle" window HP	Variable	Type 4	9,000	9,000	R-32
7	Through-the-wall HP	Variable	Type 4	8,000	4,500	R-410A

Testing is expected to conclude by the end of August 2024. The team intends to use the resultant performance data to validate EPA's "Final Draft Test Method to Determine Room Air Conditioner Heating Mode Performance" (2024). Additionally, results will help the industry to better understand performance across products with different form factors and other varying features. As these products begin to enter the market, both end users and programs will need to navigate a confusing plethora of product features, form factors, performance characteristics, and product ratings. Continued collaboration with stakeholders along the entire supply chain and data from CalNEXT and other organizations will help define the promising future of MHPs.

Equity Considerations for Residential Heat Pumps

In 2021, President Biden created the Justice40 Initiative to outline accountability for federal agencies delivering 40% of overall benefits from federal investments to disadvantaged communities with tracking towards that performance (The White House 2021). The Justice40 Initiative identifies disadvantaged communities using a mapping approach, focusing on those "marginalized by underinvestment and overburdened by pollution" (The White House 2023). The Inflation Reduction Act (2022), mentioned above for its potential to support technologies like MHPs by promoting energy efficiency and clean energy, provides opportunities specifically for multifamily residential building occupants. Low-income rental housing tenants can benefit from tax credits as efficiency incentives: even though the building owner will receive the rebates, they would be more likely to invest in energy efficient technologies due to the availability of tax credits. In addition to energy-bill related savings, tenants would benefit from improved indoor air quality and overall pollution reduction.

Closer to home for CalNEXT, Governor Newsom of California has established more localized commitment to funding disadvantaged communities through clean and healthy homes (Newsom 2022). Incorporating these communities into the process as early as possible ensures that the benefits and burdens of the energy sector are equitably distributed. To minimize the risk of perpetuating inequity, programs and policies must be developed with intentional consideration of potential unintended consequences on vulnerable populations. Micro heat pumps are a technology that has the potential to have considerable impact on disadvantaged communities such as those living in affordable housing.

Conclusion

Micro heat pumps are a promising group of products with tremendous potential to unlock new pathways of building decarbonization at scale and fulfill California's goals to deploy six million heat pumps along with helping national efforts towards decarbonization in the electricity sector. These new products are rapidly entering the marketplace with potential to address the high costs to electrify, address market needs for different form factors and noise, and other challenges in the market such as limited electrical capacity within existing infrastructure. However, MHPs are still in the early market development stages and require robust lab and field validation of performance.

While MHPs have garnered significant interest from energy efficiency stakeholders as a missing tool in the building decarbonization toolkit, there are still barriers for deployment, particularly related to test procedures, product designation, features, and comparative performance. Manufacturers, federal standards and specification bodies, and other energy efficiency stakeholders are working collaboratively to address these barriers and support for model that can achieve colder climate operation below 0°F while efficiently heating and cooling homes even in the variably harsh conditions in climate zones found in the northeast and northwest. DOE and EPA efforts to develop test procedures have showcased the support and engagement that manufacturers, energy efficiency advocates, and other stakeholders are willing to show for MHPs as their presence increases within the U.S. market. Studies and testing efforts including NEEA, CalNEXT, and others will provide visibility into actual product performance, consumer preferences, and determine validity of manufacturer performance based on the recently released ENERGY STAR specification.

With increasing numbers of MHP models in the U.S. market there will be new questions to answer about how to effectively develop the necessary market incentives to support access to equitable and efficient heating and cooling.

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