Clean Heat for All: Taitem Measurement and Verification

Final Report | Report Number 25-21 | May 2025 | Re-issued October 2025

NEW YORK STATE

NYSERDA
New York State Energy Research and Development Authority

50 YEARS 1975-2025

NYSERDA’s Mission:

NYSERDA catalyzes New York’s clean energy transition.

Our Vision:

Clean energy that supports a healthier and thriving future for all New Yorkers.

Our Promise to New Yorkers:

NYSERDA serves New York State as a trusted and credible resource for energy information, policies, and programs, through objective analysis and planning, innovative solutions, and impactful investments that are valued by New York residents and businesses.

NYSERDA Record of Revision

Document Title
(25-21) Clean Heat for All Pilot: Taitem Measurement and Verification May 2025 | Re-issued October 2025

Revision Date	Description of Changes	Revision on Page(s)
October 27, 2025	Updated names of manufacturers. ‘Midea’ became ‘Midea America’ and ‘Gradient Comfort’ became Gradient	Throughout body of report
October 27, 2025	Sec 1.4.4 - Clarified humidification feature would not be included in production model PWHP	P. 8
October 27, 2025	Sec 4.1 – removed proprietary language about modifications to compressor algorithms	P. 24
October 27, 2025	Sec. 4.3 – clarified language; changed ‘failed’ to ‘malfunctioned’	P. 25
October 27, 2025	Sec. 5.1 – clarified language to specify that more testing is needed to support that hypothesis.	P.29
October 27, 2025	Sec. 6.6 – added clarification that a 9k BTU capacity heat pump was requested for this program. As it was written before, it could be interpreted as the report asserting the manufacturers oversized their heat pumps.	p. 36
October 27, 2025	Appendices A and B—Links to external appendix files temporarily removed.	p. A-1–B-29

Clean Heat for All Pilot: Taitem Measurement and Verification

Final Report

Prepared for:

New York State Energy Research and Development Authority

Albany, NY

James Mannarino
Senior Project Manager, NYSERDA

Jordan Bonomo
Senior Program Manager, NYCHA

Sinan Chen
Lead Project Engineer, NYPA

In coordination with:

New York City Housing Authority and New York Power Authority

New York, NY

Prepared by:

Taitem Engineering

Ithaca, NY

Nate Goodell
Distinguished Engineer

George Aiken
Project Engineer

Jon Harrod
Senior Energy Analyst

NYSERDA Report 25-21 | NYSERDA Contract 215459 | October 2025

Notice

Preferred Citation

New York State Energy Research and Development Authority (NYSERDA). 2025. "Clean Heat for All Pilot: Taitem Measurement and Verification, Final Report." NYSERDA Report Number 25-21. Prepared by Taitem Engineering, Ithaca, NY. nyserda.ny.gov/publications

Abstract

This report presents the results of a field demonstration of packaged window heat pumps (PWHPs) as a scalable, lower-cost, low-disruption retrofit solution for electrifying buildings’ heating and cooling systems. Through the Clean Heat for All (CH4A) Pilot, New York City Housing Authority (NYCHA), New York State Energy Research and Development Authority (NYSERDA), and the New York Power Authority (NYPA) selected two PWHP models by Midea America Corp. (Mide America) and Gradient for installation in 24 apartments. Taitem Engineering provided measurement and verification (M&V), supported by MaGrann Associates. While this demonstration focuses on evaluating PWHP viability for NYCHA buildings, PWHPs hold potential as a heat pump electrification retrofit solution for many buildings in New York City and elsewhere. The demonstration showed strong performance in terms of energy savings, occupant comfort, and ease of installation, although further study is needed in colder climates and across diverse building types.

Keywords

heating, ventilation, and air conditioning (HVAC), electric air source heat pump (ASHP), split or mini-split heat pump, variable refrigerant flow (VRF) heat pump, packaged window heat pump (PWHP), heat pump condensate management, refrigerant lines, A2L refrigerants, ramp up, variable speed compressor, short cycling, compressor control, condensate pumps and filters, float switch, setback temperature, building electrification retrofit, decarbonization, measurement and verification (M&V), nonspecialized labor or installers, demand diversity, peak riser demand, temperature and humidity data loggers, current transformer (CT) sensor, eGauge power, Building Automation and Control Network (BACnet), lead and asbestos abatement, heating season (NYC), cooling season (NYC)

Acknowledgment

NYSERDA would like to acknowledge the leadership and support provided by NYCHA, without which Clean Heat for All would not have been possible; particularly, Jordan Bonomo, Siobhan Watson, Daniel Melo, and Vlada Kenniff. Additionally, the tenants of NYCHA’s Woodside Houses who participated in this pilot and provided invaluable feedback on product performance. Finally, thank you to the teams at NYPA, Midea America, Gradient, and Taitem Engineering and Magrann Associates for their work and partnership.

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

ºF	degrees Fahrenheit
A	amperes
Btu/h	British thermal units per hour
Btu/HDD/sf	British thermal units per heating degree day per square foot
CEER	combined energy efficiency ratio
cfm	cubic feet per minute
CH4A	Clean Heat for All Challenge
COP	coefficient of performance
CT	current transformer
dB	decibel
EER	energy efficiency ratio
GWP	global warming potential
HDD	heating degree days
HFC	hydrofluorocarbon
HSPF	heating seasonal performance factor
HVAC	heating, ventilation, and air conditioning
kBtu/sf/yr	thousand British thermal units per square foot per year
kW	kilowatt
kW/apt	kilowatt hours per apartment
kWh	kilowatt hours
M&V	measurement and verification
NYCHA	New York City Housing Authority
NYPA	New York Power Authority
NYSERDA	New York State Energy Research and Development Authority
Pa	Pascal
PTAC	packaged terminal air conditioner
PTHP	packaged terminal heat pump
PWHPs	packaged window heat pumps
RFP	request for proposal
SEER	seasonal energy efficiency ratio
V	volt
VRF	variable refrigerant flow

Definitions

A2L refrigerants are low-global warming potential (GWP) hydrofluorocarbon (HFC) refrigerants with mild flammability, increasingly used in heat pump systems to reduce environmental impact while meeting safety standards.

BACnet (Building Automation and Control Network) is a standardized communication protocol used in multifamily buildings to enable interoperability between building automation devices, such as HVAC, lighting, and security systems, for centralized monitoring and control.

Building electrification retrofit refers to the process of upgrading existing structures by replacing fossil fuel-based systems with electric alternatives—such as heat pumps—for heating, cooling, and hot water to reduce carbon emissions and improve energy efficiency.

Compressor control algorithm is the set of logic and parameters embedded in HVAC control systems that modulates compressor speed, capacity, and cycle timing to maintain target temperatures while optimizing energy efficiency, reducing short-cycling, and extending equipment life.

Condensate pumps and filters are components used in HVAC systems to collect and move condensed water from heat pump units to a proper drainage location, with filters ensuring debris does not clog the pump or drainage system.

Cooling season (NYC) generally refers to the warmer months, typically from June through September, when indoor cooling systems are in active use, though it is not formally defined by city code like the heating season.

CT sensor (current transformer sensor, or CT) is a device used to measure electrical current flow in circuits, enabling monitoring and analysis of energy consumption for systems like heat pumps or lighting.

Decarbonization is the reduction or elimination of greenhouse gas emissions from building operations by transitioning to electric systems powered by clean energy and improving overall energy efficiency.

Demand diversity refers to the variation and offsetting of peak energy usage patterns among multiple units or systems, which can reduce overall peak demand and improve the efficiency of shared heating, cooling, or electrical infrastructure.

eGauge power meter is an energy monitoring device that measures real-time electrical consumption and generation across multiple circuits, using current transformers and voltage inputs to provide detailed data for performance analysis and verification.

Electrical riser is a vertical distribution system that carries electrical power between floors in a building, connecting the main service panel to individual units or subpanels through conduit, cabling, and junction boxes.

Electric air source heat pump (ASHP) systems provide both heating and cooling entirely through electricity, relying on a refrigerant cycle to absorb and release heat between indoor and outdoor air, for efficient space heating and cooling, eliminating the need for fossil fuel-based equipment and supporting building decarbonization.

Float switch is a safety device used in HVAC systems to detect rising condensate water levels; it automatically shuts off the system or activates a pump to prevent overflow and water damage.

Heat pump condensate management in multifamily buildings involves collecting, draining, and safely disposing of the water produced when heat pumps remove moisture from the air during cooling or dehumidification to prevent water damage and maintain system efficiency.

Heating season (NYC) refers to the period from October 1 through May 31 during which building owners are legally required to provide heat when outdoor temperatures fall below specified thresholds, as defined by New York City Housing Maintenance Code.

HVAC (heating, ventilation, and air conditioning) refers to the systems used in multifamily buildings to regulate indoor temperature, air quality, and humidity, ensuring occupant comfort and maintaining healthy living conditions.

Lead and asbestos abatement in multifamily buildings involves the identification, containment, and safe removal or remediation of hazardous lead-based paint and asbestos-containing materials to protect occupant health and ensure regulatory compliance during renovation or demolition activities.

Measurement and verification (M&V) in assessing packaged window heat pump (PWHP) performance involves systematically collecting and analyzing data on energy use, indoor comfort, and operational conditions to validate the actual performance and effectiveness of the PWHPs in multifamily buildings.

Nonspecialized labor or installers in the context of installing packaged window heat pumps (PWHPs) refers to the ability to complete installation using general construction or maintenance workers without requiring certified HVAC technicians, enabling faster and potentially lower-cost deployment in buildings.

Packaged window heat pump (PWHP) systems are self-contained, through-window ASHP units that provide both heating and cooling by transferring heat to or from the outdoor air, offering a compact and energy-efficient alternative to conventional HVAC systems.

Peak riser demand in multifamily buildings refers to the highest simultaneous electrical load observed on a vertical distribution system (riser) serving multiple units, critical for sizing and managing shared electrical infrastructure.

Ramp up, in the context of variable speed compressors, refers to the gradual increase in compressor speed or output in response to rising heating or cooling demand, allowing variable speed systems to operate efficiently and avoid sudden energy spikes or mechanical stress.

Refrigerant lines are insulated pipes that carry refrigerant between the indoor and outdoor units of heat pump systems in multifamily buildings, enabling heat transfer for heating and cooling functions.

Setback temperature refers to a preprogrammed indoor temperature—typically lower in winter or higher in summer—used during unoccupied periods to reduce HVAC energy use while maintaining basic comfort and system efficiency.

Short cycling refers to the frequent and premature turning on and off of a heat pump or compressor, often caused by improper sizing or control issues, which can reduce efficiency, increase wear, and shorten equipment lifespan.

Split or mini-split heat pump systems are ASHPs consisting of an outdoor unit connected to one or more indoor air handlers, delivering zoned heating and cooling without ductwork and providing high energy efficiency and installation flexibility.

Temperature and humidity data loggers are electronic devices used to continuously record environmental conditions, enabling monitoring of indoor climate and verification of HVAC system performance.

True RMS energy data refers to measurements that accurately calculate the root mean square (RMS) of voltage and current even in the presence of distorted or non-sinusoidal waveforms, providing precise energy monitoring in complex electrical systems.

Variable refrigerant flow (VRF) heat pump systems are ASHPs using a network of refrigerant lines to connect multiple indoor units to a single outdoor unit, allowing simultaneous, zoned heating or cooling with high efficiency and simultaneous heating and cooling temperature control.

Variable speed compressor refers to a type of compressor used in heat pump systems that can adjust its operating speed to match heating or cooling demand, improving energy efficiency, comfort, and system longevity compared to single-speed models.

Executive Summary

The New York City Housing Authority (NYCHA) has set ambitious goals for decarbonizing its housing stock. Finding efficient electric alternatives to fossil fuel heating systems and room air conditioners has emerged as a central challenge in this effort. Many currently available heat pump solutions present several challenges, including high costs, long implementation and construction timelines, electrical infrastructure improvements, the need to erect scaffolding, significant disruption to occupants, and new wall penetrations for refrigerant lines that can sometimes trigger lead or asbestos abatement.

As an alternative, a packaged window heat pump (PWHP) that nonspecialized installers can fit into an existing window opening represents a cost-effective, scalable approach for electrifying existing NYCHA properties, as well as buildings throughout New York State and beyond.

As a suitable PWHP product did not exist on the market, NYCHA partnered with the New York State Energy Research and Development Authority (NYSERDA) and the New York Power Authority (NYPA) to develop actionable PWHP performance specifications and, subsequently, a competitive request for proposals (RFP) seeking a PWHP product meeting those specifications. In late 2021, the Clean Heat for All (CH4A) pilot RFP was released and guaranteed winners a substantial initial order of at least 10,000 PWHPs that met those specifications. At a high level, successful PWHPs were required to:

- Plug into a standard 120-volt (V), 15-ampere (A) household circuit.
- Achieve a coefficient of performance (COP) of 1.85 at 17 degrees Fahrenheit (ºF) outdoor temperature, with a heating output of 9,000 British thermal units per hour (Btu/hr).
- Incorporate features to minimize electrical demand.
- Be suitable for installation by NYCHA property management staff, without requiring a plumber, mechanical contractor, or other skilled tradesperson.
- Be installable in under two hours, with minimal disruption to occupants.
- Feature easy, intuitive operation; operate quietly enough not to disturb tenants; and meet occupant comfort needs.
- Minimize window obstruction, thermal bridging, and air leakage.

