Multifamily Passive House Certification: A New Reach Standard for Vermont?

Efficiency Vermont R&D Project: Resilience

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Karen S. Bushey

Special thanks to Emma Casavant

Efficiency Vermont
20 Winooski Falls Way
Winooski, VT 05404

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Executive Summary

Efficiency Vermont has a long history of involvement with multifamily new construction (MFNC) in Vermont. The Efficiency Vermont High-Performance standard (EVTHP) evolved as a cost-optimized reach goal for the Efficiency Vermont MFNC program, to complement a moderate baseline program associated with lower incentives. In parallel, the Vermont energy code has steadily evolved and is on a trajectory toward a net-zero-ready requirement for new homes by the year 2030. As the code becomes more stringent, available energy savings from MFNC programming is diminishing. In 2024, EVTHP transitioned from a reach goal to the new EVT program standard for MFNC. As it responds to each triennial code cycle, EVTHP is approaching the level of the Passive House (PH) standard with key attributes such as balanced ventilation, continuous thermal barriers, and increased airtightness for the building and dwelling units.

Efficiency Vermont researchers conducted a study of ten multifamily projects and evaluated real-world building data in order to investigate energy performance and cost impacts. Researchers found that PH projects show an average of 19% lower operational energy use when compared to EVTHP buildings in the study, with less variability in performance. This could be attributed to the PH standard's more rigorous performance requirements and on-site verification. PH benefits to owners and developers were tangible and perceived. PH certification adds complexity and cost to a project; however available incentives may be substantial enough to cover much of the incremental costs.

Based on this study, we recommend that Efficiency Vermont consider supporting Passive House certification as a new reach goal for MFNC projects, alongside the current EVTHP program. In addition to energy benefits and alignment with a nationwide standard, PH as a reach goal could accelerate market transformation based on the training and education that are key components of meeting program requirements, resulting in a broader workforce of high-performance-aligned contractors and third-party consultants in our state.

Introduction

Comparing Standards

This study compares two highly performing standards, EVTHP and PH certification, both for multifamily new construction. The research considered the cost-effectiveness of achieving PH certification for multifamily buildings vs. meeting the EVTHP standard by comparing energy consumption and available cost data of completed EVTHP and PH buildings, paired with qualitative data from interviews with developers and stakeholders.

The research studied the feasibility of PH certification becoming a reach goal for the Efficiency Vermont MFNC program, allowing for continued energy savings as energy codes improve. The program decisions will affect all developers building multifamily new construction or gut rehabilitation in the state of Vermont. It will have enhanced importance for affordable housing developer partners who have embraced High Performance construction at a higher rate than market-rate partners due to Vermont affordable housing funding requirements and the resulting low energy consumption, which allows perpetually affordable operation of their buildings.

Other studies have been conducted comparing Passive House to various standards and energy codes (RDH Building Science, 2023), but this research is unique because its base comparison standard, EVTHP for MFNC, is already at a level far above national energy standards—it is designed to be close to Passive House but more easily attainable.

Passive Building

A rigorous performance-based certification that requires specific thermal comfort metrics, a maximum space-heating or -cooling energy demand, a maximum source energy, and a high level of airtightness.

Background

Definitions

Vermont has lofty energy goals. The Vermont Department of Public Service's 2022 Vermont Comprehensive Energy Plan calls for 100% of all new buildings to be net-zero-ready by 2030 through building energy standards. The plan defines net-zero-ready as "a highly efficient and cost-effective building, designed and constructed so that renewable energy could offset all or most of its annual energy consumption" (Vermont Department of Public Service, 2022, p. 180). PH certification and EVTHP for MFNC could both be considered vehicles to move us closer to achieving this goal, but at different rates.

There is only one certified PH multifamily building in Vermont, compared to about 60 multifamily buildings that have completed the EVTHP program since its creation in 2016. Researchers compared the programs to better understand the differences in requirements and incentives and