Two teams, Midea America Corp. (Midea America) and Gradient were selected to develop a PWHP model for a field demonstration. Teams installed 36 PWHPs from each manufacturer across 24 typical NYCHA apartments, resulting in a full demonstration of 72 PWHPs.

Taitem Engineering, under contract with NYSERDA, provided measurement and verification (M&V) services for this demonstration. As part of the M&V services, Taitem collaborated closely with the manufacturers, NYCHA, NYPA, and NYSERDA to facilitate product improvements. Each manufacturer also leveraged findings from the field demonstration to improve their designs. This report presents Taitem's study results, along with additional data on air leakage, sound levels, and installation times provided by MaGrann Associates.

Table ES-1. Summary of Field Results: Installation, Operation, and Occupant Satisfaction

Category	Details
Power	Plugs into standard outlet
Install Time	Less than 2 hours
Maintenance	• Regular filter changes required • Residents now perform filter changes themselves • Filters are field-swappable
Heating	• Maintains winter average: 74.5°F • 89% of occupants report "just right" comfort • 11% report "too warm" (indicating ample capacity)
Occupant Survey	• 81% satisfied • 17% neutral • Only 2% are dissatisfied
Air Leakage	• Minimal impact on infiltration or drafts compared to existing windows
Noise Level	• Under 50 dB at low fan speed
Infrastructure Impact	• No infrastructure upgrades needed • Uses novel condensate dispersal
Peak Power Draw	• Less than expected • Average 50% increase in peak kW at risers (modest compared to existing use)
Energy Efficiency	• Highly efficient and effective • COP >4 at 47°F[a] • COP >2 at 5°F[a]

[a] Lab-based results.

The results to date are very promising:

- Both manufacturers developed PWHPs that operate on a standard household outlet.
- Both PWHPs employed novel condensate management techniques that eliminated the need for drain piping.
- Electrical loads remained within the capacity of existing infrastructure. No tripped breakers or blown fuses occurred within apartments or at electrical risers serving multiple apartments.
- PWHPs appear significantly more efficient than the central steam systems they replaced. NYCHA preliminary cost savings estimates for this installation are approximately 50%. (See Bonomo (2025) slide 22 for details).
- Monitoring data and occupant feedback indicate that the PHWPs maintain comfortable apartment temperatures.

This success does, however, come with some caveats:

- The winter during the initial demonstration period (2023–2024) was relatively mild, so evaluators could not extensively monitor PWHP performance in very cold weather. Further study in colder climate zones and more building types could help determine the extent to which these systems are widely applicable.
- Residents appear to have used the PWHPs in very different ways, which significantly affected the energy use. Further study on usage patterns could help provide insights into what impacts different use patterns had on equipment efficiency and overall energy consumption.

While longer-term research is warranted to examine the real-world performance and electrical demand impacts, this initial field demonstration shows PWHPs offer a promising solution for decarbonizing NYCHA's housing stock and many other types of buildings.

1 Introduction

This section provides an overview of the Clean Heat for All NYCHA pilot, including its background, the study's objectives, the project location, and key PWHP performance details. It establishes the context for this joint pilot and field demonstration and outlines the technical requirements and evaluation criteria.

1.1 Background on the Clean Heat for All Pilot Program

The New York City Housing Authority (NYCHA) has set ambitious goals for decarbonizing its housing stock. Space heating and cooling consume the most energy in buildings, so NYCHA has prioritized finding efficient electric heat pump alternatives to fossil-fuel heating systems and room air conditioners. However, two commonly used approaches, variable refrigerant flow (VRF) and split heat pumps, have significant drawbacks: high costs, lengthy implementation times, the need for electrical service and distribution upgrades, new wall penetrations for refrigerant lines that can sometimes trigger lead or asbestos abatement, and substantial disruption to occupants. The transition to lower global warming potential (GWP), mildly flammable (A2L) refrigerants has further increased costs and engineering complexity for these field-assembled systems.

Modern packaged terminal heat pumps (PTHPs) can offer a viable solution in buildings with existing through-wall packaged terminal air conditioner (PTAC) sleeves. However, most NYCHA buildings lack these sleeves, so installing PTHPs would require new wall penetrations.

The emergence of "over-the-sill" air conditioners with saddle-shaped designs that minimize window blockage has introduced a promising alternative. A packaged window heat pump (PWHP) that nonspecialized installers can place in an existing window opening presents a cost-effective, scalable approach to electrifying NYCHA properties. This solution may also find broad application in multifamily retrofits throughout the Northeast and beyond.

As no suitable PWHP product existed on the market, NYCHA partnered with New York State Energy Research and Development Authority (NYSERDA) and New York Power Authority (NYPA) to develop a competitive solicitation. In 2022, they launched CH4A, which guaranteed the winner a substantial initial order for a PWHP that met NYCHA's criteria. At a high level, the solicitation required successful entries to:

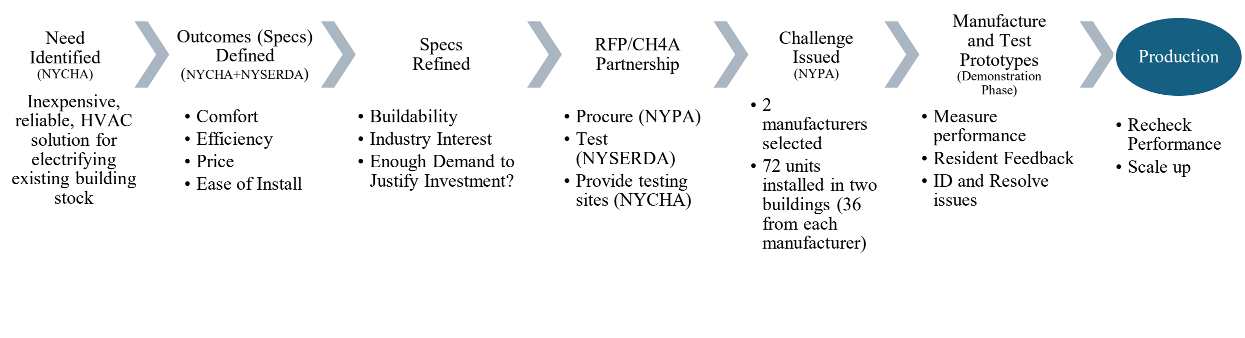
- Use an over-the-sill form factor for installation in existing window openings.
- Plug into a standard 120-volt (V), 15 amperes (A) household circuit.
- Achieve COP of 1.85 at 17 degrees Fahrenheit (ºF) outdoor temperature with a heating output of 9,000 British thermal units per hour (Btu/hr).
- Incorporate features that minimize electrical demand.
- Allow installation by non-specialized labor (e.g., property management staff), without requiring a plumber, mechanical contractor, or other skilled tradesperson.
- Install within a few hours and cause minimal occupant disruption.
- Meet occupant comfort needs.
- Provide easy, intuitive operation.
- Minimize window obstruction, thermal bridging, and air leakage.
- Operate quietly enough not to disturb occupants.

NYSERDA supported the development of technical specifications for the CH4A solicitation and funded performance testing during the initial product demonstration phase. NYPA managed procurement and contracting.

The challenge received six entries. From those, evaluators selected two products, one from Midea America and one from Gradient, for field demonstration. Crews installed 36 units from each manufacturer in 12 typical NYCHA apartments, resulting in a full demonstration of 72 PWHPs in 24 NYCHA homes.

Taitem Engineering, under contract with NYSERDA, provided measurement and verification (M&V) services for the demonstration. As part of the M&V services, Taitem worked closely with the manufacturers, NYCHA, NYPA, and NYSERDA to facilitate product improvements. This report presents Taitem's findings and includes additional data on air leakage, sound levels, and installation times provided by MaGrann Associates.

Figure 1. Clean Heat for All Challenge Measurement and Verification Project Summary: Major Milestones



1.2 Study Objectives

Taitem's mandate was to verify that the selected products met Clean Heat for All program specifications. These specifications included both quantitative metrics, such as power consumption, and qualitative measures, including tenant surveys. Initially, Taitem designed the study based on a conventional M&V approach that emphasized impartial measurement and evaluation. This method recommends changes only when evaluators observe serious problems. It relies heavily on data collected via direct monitoring of equipment and environments with analysis at predefined intervals, treating occupant surveys and site observations as secondary sources of information.

However, early stakeholder feedback showed that this approach would not best serve the project. In response, Taitem modified the study design to provide rapid feedback that could inform ongoing product development. By reporting operational issues as they emerged, Taitem enabled manufacturers to make timely corrections during the field demonstration. Evaluators (i.e., The NYCHA, NYPA, and NYSERDA project oversight team with support from the Taitem & MaGrann M&V technical staff) then reviewed these improvements within the study timeframe.

The M&V scope included:

1. Energy consumption: Measured energy use for each PWHP at the apartment circuit breaker.
2. Peak demand and demand diversity: Analyzed peak power demand impacts for multiapartment electrical risers.
3. Room temperatures: Measured room temperatures post-retrofit in spaces with and without PWHPs.
4. Discharge temperatures: Tracked the temperature of heated or cooled air exiting the PWHP.
5. Air leakage: Measured air leakage before and after installation.
6. Sound levels: Recorded decibel levels at standard distances from the units.
7. Occupant experience: Collected occupant feedback on thermal comfort, ease of use, product size, noise levels, and overall satisfaction.
8. Installation and maintenance: Evaluated installation time and difficulty and gathered NYCHA staff feedback on routine maintenance and reported issues.
9. Functional testing: Documented controls, general operation, and achievement of other CH4A functional requirements, including condensate management.

In addition to the field data and observations noted above, Evaluators also used field demonstration data and third-party laboratory testing to determine compliance with CH4A specifications. This report also highlights unexpected and noteworthy findings. It does not evaluate measured efficiencies, energy savings relative to baseline fossil fuel use, or direct comparisons between the Gradient and Midea America units.

1.3 Project Location

NYCHA selected two buildings with identical layouts within the Woodside Houses complex in Woodside, Queens, New York City, for the field demonstration (Figure 2). Each building has six floors with eight apartments per floor. The buildings use master meters for electricity, and NYCHA pays all utility costs.

A central gas-fired steam boiler plant and distribution system provide heating to the entire Woodside complex. Each room receives heat from a radiator or, in bathrooms, from radiation through the main steam riser. Tenants can control their in-apartment temperatures to a limited extent using shutoff valves on radiators, in some instances, and/or opening windows. Each apartment stack is connected to a shared electrical riser that carries three phases of power; each apartment panel uses two of the three phases.

NYCHA staff installed PWHPs in two apartment stacks (Riser A and Riser B), totaling 12 apartments per building. Building M received Midea America PWHPs, and Building G received Gradient PWHPs. Each apartment has a living room, kitchen, bathroom, and two bedrooms. Installers placed a PWHP in each living room and both bedrooms, totaling three per apartment and 36 PWHPs per building. Radiators in each apartment were disconnected and removed and the steam risers were shut off.

Figure 2. Map of Project Location

Note red circles and arrows indicating buildings where PWHPs are installed.

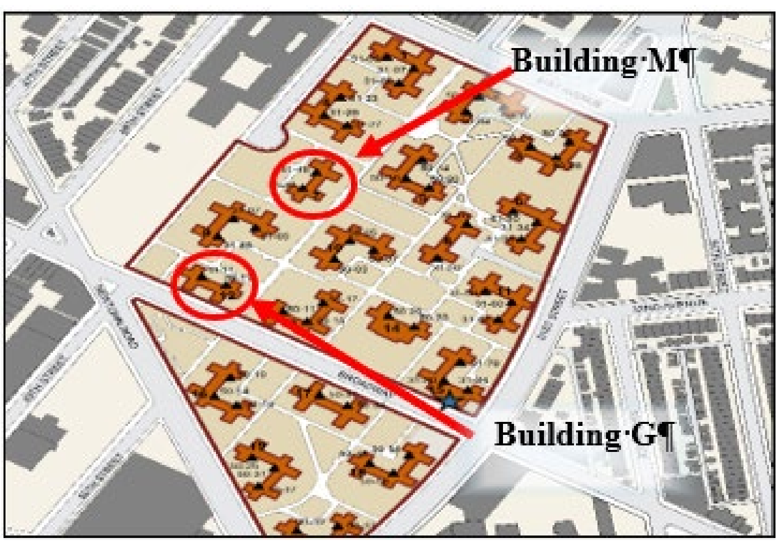
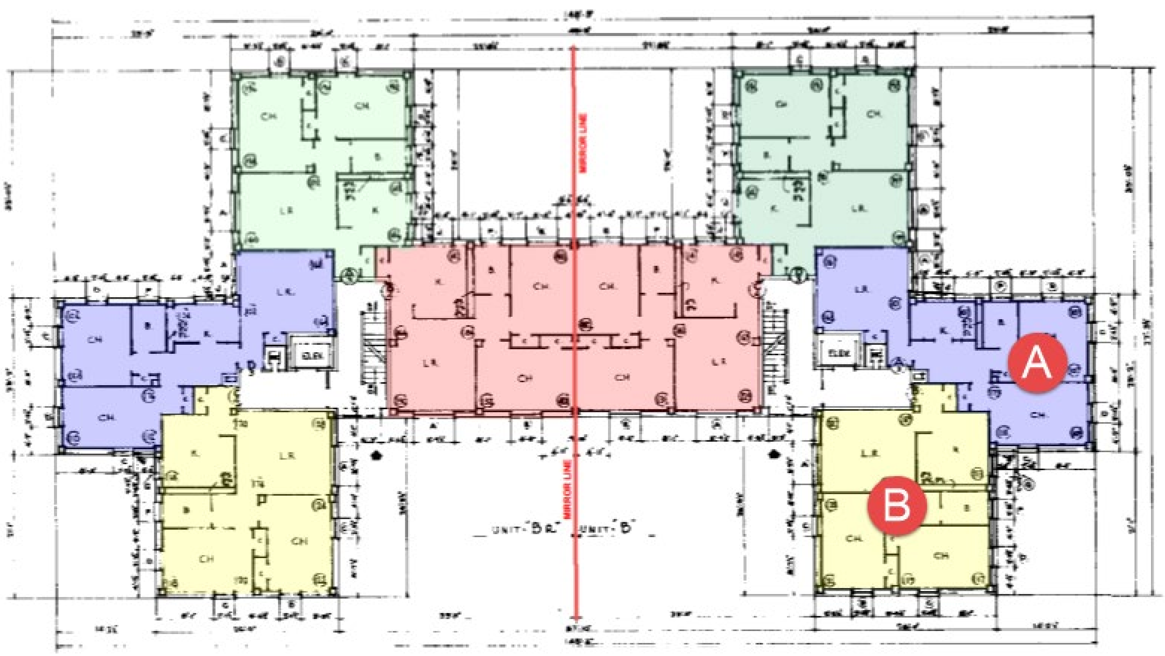


Figure 3. Image of Building M, Exterior

Note red outlines around installed PWHPs.

Figure 4. Floor Plan for Typical Woodside Buildings and Apartments

Red circular A and B apartment risers where PWHPs were installed.



1.4 Product Details

This section outlines the technical specifications, shared features, and unique characteristics of the two PWHP models selected for the CH4A field demonstration. It also describes key design elements, installation processes, and condensate management systems developed to meet program requirements.

1.4.1 Shared Product Features

Although the Midea America and Gradient PWHPs resemble standard window air conditioners or other saddle-style heat pump systems, they share several key features developed specifically for the CH4A project that significantly increase their effectiveness:

- Employ a saddle-style form factor with indoor and outdoor sections joined by a hinged connector, allowing easy installation and maintenance while minimizing window obstruction and air leakage.
- Deliver a nominal capacity of 9,000 Btu/hr down to 17F.
- Operate on a dedicated 120V, 15A circuit.
- Provide low ambient heating operation (both manufacturers report operation down to -13F).
- Include integrated condensate removal mechanisms that eliminate the need for drain piping.
- Incorporate custom control logic to reduce peak heating demand.
- Address occupant comfort with design features that manage directional airflow at head and torso level.
- Support BACnet communication capability.
- Use R-32 refrigerant, which has a significantly lower global warming potential than R-410A.
- Built and designed for long-term durability with a minimum 10-year compressor warranty.

The CH4A solicitation also included a point-based scoring system for desirable noncritical features, such as extended cold climate performance, wireless BACnet, and accelerated demonstration unit production.

Both products follow a similar installation process: Installers mount a support bracket in the window opening, lift the unit into place, and tilt the outdoor component into a vertical position. They seal perimeter gaps with a compressible foam gasket.

Figure 5. Representative Images from Field Installation

1.4.2 Midea America

The Midea America PWHP weighs 130 pounds and fits windows 27 inches or wider. The performance metrics are presented in Table 1, with additional details provided in the manufacturer's product data sheet (See Section 7.2, Appendix A.5 for more measurements and additional specifications).

Table 1. Midea America Unit: Performance Metrics

Source: Manufacturer-provided Intertek test data (Xiao, Allan and Cai, Elvis. December 4, 2024) and Midea America website.

Mode	Outdoor Temp (ºF)	Capacity (Btu/hr)	Efficiency	Seasonal Efficiency Rating
Cooling	95	9,010	11.81 (EER)	CEER 16
Heating	47	9,256 [a]	4.01 (COP) [a]	SEER2 18.76
Heating	17	9,152 [a]	2.50 (COP) [a]	—
Heating	5	9,620 [a]	2.10 (COP) [a]	HSPF2 10.12
Heating	-13	5,050	1.41 (COP)	—

[a] Represents Intertek testing data.

Figure 6. Midea America Unit: Installation Images

Images captured during functional testing and installation demonstration.

1.4.3 Gradient

The Gradient PWHP weighs 140 pounds and fits in windows 26 inches or wider. The performance metrics are presented in Table 2, with additional details in the manufacturer's product data sheet (See Section 7.2, Appendix A.5 for more measurements and additional specifications).

Table 2. Gradient Unit: Performance Metrics

Source: Gradient-provided performance metrics.

Mode	Outdoor Temp (ºF)	Capacity (Btu/hr)	Efficiency
Cooling	95	9,300	13.6 (EER)
Heating	47	9,000	4.04 (COP)
Heating	17	9,000	2.37 (COP)
Heating	5	7,200	2.06 (COP)
Heating	-13	7,026	1.59 (COP)

Figure 7. Gradient Unit: Installation Images

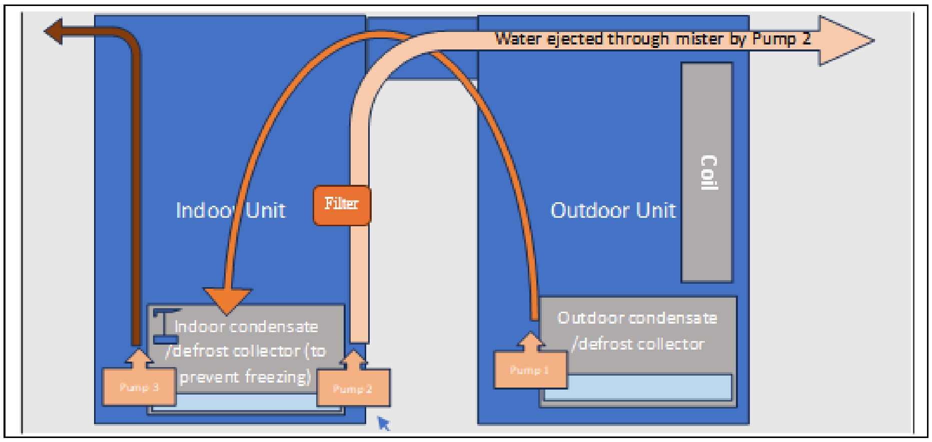
1.4.4 Condensate Handling Details

Both products meet the CH4A requirement for self-contained condensate management systems. By eliminating the need for a condensate drain and plumbing, these features significantly reduce installation complexity and cost.

The Midea America PWHP collects condensate from the indoor coil in a reservoir in the indoor section. It also pumps defrost meltwater from the outdoor section to the indoor reservoir. A second pump ejects water from this reservoir outdoors as a fine mist. A third pump in the indoor section can disperse water into the indoor airstream for humidification if desired (note: optional humidification was a feature of the Midea America PWHP provided for the Pilot; this feature is not included in the updated production version).

Figure 8. Midea America System Components with Demonstration-phase Improvements

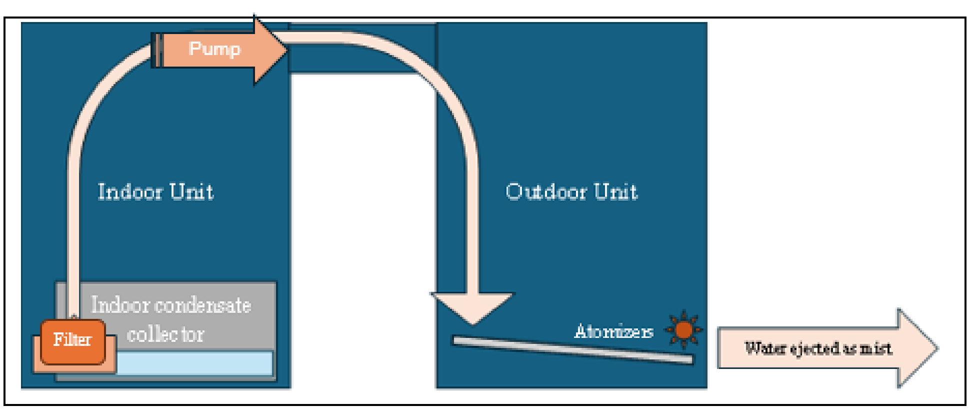
Pump 1 returns condensate and defrost meltwater from the outdoor coil to the indoor reservoir, preventing it from freezing. Pump 2 ejects water from the indoor condensate reservoir to the outdoors as a fine mist, protected by a cleanable inline filter that prevents nozzle clogging.
Pump 3 disperses condensate and defrost water into the indoor air for humidification (note: this humidification function was included in the first version and is not a feature of the updated production PWHP).



The Gradient PWHP uses a single pump to deliver condensate from the indoor coil to an outdoor drain pan, where the system atomizes and emits it as vapor. The system collects defrost meltwater in this outdoor drain pan and atomizes and emits it.

Figure 9. Gradient System Components with Demonstration-phase Improvements

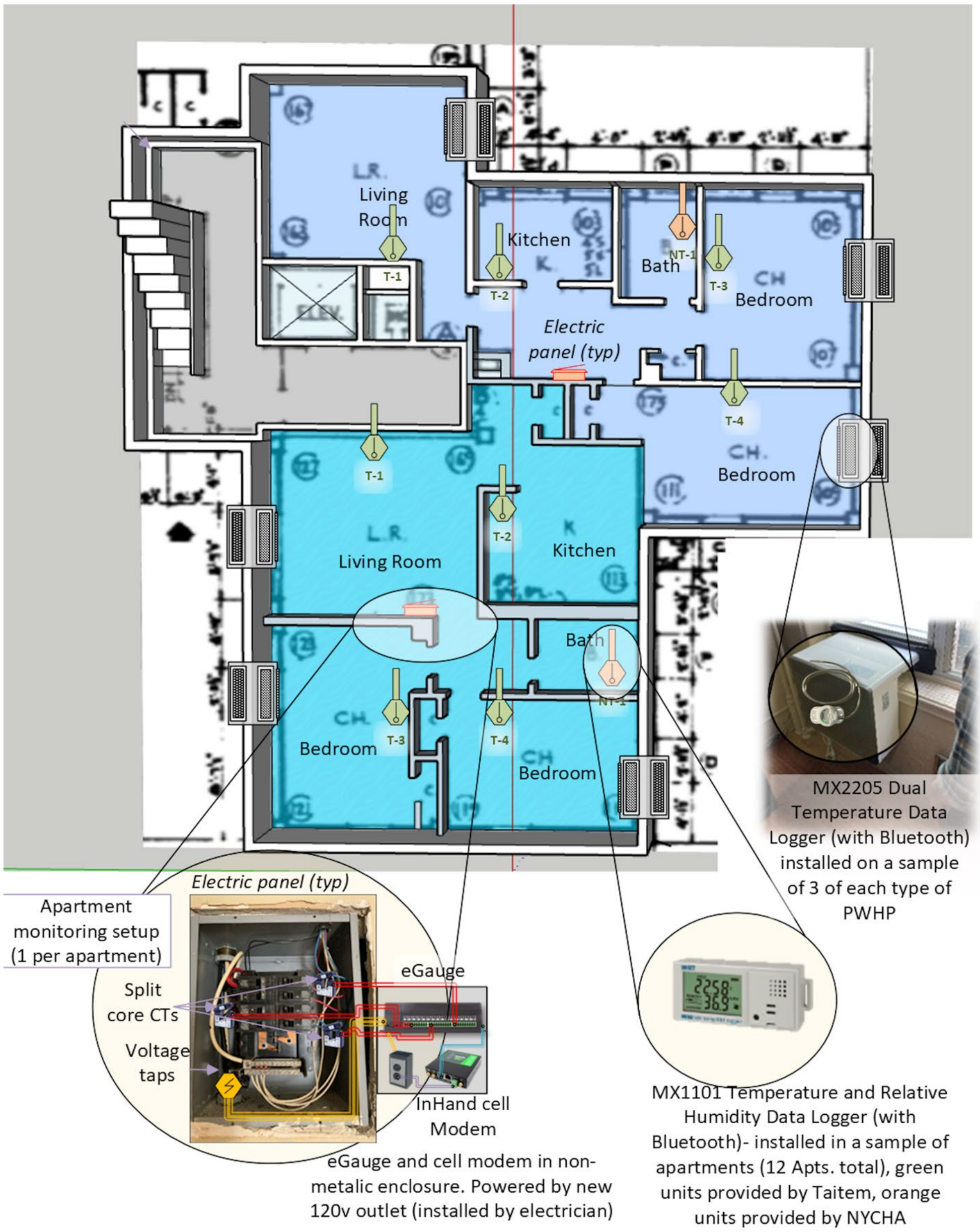
A single pump delivers water from the indoor condensate reservoir to outdoor atomizers.
A cleanable filter protects the pump from indoor-side debris; outdoor-side water bypasses filtration (deemed unnecessary for the atomizers). The system automatically mists condensate and defrost water to the outdoors through the unit's bottom front panel. Electric resistance heat prevents defrost water from freezing before it is ejected.



2 Data Collection Methods

The team collected data using the methods described below. Figure 10 illustrates the apartment-level monitoring setup.

Figure 10. Typical Monitoring Setup for A and B Line Apartments



As part of the M&V process, the team measured the following parameters through ongoing monitoring or on-site field verification:

- Energy consumption: The team installed an eGauge power and energy meter, along with a cellular modem located in an enclosure next to each apartment's electrical panel. Split-core current transformers measured current consumption on each PWHP branch circuit, which was paired with measured voltage at each apartment panel for True RMS energy data. The data analysis covered a heating season (October 15, 2023-April 14, 2024), a partial cooling season (May 28–July 31, 2024), and the full demonstration period (October 15, 2023–July 31, 2024).
- Peak riser demand and demand diversity: The team measured peak demand for each PWHP using the installed power meters. The team also made use of current transformers and eGauge meters installed by NYCHA prior to the PWHP installations on the 3 electrical risers in each multiapartment stack (2 stacks per building, 3 risers per stack, totaling 4 apartment stacks and 12 electrical risers) to evaluate aggregate demand and demand diversity. This report leverages those meters to present peak electrical demand at the riser level as raw amperage or kilowatt (kW), and as a percentage of each riser's maximum ampacity. We also examined the timing of demand peaks and pre-installation vs. post-installation load changes.
- Room temperatures: The team installed Hobo MX1101 temperature/humidity data loggers in the living room, both bedrooms, the kitchen, and the bathroom of 12 sample apartments (5 loggers per apartment). NYCHA staff also installed a subset of these loggers before the retrofit, which allowed for a comparison of pre- and post-retrofit temperatures. The report includes space temperature averages for the heating and cooling seasons, as well as heating season minimums.
- Discharge temperatures: We measured supply air temperature in three PWHPs of each type using Hobo MX2205 dual temperature data loggers. The team also monitored supply air temperatures using additional temporary data loggers during both functional testing visits to assess temperatures under specific operating conditions.
- Air leakage: The team performed air leakage testing before and after installation using a Minneapolis Duct Blaster. We tested wall/window assemblies with and without the PWHP installed. We isolated the wall/window area (approximately 4 ft x 7 ft) using a gasketed foam board frame with plastic sheeting or by tapping a plastic sheeting directly to the wall surface. We measured air leakage at a negative pressure of 75 Pascal (Pa) relative to the outdoors.
- Sound levels: The team recorded indoor sound levels using both an iPhone app and sound level meters, which gave similar results. We recorded sound at 4 ft above the floor and 3 ft in front of the heat pump.
- Occupant experience: The team distributed an 11-question survey on thermal comfort, ease of use, usage patterns, product loudness and size, and overall satisfaction. Residents submitted responses via text, email, and a lobby drop box. Some were completed with assistance from NYCHA and MaGrann staff.
- Installation and maintenance: The team observed product installations and recorded installation time by activity (unboxing, removing existing window unit and cleaning area, mounting bracket, mounting heat pump, and air sealing opening). They also reviewed service records and work orders.
- Functional testing: The team directly observed controls, comfort, and general operation, along with other CH4A functional requirements, including condensate management.

The M&V approach taken for this project was highly customized. Traditional M&V projects emphasize impartial measurement and avoid recommending changes to equipment operation unless they discover a problem with the equipment, installation, or use case that could compromise the results. Analysis is conducted at predefined intervals and, although occasionally supplemented by onsite observations during equipment installation or retrieval or occupant surveys, it relies almost entirely on data collected from deployed sensors.

This project began with a largely traditional M&V approach. However, as the project evolved, it became apparent that the pace of product development and the type of insights most valuable to stakeholders require a more flexible strategy. These factors prompted a more ad hoc and targeted analysis approach, first identifying issues and then confirming their resolution. Early detection of issues led to some substantive modifications to field units and informed final product design. This also allowed the team to verify many of the targeted modifications and system improvements implemented during the monitoring process.

To support this more adaptive structure, the team implemented several key additions and modifications to the traditional M&V process:

- Conducted commissioning-style functional testing and field observations under simulated conditions during the demonstration phase and again with production models. This enabled the inspection of features that were not easily captured through datalogging, revealing qualitative insights into system operation.
- Performed ongoing rounds of targeted trend reviews while maintaining open communication about findings, concerns, and areas of investigation with each manufacturer. These reviews helped identify issues, explore causes, coordinate targeted product modifications and system improvements, and observe their impacts in real-time, significantly reducing turnaround time for PWHP modifications and improvements.
- Applied strategies from Real Time Energy Management projects, including automated alerts for peak riser power thresholds. These alerts notified NYCHA when consumption approached electrical circuit breaker limits or other electrical risks. The team also programmed alerts for communications losses or irregular values in apartment-level eGauges, minimizing the need for regular manual data integrity checks.

This modified M&V process proved highly effective. It uncovered—and allowed for relatively quick resolution of—several issues that standard manufacturer quality assurance, quality control, and/or customer feedback protocols may have missed.

3 Results

Table 3 summarizes the key metrics and performance data from the heating and cooling periods.

Table 3. Heating and Cooling Performance Data

Performance Metric	Midea America	Gradient
Heating Performance Data, *October 15, 2023–April 26, 2024*[a]		
Average Indoor Temperature	75.6ºF	73.4ºF
Min Indoor Temperature	64.3F (unused near bedroom)	58.4F (unused far 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[b]	1.79 kW/PWHP (3.99 kW/apt)	1.31 kW/PWHP (2.94 kW/apt)
Average Peak Power Draw[c]	1.08 kW/PWHP (2.46 kW/apt)	0.92 kW/PWHP (2.05 kW/apt)
Cooling Performance Data, *May 28–July 31, 2024*		
Average Indoor Temperature	77.5ºF	75.2ºF
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[b]	1.29 kW/PWHP (2.88 kW/apt)	0.94 kW/PWHP (2.15 kW/apt)
Average Peak Power Draw[c]	0.66 kW/PWHP (1.50 kW/apt)	0.73 kW/PWHP (1.74 kW/apt)
General Performance Data		
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
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

[a] Gradient units were installed on December 13, 2023; only partial data was collected and reported for winter 2023–2024.

[b] Absolute maximum peak power draw represents the highest recorded demand from a single PWHP or apartment. Note that both summer and winter data include periods during which system tuning was actively in progress.

[c] Average peak power draw reflects the mean of peak occurrences from each individual PWHP or apartment. This metric provides an indicator of the typical maximum draw per unit and is a useful metric when considering peak electrical draws in aggregate or for the purposes of evaluating diversity factors.

3.1 Energy Consumption and Apartment-Level Demand

During the heating season, Building M averaged 1,465 kWh per apartment in electric consumption, while Building G averaged 1,804 kWh. Both buildings exhibited significant variations in consumption between apartments. Within individual apartments, notable differences in consumption occurred between PWHPs. In some apartments, the living room units used the most energy, whereas in others, one of the bedrooms used more. Tenants had no limitations on the use of their PWHPs; they could turn the PWHPs on or off, change the mode between cooling and heating, and set the temperatures between 55ºF and 85ºF as desired.

Both PWHP products featured sequencing controls that prevented them from immediately ramping up to peak power in heating mode. The highest heating-season peak power demand measured for individual PWHPs was 1.79 kW for Midea America and 1.31 kW for Gradient. Although Midea America's peak demand approached the limit of a 15A circuit, no issues with tripped circuit breakers were reported. The peak apartment-level demand across all three PWHPs in an apartment was 3.99 kW for Midea America and 2.94 kW for Gradient, with no tripping of apartment circuit breakers reported.

While the soft ramp control sequence was neither required nor implemented by either manufacturer in cooling mode, the cooling season consumption was significantly lower than during the heating season. Average consumption was 434 kWh for Midea America and 615 kWh for Gradient. Large variations were again observed both within and between apartments. Per-unit and per-apartment demand peaks were also lower in cooling mode.

Monitoring of individual PWHP circuits provided insights into both cycling and occupant usage patterns, which are described in section 4.

3.2 Riser Demand and Demand Diversity

Although PWHPs increased demand on the electrical risers—which is expected, as heating demand originally met by NYCHA's steam heating system is now met by electric PWHPs—the increases have generally been modest and within the capacity of the existing conductors. Significant variability in loads unrelated to heating, ventilation, and air conditioning (HVAC) made isolating the effect of the PWHPs on peak demand difficult. When we extended the analysis to include data from beyond the demonstration period into winter 2024–2025, we began to observe some clustering of peak load events. However, the data clearly show that non-HVAC base loads play a significant (and highly variable) role in triggering peak load events.

Table 4. Peak Demand Events for Electrical Risers

Building M Riser A	Building M Riser B	Building G Riser A	Building G Riser B
15.4 kW (1/22/2025)	20.6 kW (1/20/2024)	15.6 kW (1/8/2025)	12.8 kW (1/22/2025)

Table 5. Occurrences of Peak Amp Draws for Individual Conductors

None of the peak events exceeded the 100A ampacity of the conductors. CT = Current Transformer; CTx-A vs CTx-B indicate different electrical risers (i.e., riser A and riser B). See Figure 4 for additional context.

Building	CT1-A	CT2-A	CT3-A	CT4-B	CT5-B	CT6-B
Building M	51.4A 1/18/2024	69.7A 1/22/2025	47.1A 1/22/2025	59.9A 1/21/2024	71.0A 1/22/2025	80.0A 1/20/2024
Building G	38.2A 7/28/2023	67.3A 1/8/2025	48.9A 1/8/2025	44.3A 7/6/2023	43.5A 1/22/2024	39.9A 1/22/2025

Table 6. Peak Events as a Percentage of Total Capacity in Building M and Building G

CT = Current Transformer; CTx-A and CTx-B indicate different risers, i.e., riser A and riser B. See Figure 4 for additional context.

	Building M - Peak Use as % of conductor max capacity					
	CT1-A	CT2-A	CT3-A	CT4-B	CT5-B	CT6-B
Pre-retrofit (January 23, 2023 - July 11, 2023)	23%	28%	29%	44%	30%	65%
Post-retrofit (July 11, 2023 - February 10, 2025)	51%	70%	47%	60%	71%	80%
Percent increase	121%	145%	60%	37%	135%	23%
Approximate date of occurence	1/18/24	1/22/25	1/22/25	12/21/24	1/22/25	1/20/24

	Building G - Peak Use as % of conductor max capacity					
	CT1-A	CT2-A	CT3-A	CT4-B	CT5-B	CT6-B
Pre-retrofit (January 23, 2023 - December 13, 2023)	49%	57%	33%	49%	35%	26%
Post-retrofit (December 13, 2023 - February 10, 2025)	38%	67%	49%	44%	44%	40%
Percent increase	-22%	19%	50%	-10%	25%	51%
Approximate date of occurence	7/28/23	1/08/25	1/08/25	7/06/23	1/22/24	1/22/25

Interestingly, several of the peak load occurrences in Building G occurred before the installation of the heat pumps. As the graphs below illustrate, changes in riser power draw following the installation of PWHPs at both buildings are relatively small compared to variability in overall consumption.

Figure 11. Building M Riser Power Draw with Installation of Heat Pumps Noted

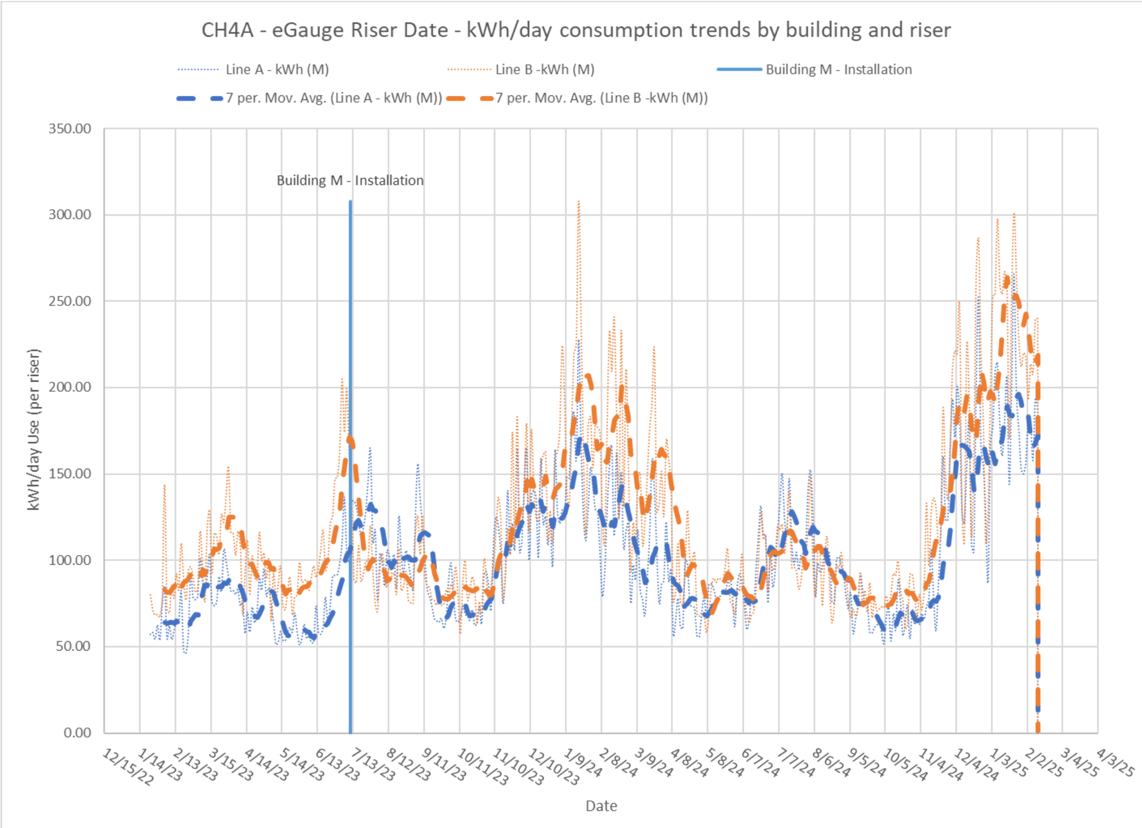
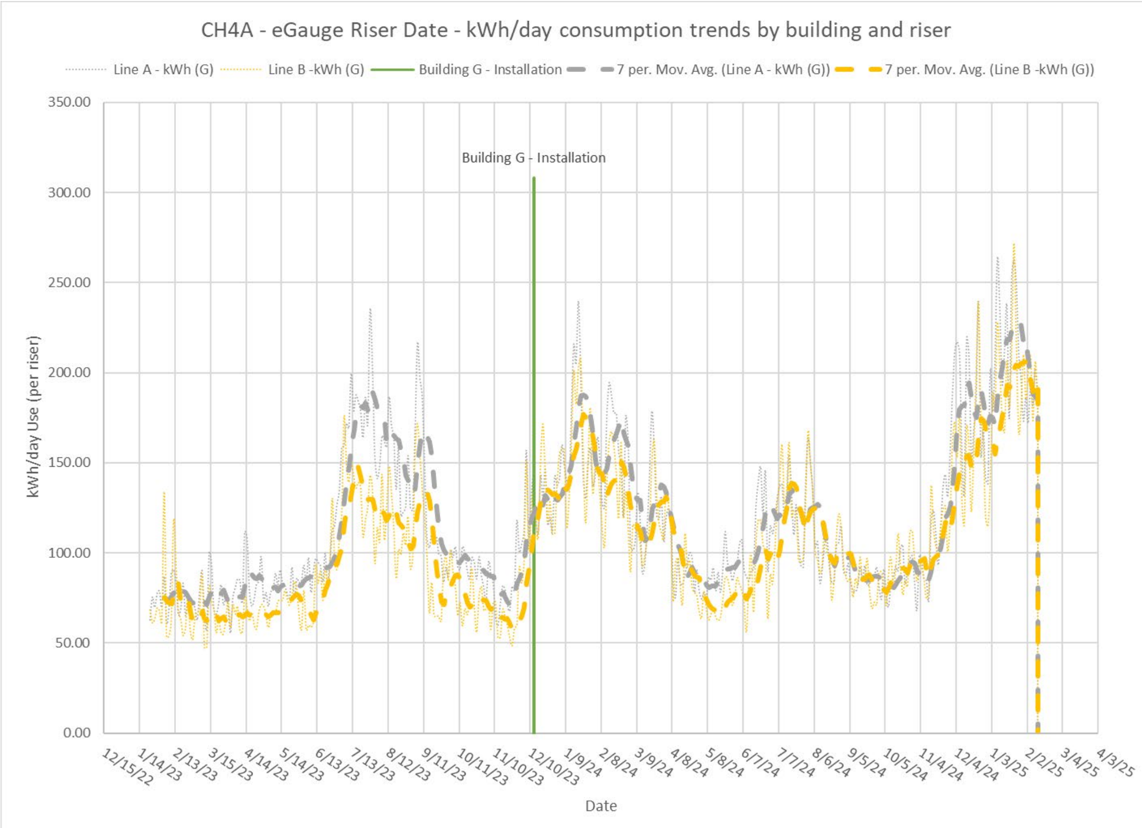


Figure 12. Building G Riser Power Draw with Installation of Heat Pumps Noted



3.3 Room Temperatures

Heating season temperatures across all apartments with PWHPs averaged 75.6ºF (Midea America) and 73.4ºF (Gradient). Most apartments maintained temperatures between 72ºF and 78ºF. Notably, the kitchen and bathroom temperatures were not significantly colder than other spaces, despite lacking a direct heat source. The lowest measured temperatures typically occurred in bedrooms where the PWHPs appeared to have been turned down or off.

Average apartment temperatures during the cooling season were 77.5ºF (Midea America) and 75.2ºF (Gradient). Space temperature trends suggest that many users operated the PWHPs similarly to a packaged air conditioner, actively cooling only the currently occupied space without necessarily maintaining a uniform cool temperature throughout the entire apartment.

3.4 Sound Levels

Field-measured sound levels with fans at high speed averaged 48.3 decibels (dB) for Midea America and 54.2 dB for Gradient. The loudest measured units were 60.2 dB (Midea America) and 55.7 dB (Gradient). As field-measured sound readings, these levels are low enough that ambient noise influenced the readings.

3.5 Air Leakage

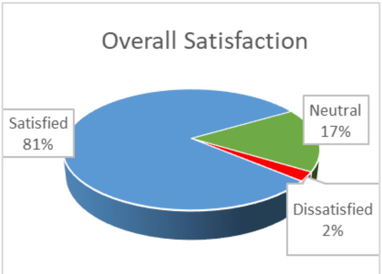
Significant variations in window condition complicated measurements of PWHP air leakage. In some cases, furniture, window trim, and other obstacles made achieving a tight fit between the test frame and the wall surface difficult, which introduced additional error. Overall differences between pre- and post-installation air leakage varied widely; average air leakage at 75 Pa ranged from a 52 cubic feet per minute (cfm) reduction to a 26 cfm increase for Midea America, and a 26 cfm reduction to a 36 cfm increase for Gradient. This indicates that air leakage rates are highly dependent on installation quality and the existing window's leakiness.

3.6 Occupant Experience

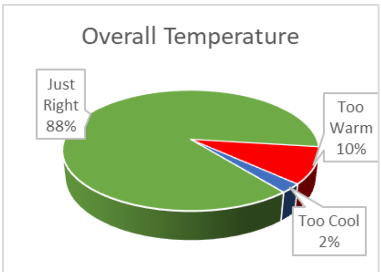
Occupant survey responses were generally positive, despite some early operational issues. Residents overwhelmingly preferred the PWHPs to steam heat. The most significant negative feedback was that some occupants felt the PWHPs were too large. In all other categories, more than 80% of respondents were satisfied (happy or neutral) with regard to temperature, ease of use, noise, and overall performance.

When questioned about thermal comfort, only one survey respondent reported insufficient heating or cooling (determined to be due to an operational issue later corrected by the manufacturer). Of the four other responses that indicated temperatures were not "just right," three reported being too warm in the winter, and one reported being too cool in the summer.

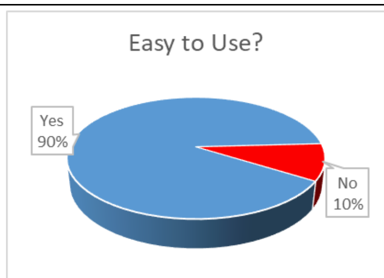
Figure 13. Clean Heat for All Challenge Overall Survey Summary



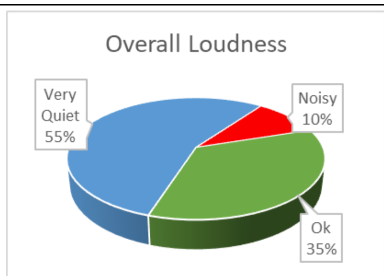
Overall satisfaction responses were extremely high. One dissatisfied response was received during the cooling season, resulting from equipment issues that were identified and corrected in the production models.



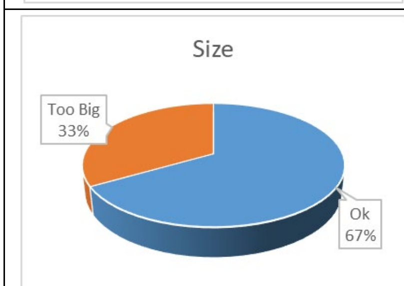
Temperature responses are similarly favorable. Notably, only one of the four “too warm” responses was received during cooling, and the other three were during the heating season. Similarly, the one “too cool” response was collected during the cooling season, indicating that if anything, the main issue with these systems is oversizing.



Ease-of-use was generally reported as good. Both manufacturers have made improvements to their interfaces, which should enhance the user experience.



The majority of respondents reported that the PWHPs were very quiet. Only 10% of respondents found the systems to be noisy. Of those reports, several can be traced back to identified and resolved operational issues (largely relating to the condensate handling).



By far, the most negative feedback received was directed at the size of the PWHPs. When asked if the size was okay or too big, roughly one-third of the respondents felt it was too big.

3.7 Installation and Maintenance

After an initial round of training, NYCHA maintenance crews consistently install units in less than 2 hours. They typically spent 45–60 minutes per PWHP for Midea America units and 45–70 minutes for Gradient units. During the project, they identified a few minor issues with installation procedures, which prompted improvements in instructions and mounting hardware.

The installation of PWHPs introduced new tasks for maintenance staff: air filter cleaning and annual maintenance or cleaning of the condensate filters. The team has incorporated these tasks into NYCHA's maintenance plans. As occupants have become more familiar with PWHPs, some have started cleaning filters themselves. The reduction in steam equipment maintenance has reportedly offset the additional staff time required for PWHPs, and overall maintenance needs do not appear to have increased.

Despite support from the NYCHA project management team, some maintenance staff reported negative opinions about the PWHPs. Their reluctance seems to stem from how significantly PWHPs depart from NYCHA's historical heating methods (oil and gas-fired steam boilers) and how the new systems shift established maintenance practices, i.e., shifting from hands-on work in a mechanical room often requiring licensed staff, to diagnosing or swapping out equipment in resident apartments. This shift also leans more on general, technology-based tasks that require different experience or training.

3.8 Functional Testing

Both PWHP models met the criteria outlined in the CH4A specifications. Functional testing and feedback from occupants and maintenance staff revealed issues with the control interfaces, mounting brackets, installation instructions, condensate management, discharge air temperature controls, and control sequences related to ramp speeds in heating and low-load operation. Section 4 discusses several of these in detail.

3.9 Ongoing Results

The monitoring period for these systems officially ended in August 2024. Most of the appended reports and all formally reported apartment-level data cover the period from October 15, 2023, to August 1, 2024. Even after the official monitoring period ended, the monitoring systems have remained in place and continued to operate through May 2025. While data from the remotely accessible eGauge systems has been available for download, NYCHA manually retrieved temperature data from loggers, with the last retrieval in January 2025.

Without completing a full re-analysis, Taitem conducted high-level reviews of apartment temperatures, energy consumption, and electrical riser peak draws for the harsher 2024–2025 winter experienced through January 2025. These reviews found no issues with occupant comfort, PWHP capacity, or peak loads on risers or apartment electric panels, although they did observe some increases in overall use in response to greater heating loads.

To provide relevant information about the impacts of that increased use, without delaying the release of current findings for ongoing data analysis, Taitem proceeded with a focused evaluation of the riser data over the extended period, with a similar expansion of the apartment level analysis. The riser-level data collection and analysis spans from January 2023 through March 2025 and is summarized in the earlier sections of this report.

Although normalized power consumption metrics were not a direct project deliverable and could not be calculated within the (less than one year) official demonstration period, they were identified as areas of interest by involved parties. In response, the team used data collected during this extended period to provide rough estimates.

The team calculated a whole-apartment electrical energy consumption per square foot for all apartments served by the new PWHPs over the full year from January 1, 2024, to January 1, 2025. The results were 33.9 thousand British thermal units per square foot per year (kBtu/sf/yr), when calculated using Real Power, and 34.6 kBtu/sf/yr, when calculated using Apparent Power. The team based the power metering entirely on riser-level electric measurements, and as such, the metrics exclude nonelectric loads such as DHW generation, cooking stove energy, and laundry systems.

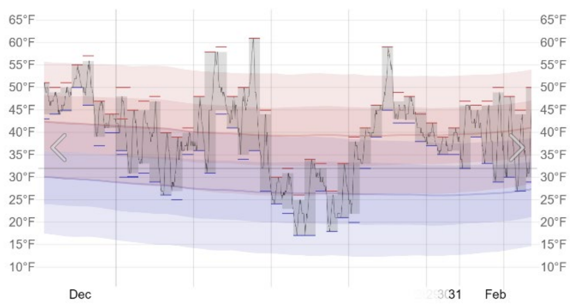
The team also calculated a second metric, British thermal units per heating degree day per square foot (Btu/HDD/sf), based on PWHP energy use for heating, normalized to ambient weather conditions. This value was calculated at 3.2 Btu/HDD/sf. Although this is a common metric for heating-only systems, it presents challenges for systems that allow room-by-room control and provide both heating and cooling. For this reason, the team used the period from November 1, 2024, to March 31, 2025, for this analysis. This period accounts for approximately 88% of the heating degree days for the 2024–2025 season, it represents a conservative approach because PWHPs operate more efficiently at warmer temperatures (which are excluded) and are more likely to be turned off when apartments are satisfied. The team excluded apartments with missing data, such as missing bedroom readings, or known data quality issues.

In comparing winter 2023–2024 with winter 2024–2025, note that "mild" refers to minimum temperatures reached. According to NYSERDA LaGuardia Airport data, winter 2023–2024 saw 3,478 heating degree days (HDDs) through March 31, while winter 2024–2025 reached 3,695 HDDs, about 6% more. In January 2025, the coldest month so far in both years, temperatures regularly fell below 20ºF and even dipped below 10ºF for a period. In contrast, temperatures in January 2024 only occasionally fell below 20ºF.

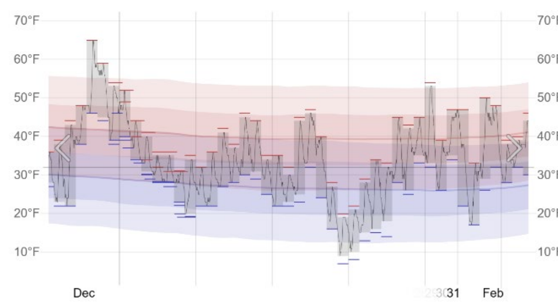
Figure 14. Daily Outdoor Temperature Ranges During 2024 and 2025 Heating Seasons

The daily range of reported temperatures (gray bars) and 24-hour highs (red ticks) and lows (blue ticks) are plotted over the daily average high (faint red line) and low (faint blue line) temperatures, with 25th to 75th and 10th to 90th percentile bands.

Source: WeatherSpark (n.d.)



2024



2025

4 Feedback for Product Development

The modified M&V approach employed in this project enabled the team to provide PWHP product design teams with feedback that led to concrete improvements. Subsequent observations confirmed that these changes resolved the identified issues without introducing new problems.

4.1 Tuning for Low-Load Operation

Early results showed that some Midea America systems cycled on and off excessively. The team alerted the manufacturer; in response, the Midea America team worked with their component suppliers to refine the operating parameters. These changes dramatically reduced cycling (see Figure 15) and should improve occupant comfort, system efficiency, and longevity.

Figure 15. Illustration of System Tuning on Packaged Window Heat Pumps Operation as Observed via Measured Energy Consumption Data

The team observed similar cycling in the Gradient systems but could not confirm that it stemmed from the same root cause. The team shared this observation; in response, Gradient has committed to improving overall PWHP performance and reduce excessive cycling through firmware and hardware improvements since the initial demonstration tests.

Although the team does not have data to determine the exact impact this cycling has on real-world efficiency, the modifications to the Midea America units show a clear operational benefit.

4.2 Controls Interface Improvements

The team discovered one unexpected issue: cats (and possibly other pets) frequently lie on top of the units. This behavior has two side effects: (1) cats clawed at the air sealing foam material; and (2) cats interacted with the top-mounted controls interfaces. This caused particular problems with Gradient's "touch knob" style interface.

Figure 16. Controls Interface Evolution

The initial Gradient controls interface is depicted on the left, and the production model controls interface is on the right.

Some cats inadvertently performed a "long button press," triggering a factory reset on the Gradient units. Normally, a factory reset may cause a minor loss of functionality or connectivity issues, but it would not have a significant functional impact. However, the demonstration-phase products lacked a complete sequence of operations in their factory programming. In cooling mode, unexpected factory resets caused condensate overflow. Gradient responded by redesigning the user interface so that a factory reset could not be triggered by the external controls.

4.3 Condensate Pump Improvements

After several months of use, some condensate pumps in the Midea America units malfunctioned, preventing both the removal of condensate water and the ejection of defrost water. Midea America responded quickly by replacing the malfunctioning components and investigating the cause and identified specific design features that made the pumps prone to clogging.

As a temporary solution, Midea America adjusted pump seals and replaced malfunctioning pumps while testing further modifications. The ultimate solution involved replacing all pumps with a redesigned component less prone to clogging. Midea America conducted extended run-time and endurance tests on the new pumps, and NYCHA continues to monitor their performance. The team installed the new pump solutions in the demonstration units in May 2024. As of May 2025, no additional issues have been reported.

4.4 Condensate Filter Improvement

Both systems experienced clogged condensate filters. The manufacturers redesigned their filters to make them larger and easier to replace. The Woodside location exposed systems to airborne particulates common in urban settings, high salt concentrations, indoor dust, lint, and hair, and pollen and other organic debris from nearby trees. These conditions made Woodside an ideal demonstration site, representative of many NYCHA properties and multifamily buildings in coastal cities.

Figure 17. Improved Inline Filter Arrangement: Midea America Production Model

Both manufacturers implemented filters with larger surface areas. This simple design change enables filters to last a full year, aligning with annual maintenance visits, significantly benefiting both occupants and maintenance teams.

4.5 Condensate System Improvements

Both manufacturers experienced and addressed issues with their novel condensate handling system. The team observed improvements to the Midea America units over a full cooling season, while the upgrades to the Gradient units, installed later, were only observed over a partial season.

Some of the issues identified and addressed on the Gradient systems include:

- Factory resets: The factory programming initially omitted the correct condensate handling sequence, which Gradient later installed through an over-the-air update. When units accidentally reset to their factory default, they failed to operate correctly. Gradient responded by redesigning the user interface to prevent accidental factory resets.
- Unit leveling: Because PWHPs are easily removable and often bumped into by people, improperly installed or shifted units can cause condensate overflow. Gradient responded by updating the installation instructions with tighter leveling tolerances and supplying an upgraded mounting bracket. During functional testing, the team inspected the new hardware and confirmed it was extremely sturdy.
- Condensate filters clogging and kinked or obstructed condensate lines: Unexpected particulate loads and kinks from manufacturing or installation obstructed the condensate lines, causing overflow or system lockouts due to high water alarms. Gradient redesigned the condensate system to improve access, extend filter life, and reduce the likelihood of kinking.
- Condensate float switches: Issues with the programming and float switch operation led to some condensate overflow events. In response, Gradient added a secondary float switch and adjusted the condensate handling programming to accurately track float switches after power loss.
- Unit sweating: Condensation formed on internal components and dripped outside the drain pan, causing leaks. Gradient resolved the issue by adding insulation to prevent condensation in those areas.

5 Additional Observations

5.1 Usage Patterns

Although the monitoring systems could not directly track occupant manipulation of setpoint or mode, the electrical monitoring data suggests that most people operate PWHPs more like a room air conditioner or space heater (on demand, turned up or on when actively in the space and turned down or off when leaving) rather than as a central system (set with a single fixed setpoint and possibly a night setback). The data collected from two apartments, shown below, illustrates the different use patterns.

Figure 18. User-driven Operation: Building M, Apartment 3B

June 20–25, 2024: User-driven on/off operation of the living room unit (orange) and bedroom (black) show clear transitions between occupied periods, indicating on-demand use rather than fixed setpoints.

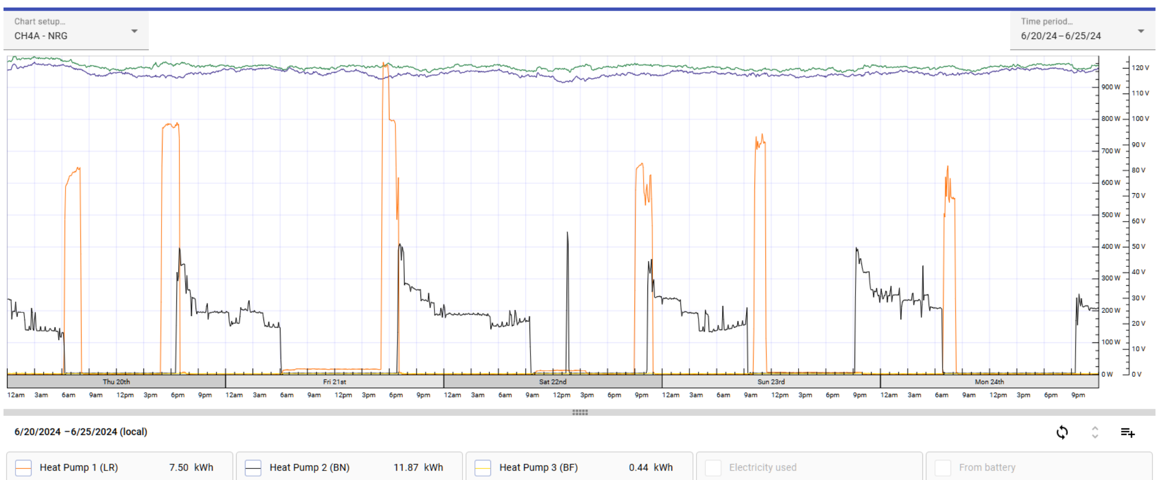
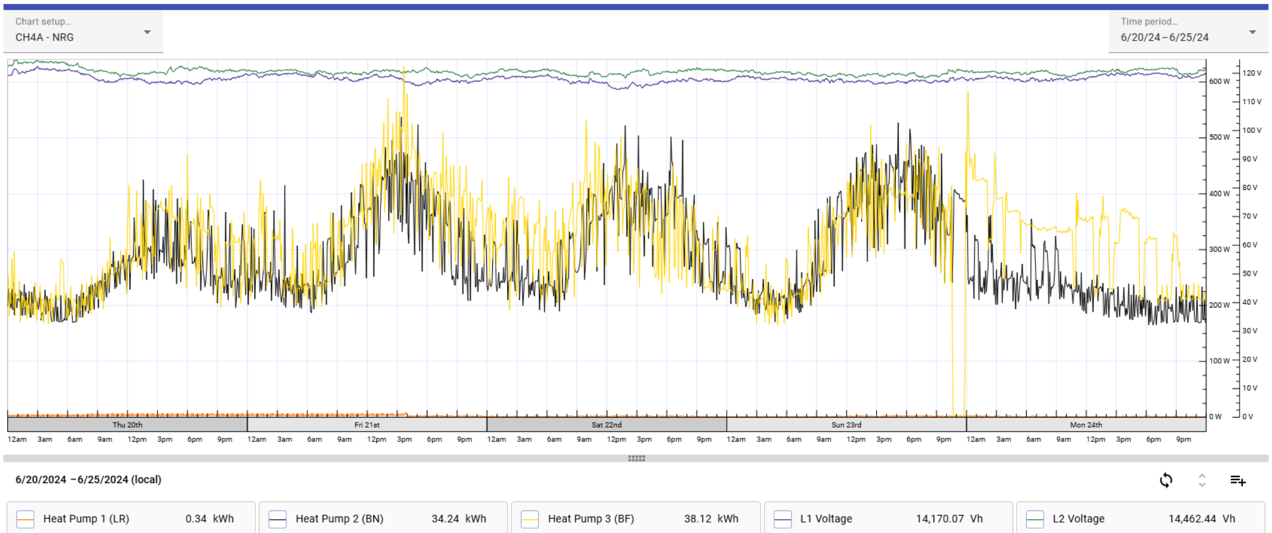


Figure 19: Continuous Operation: Building M, Apartment 6B

June 20–25, 2024: Far bedroom (black) and near bedroom (yellow) units show steady use, indicating a fixed setpoint strategy and continuous operation.



This finding warrants further investigation. This comparison suggests the reduced run time and load from intermittent use and frequent setbacks resulted in lower energy use. This contradicts a commonly accepted theory, which states that heat pumps should operate with a fixed setpoint instead of using night setbacks to minimize energy use. It should be noted that this observation is based on a relatively small sample set and further research on this hypothesis is needed before a firm conclusion can be reached.

5.2 Low-Load Operation

During low-load heating conditions, both PWHPs cycled on and off frequently, and some occupants reported uncomfortably cool discharge air. The apartments at Woodside demonstrate the challenges systems like this face. We found a tenfold difference in HVAC energy use between the lowest- and highest-use apartments. The difference in usage between a low-use apartment's spare bedroom and the living room of a higher-use apartment is even greater (more than the ten-fold apartment level differences noted above), and installers placed the same capacity PWHP units in each.

Maximum output matters in very hot and cold weather, but minimum output can have just as significant an impact on occupant comfort in milder, more typical conditions. A unit that operates continuously in low-load situations cycles less, improves efficiency, and reduces wear and tear. A lower minimum output also allows for more comfortable discharge temperatures. We believe manufacturers should focus on improving the low-load operation point, and designers should consider this an important criterion when implementing room-by-room space conditioning solutions. The request for proposal (RFP) specified a 6,000 Btu/h unit as a bonus criterion: Midea America has indicated its intention to produce one of these units, while Gradient has not yet committed to doing so at the time of writing.

5.3 Discharge Air Temperature and Occupant Comfort

We observed no lack of heating capacity during the winter demonstration period. If anything, the revers was noted: occupants reported more overheating than underheating. However, we observed some potential issues with perceived draftiness during our functional testing.

HVAC systems that introduce supply air at waist height can significantly impact user comfort due to the temperature and speed of that air. Smaller bedrooms offer limited furniture layout options, so occupants often sit directly in the supply air path. We suspect that this led to more active user adjustments, as users will turn off or reduce settings if they feel cold air blowing on them or raise the setpoint to get warmer discharge air.

In response to beta tester feedback about cold discharge air temperature in heating mode when seated near the unit, Gradient implemented a "comfort mode." This mode raises the discharge air temperature targets in heating mode and causes slightly increased cycling, but improves comfort for occupants in the air stream.

5.4 Baseload Energy Use

HVAC energy use significantly contributed to total energy use in each apartment building; however, baseload electrical use (apartment electrical use excluding PWHP use) matched it in magnitude, even during peak heating periods. In Building M, baseload electrical use averaged 56% of the total in January 2024. In Building G, it averaged 34% over the same period. Figures 19 through 22 illustrate the same trends over an extended monitoring period (December 31, 2023–February 12, 2024). This indicates the potential for significant energy savings by reducing resident plug loads.

Figure 20. Building M: Line A, Riser kW

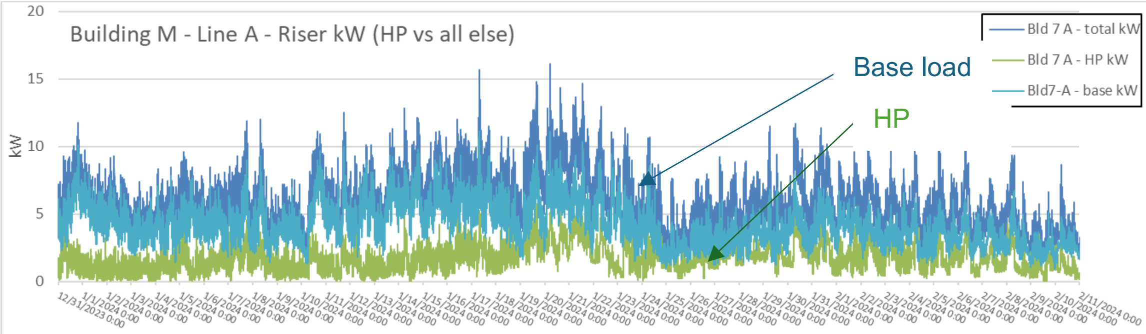


Figure 21. Building M: Line B, Riser kW

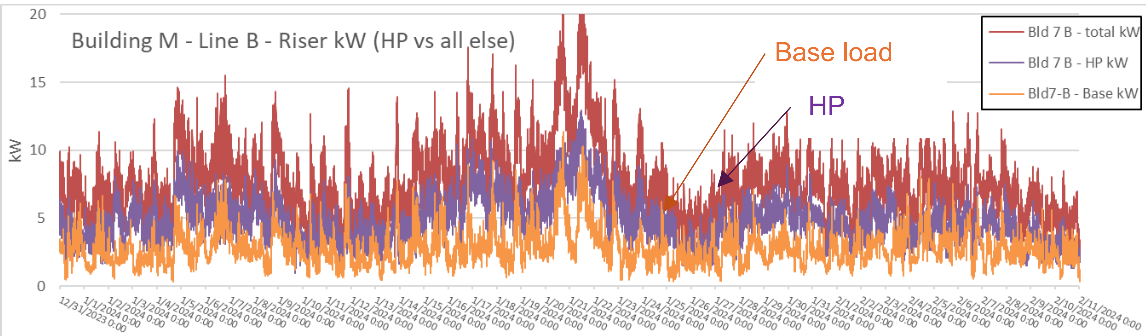


Figure 22. Building G: Line A, Riser kW

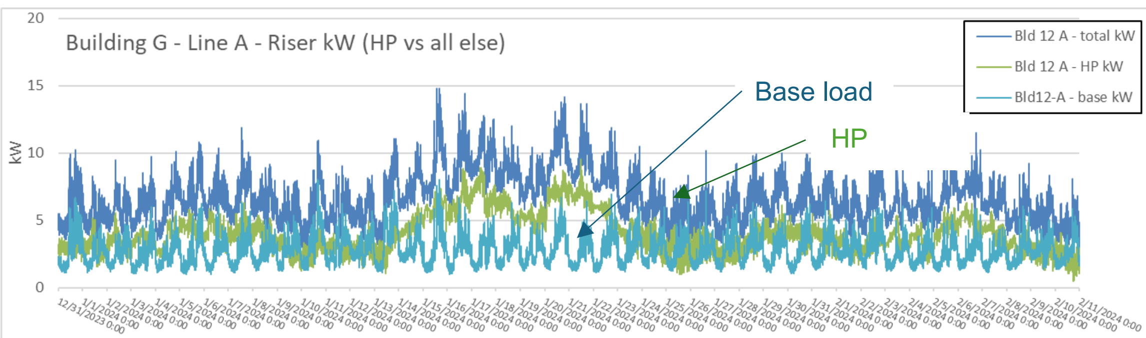
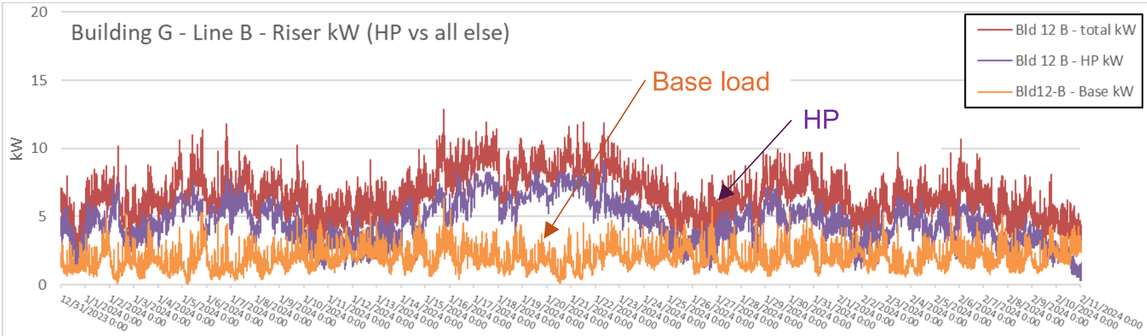


Figure 23. Building G: Line B, Riser kW



6 Conclusions and Directions for Future Research

6.1 Packaged Window Heat Pumps Are a Viable Solution

Our results show that PWHPs 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. These systems can reliably maintain comfortable indoor temperatures during both heating and cooling seasons. Initial feedback from NYCHA, coupled with lab-based COP testing and our observations, indicates that the units meet their efficiency targets. Residents surveyed also express a strong preference for PWHPs over the previous steam system.

Apartment staff can complete PWHP installations well within the 2-hour target. While any electrification project requires evaluating the impact of new loads on existing electrical infrastructure, the site's realized peak loads came in lower than NYCHA's initial design calculations predicted. Our results confirm that Woodside Homes' existing electrical infrastructure adequately supported the installation of PWHPs.

6.2 Standards Will Support Market Growth

Clean Heat for All specifications and the PWHPs evaluated in this study were developed specifically for NYCHA's use case. Although demonstration units still present some unresolved issues with condensate dispersal and controls, they meet the CH4A program requirements. As these PWHPs transition from demonstration to production, manufacturers will continue to improve these products.

PWHPs share features with window air conditioners, PTACs, and other packaged heat pumps, but they also have distinct characteristics. As this product market grows, industry stakeholders must develop consistent methods for rating and certifying these units. One of the greatest risks to market adoption of PWHPs is the possibility that early success will trigger low-cost knock-off products that underperform, damaging the entire product category's reputation. Strong standards and clear certification labeling will help mitigate that risk.

6.3 Occupants Use Packaged Window Heat Pumps Differently

Our observations indicate that occupants use PWHPs differently from central or whole-apartment HVAC systems. Instead of making small, infrequent adjustments to a central thermostat, occupants change settings when entering or leaving a room. This on-demand pattern resembles that of room air conditioners and unit heaters.

Historically, efficiency experts have recommended a "set-it-and-forget-it" approach to operating heat pumps. Their rationale is that properly sized heat pumps tend to recover slowly from temperature setbacks. Frequently adjusting the thermostat, raising or lowering the temperature, can cause the system's compressor to ramp up to maximum capacity rather than operating continuously near maximum efficiency and reducing overall efficiency. Additionally, these temperature swings can lead to comfort complaints and may unnecessarily activate supplemental (and often less efficient) heating systems.

Our observations and resident feedback suggest that PWHPs maintain comfortable temperatures even with deep setbacks and controlled heating ramp speeds. We hypothesize that these usage patterns result in lower average winter apartment temperatures than a fixed setpoint approach. We further speculate that the reduced heat loss from these lower average temperatures may offset any efficiency losses during recovery from setbacks. This on-demand style of use also appears to create higher discharge air temperatures during occupied periods, which can improve comfort for residents sitting in the unit's discharge air stream. As stated before, because this is a hypothesis based on limited data, additional study on the potential energy-saving impacts of on-demand heat pump usage is needed.

We inferred occupant behavior from temperature and power measurements. Based on these findings, we must ask whether an on-demand case use presents any inherent drawbacks. If not, the next question is whether system efficiency can be improved, given that users are likely to operate the units this way.

We believe this subject merits further study, especially in the context of room-based heating and cooling systems. Leveraging BACnet data to track operating modes, setpoints, and run times could offer more granular insights into usage patterns and support this research.

6.4 Regulatory Questions Remain

How building departments and other oversight organizations classify PWHPs may impact their adoption. Will they treat them as portable appliances or as permanent space conditioning devices? How will their installation affect requirements for window area, operability, and egress? These questions remain unresolved.

6.5 Field Measurements of Efficiency and Power Diversity Are Still Needed

Laboratory testing and this initial field demonstration show that PWHPs offer a promising option for multifamily buildings. However, we still need to document their energy performance under real-world conditions. The wide variation in usage we observed suggests that reliable efficiency measurements require a larger sample size. The products' BACnet capabilities and internal monitoring systems may simplify data collection.

To accurately measure power diversity, a large-scale demonstration will be necessary. This analysis will require a large sample size to capture the wide variation in both PWHP and baseload use. Sites with several years of riser data to establish baseline conditions will best support this kind of study.

6.6 Partial-Load Operation Needs Further Attention

All apartments maintained interior temperatures, even when one PWHP was turned off or became inoperable. However, our monitoring data revealed significant cycling during mild weather. Manufacturers could reduce cycling by developing smaller units for low-load rooms and modifying designs to allow lower minimum output levels.

We believe manufacturers should prioritize improving the low-load operation point, and designers should treat this as a key criterion when selecting room-by-room conditioning solutions.

This proposed area of further research stems from M&V findings and should not be interpreted as a claim that manufacturers oversized their products. The Clean Heat for All Pilot specified 9,000 BTU PWHPs to cover the full range of NYCHA room sizes and apartment layouts, from small bedrooms to large, top-floor corner living rooms. Initial load calculations indicated that this capacity would adequately meet heating demand across typical apartments. For the first demonstration, the team also limited the request to a single capacity PWHP. This was meant to reduce development burden on manufacturers and encourage a robust response to the RFP.

6.7 The CH4A Model of Cooperative Product Development Can Be a Real Game Changer

CH4A enabled NYCHA to transition from being a passive purchaser of existing products to an active participant in developing novel technology. Key components of this approach include:

- Clearly defined technical requirements based on NYCHA’s specific needs.
- Strategic use of NYCHA’s purchasing power to create an initial market.
- Modified M&V approach proving fast feedback and supporting field testing of product improvements.
- Active collaboration among all stakeholders.

PWHPs will help NYCHA meet its decarbonization goals and may also see wide adoption in retrofits elsewhere. The CH4A model may serve as a valuable framework for other entities seeking to drive innovation in energy efficient technology.

7 Guide to Appendices

7.1 Introduction

This appendix compiles the reports, background documentation, and supporting materials issued during the course of this study. We intend it to serve as a resource for individuals and organizations seeking deeper insights into the study's results. We have organized the appendix into several sections and provided descriptions of each section and its documents below. We also ask readers to view the findings of these reports as indicative of PWHP performance at a given time. In many cases, the PWHPs evaluated in these appendix reports were initial prototype versions. Many performance issues have been addressed by Midea America and Gradient, and we encourage readers to contact manufacturers for the most up to date PWHP performance specifications.

7.2 Appendix A. M&V Process Documents and Background

This section includes the background documentation that supports the foundation of this study.

- A.1 CH4A: M&V Plan, Final
  This document is the official M&V plan for this study and details the equipment and methods used to monitor and analyze data from subject apartments.
- A.2 Study Goals and Scope
  Issued on May 2, 2025, this document, originally from the M&V RFP, outlines the goals and scope of the study.
- A.3 Specifications and Verification Summary
  Issued on May 2, 2025, this document, originally from the M&V RFP, lists the performance specifications for the heat pumps and explains the verification methods.
- A.4 Project Team
  Dated May 2, 2025, this document lists the primary project team members and their email addresses.
- A.5 Product Cut Sheets
  Issued May 2, 2025, this document included the manufacturers' specification sheets.

7.3 Appendix B. M&V Reports

This section includes all issued reports, such as progress reports with seasonal data analysis, air leakage and sound testing results, commissioning and functional testing reports, and installation documentation.

- B.1 Heating Season Analysis
  This section contains reports analyzing heating season data.

- B.1.1 CH4A: Initial Heating Season Analysis, Summary
  This report, issued on April 11, 2024, summarizes key findings from heating analysis reports and functional testing through April 2024.
- B.1.2 CH4A: Initial Heating Season Bin Analysis
  Released on April 9, 2024, this report provides a graphical breakdown of energy use, peak power demand, and space temperatures for each apartment by organizing the data into “bins” and showing the amount of time each apartment operated within each range.
- B.1.3 CH4A: Diversity Analysis
  Issued on April 11, 2024, this report analyzes the peak heat pump power demand at the riser level and discusses diversity factors that compare actual peak use to theoretical simultaneous peak operation
- B.1.4, CH4A: Reprogramming Review, Midea
  Issued on April 9, 2024, this report presents an initial graphical analysis of changes that Midea made to its control algorithm to reduce short cycling during low-load operation.
- B.1.5 CH4A: Peak Heating Observations
  Issued on April 9, 2024, this report presents a detailed apartment- and heat pump-level analysis of the peak heating load period for winter 2023–2024.
- B.1.6 CH4A: Seasonal Heating Observations
  Issued on April 9, 2024, this report presents a detailed apartment- and heat pump-level analysis of the overall 2023–2024 heating season.
- B.1.7 CH4A: Preliminary Riser Impact Evaluation
  Issued on April 9, 2024, this report provides the initial analysis of riser-level peak power consumption, including total electric usage and heat pump-only power consumption.
- B.1.8 Defrost Cycle Observations, Gradient
  Issued on April 9, 2024, this report analyzes defrost behavior in Gradient heat pumps.CH4A: Diversity Analysis
- B.1.9 CH4A: Programming Changes, Midea
  Issued on June 3, 2024, this report presents a detailed statistical analysis of Midea’s revised control algorithm intended to reduce short cycling during low-load operation.

- B.2 Cooling Season Analysis
  This section includes all reports covering the cooling season and full-period operation for both systems.

  - B.2.1 CH4A: Cooling Season Summary
    Issued on February 21, 2025, this report summarizes cooling performance and related testing as of February 2025.
  - B.2.2 CH4A: eGauge-Based Cooling Observations, Gradient
    Issued on February 21, 2025, this report presents an initial graphical analysis of cooling data for Gradient heat pumps.
  - B.2.3 CH4A: Full Period Data Analysis, Gradient
    Issued on February 21, 2025, this report presents a detailed apartment- and heat pump-level analysis of the heating and cooling data for Gradient heat pumps.

- B.2.4 CH4A: Peak Cooling Data Overview, Gradient
  Issued on February 21, 2025, this report presents a detailed apartment- and heat pump-level analysis of the 2024 peak cooling load period for Gradient heat pumps..
- B.2.5 CH4A: Season Cooling Data Overview, Gradient
  Published on February 21, 2025, this report presents a detailed apartment- and heat pump-level analysis of the overall 2024 cooling season for Gradient heat pumps.
- B.2.6 CH4A: eGauge-Based Cooling Observations, Midea
  Published on February 21, 2025, this report presents an initial graphical analysis of cooling data for Midea heat pumps.
- B.2.7 CH4A: Full Period Data Overview, Midea
  Published on February 21, 2025, this report presents a detailed apartment- and heat pump-level analysis of heating and cooling data for Midea heat pumps.
- B.2.8 CH4A: Peak Cooling Data Overview, Midea
  Published on February 21, 2025, this report presents a detailed apartment- and heat pump-level analysis of Midea heat pump performance during the 2024 peak cooling load period.
- B.2.9 CH4A: Season Cooling Data Overview, Midea
  Published on February 21, 2025, this report presents a detailed apartment- and heat pump-level analysis of Midea heat pump performance during the 2024 cooling season.

- B.3 High-Level Analysis Extension, 2024–2025
  This emailed communication, dated May 2, 2025, presents a high-level review of data collected after the formal end of the analysis period. It highlights general trends and compares them with earlier findings. Updated graphics from the extended monitoring period are included for each apartment system.
  - B.3.1 High-Level Analysis Extension, 2024–2025
- B.4 Air Leakage, Thermal Bridging, and Sound Measurements
  This section provides details of on-site testing for air infiltration and acoustic performance of both heat pumps.
  - B.4.1 NYCHA Woodside Air and Sound Testing, Midea
    This report presents the results of air leakage and acoustic testing conducted on July 11, 2023, for Midea heat pumps.
  - B.4.2 NYCHA Woodside Air and Sound Testing, Gradient
    This report presents the results of air leakage and acoustic testing conducted on December 11, 2023, for Gradient heat pumps.
  - B.4.3 NYCHA Woodside Air Leakage Testing, Gradient
    This report presents the results from the second round of air leakage testing conducted on August 27, 2024, for Gradient heat pumps.
  - B.4.4 NYCHA Woodside Sound Testing Report, Midea
    This report presents the results from the second round of air acoustic testing conducted on September 28, 2023, for Midea heat pumps.

- B.5 Commissioning Observations
  This section includes reports on functional testing for demonstration and production units from both manufacturers.
  - B.5.1 CH4A: Initial Commissioning Observations, Gradient
    This report presents the results from two days of functional testing conducted on March 7–8, 2025, on Gradient's demonstration heat pump.
  - B.5.2 CH4A: Initial Commissioning Observations, Midea
    This report presents the results of two days of functional testing conducted on March 7–8, 2025, on Midea's demonstration heat pump.
  - B.5.3 Taitem Functional Test Memo, Gradient Production Unit
    This report presents the results of two days of functional testing conducted on March 12–13, 2025, on Gradient's production heat pump.
  - B.5.4 Taitem Functional Test Memo, Midea Production Unit
    This report presents the results of two days of functional testing conducted on March 12–13, 2025, on Midea's production heat pump.
- B.6 Installation Reports
  This section documents the initial installation of M&V equipment across all subject apartments for both manufacturers.
  - B.6.1 CH4A: M&V Installation Summary, Building M
    This report details the installation process conducted on October 6, 2023, for M&V equipment in apartments with Midea heat pumps.
  - B.6.2 CH4A: M&V Installation Summary, Building G
    This report details the installation process conducted on December 28, 2023, for M&V equipment in apartments with Gradient heat pumps.

8 References

Bonomo, Jordan. 2025. "Clean Heat for All Introduction & Program Updates." New York City Housing Authority (NYCHA). https://be-exchange.org/wp-content/uploads/2025/01/20250116_CleanHeat_Slides-UPDATED.pdf

Begin, Ryan, and Anthony Cacciotti. 2024. TREAU, Inc. Test Report. Report No. 105840254CRT-001. Intertek Testing Services. October 22.

Xiao, Allan, and Elvis Cai. 2024. GD Midea Air-Conditioning Equipment Co., Ltd. Test Report. Report No. 241107039GZU-00. Intertek Testing Services. December 4.

WeatherSpark. N.d. "Daily Outdoor Temperature Ranges During 2024 and 2025 Heating Seasons." https://weatherspark.com

Appendix A. M&V Process Documents and Background

This section includes the background documentation that supports the foundation of this study.

Appendix A.1 CH4A: M&V Plan

This portion of Appendix A is temporarily unavailable.

Appendix A.2 Study Goals and Scope

This portion of Appendix A is temporarily unavailable.

Appendix A.3 Specifications and Verification

This portion of Appendix A is temporarily unavailable.

Appendix A.4 Project Team

This portion of Appendix A is temporarily unavailable.

Appendix A.5 Product Cut Sheets

This portion of Appendix A is temporarily unavailable.

Appendix B. M&V Reports

This section includes all issued reports, such as progress reports with seasonal data analysis, air leakage and sound testing results, commissioning and functional testing reports, and installation documentation.

Appendix B.1 Heating Season Analyses

This section contains reports analyzing heating season data.

Appendix B.1.1 CH4A Initial Heating Seasonal Analysis, Summary

This portion of Appendix B is temporarily unavailable.

Appendix B.1.2 CH4A: Initial Heating Season Bin Analysis

This portion of Appendix B is temporarily unavailable.

Appendix B.1.3 CH4A: Diversity Analysis

This portion of Appendix B is temporarily unavailable.

Appendix B.1.4 CH4A: Reprogramming Review, Midea

This portion of Appendix B is temporarily unavailable.

Appendix B.1.5 CH4A: Peak Heating Observations

This portion of Appendix B is temporarily unavailable.

Appendix B.1.6 CH4A: Seasonal Heating Observations

This portion of Appendix B is temporarily unavailable.

Appendix B.1.7 CH4A: Preliminary Riser Impact Evaluation

This portion of Appendix B is temporarily unavailable.

Appendix B.1.8 CH4A: Defrost Cycle Observations, Gradient

This portion of Appendix B is temporarily unavailable.

Appendix B.1.9 CH4A: Programming Changes, Midea

This portion of Appendix B is temporarily unavailable.

Appendix B.2 Cooling Season Analysis

Appendix B.2.1 CH4A: Cooling Season Summary

This portion of Appendix B is temporarily unavailable.

Appendix B.2.2 CH4A: eGauge-Based Cooling Observations, Gradient

This portion of Appendix B is temporarily unavailable.

Appendix B.2.3 CH4A: Full Period Data Analysis, Gradient

This portion of Appendix B is temporarily unavailable.

Appendix B.2.4 CH4A: Peak Cooling Data Overview, Gradient

This portion of Appendix B is temporarily unavailable.

Appendix B.2.5 CH4A: Seasonal Cooling Data Overview, Gradient

This portion of Appendix B is temporarily unavailable.

Appendix B.2.6 CH4A: eGauge-Based Cooling Observations, Midea

This portion of Appendix B is temporarily unavailable.

Appendix B.2.7 CH4A: Full Period Data Overview, Midea

This portion of Appendix B is temporarily unavailable.

Appendix B.2.8 CH4A: Peak Cooling Data Overview, Midea

This portion of Appendix B is temporarily unavailable.

Appendix B.2.9 CH4A: Seasonal Cooling Data Overview, Midea

This portion of Appendix B is temporarily unavailable.

Appendix B.3 High-Level Analysis Extension, 2024–2025

This emailed communication, dated May 2, 2025, provides a high-level review of data collected after the formal end of the analysis period. It highlights general trends and compares them with earlier findings. Updated graphics from the extended monitoring period are included for each apartment system.

This portion of Appendix B is temporarily unavailable.

Appendix B.4 Air Leakage, Thermal Bridging, and Sound Measurements

This section provides on-site testing details for air infiltration and acoustic performance of both heat pumps.

Appendix B.4.1 NYCHA Woodside Air and Sound Testing, Midea

This portion of Appendix B is temporarily unavailable.

Appendix B.4.2 NYCHA Woodside Air and Sound Testing, Gradient

This portion of Appendix B is temporarily unavailable.

Appendix B.4.3 NYCHA Woodside Air Leakage Testing, Gradient

This portion of Appendix B is temporarily unavailable.

Appendix B.4.4 NYCHA Woodside Sound Testing Report, Midea

This portion of Appendix B is temporarily unavailable.

Appendix B.5 Commissioning Observations

This section includes reports on functional testing for demonstration and production units from both manufacturers.

Appendix B.5.1 CH4A: Initial Commissioning Observations, Gradient

This portion of Appendix B is temporarily unavailable.

Appendix B.5.2 CH4A: Initial Commissioning Observations, Midea

This portion of Appendix B is temporarily unavailable.

Appendix B.5.3 Taitem Functional Test Memo, Gradient Production Unit

This portion of Appendix B is temporarily unavailable.

Appendix B.5.4 Taitem Functional Test Memo, Midea Production Unit

This portion of Appendix B is temporarily unavailable.

Appendix B.6 Installation Reports

This section documents the initial installation of M&V equipment across all subject apartments for both manufacturers.

Appendix B.6.1 CH4A: M&V Installation Summary, Building M

This portion of Appendix B is temporarily unavailable.

Appendix B.6.2 CH4A: M&V Installation Summary, Building G

This portion of Appendix B is temporarily unavailable.

NYSERDA, a public benefit corporation, offers objective information and analysis, innovative programs, technical expertise, and support to help New Yorkers increase energy efficiency, save money, use renewable energy, and reduce reliance on fossil fuels. NYSERDA professionals work to protect the environment and create clean-energy jobs. NYSERDA has been developing partnerships to advance innovative energy solutions in New York State since 1975.

To learn more about NYSERDA's programs and funding opportunities, visit nyserda.ny.gov or follow us on X, Facebook, YouTube, or Instagram.

New York State Energy Research and Development Authority

17 Columbia Circle
Albany, NY 12203-6399

toll free: 866-NYSERDA
local: 518-862-1090
fax: 518-862-1091

info@nyserda.ny.gov
nyserda.ny.gov

NEW YORK STATE

NYSERDA
New York State Energy Research and Development Authority

50 YEARS 1975-2025

State of New York
Kathy Hochul, Governor

New York State Energy Research and Development Authority
Charles Bell, Acting Chair | Doreen M. Harris, President and CEO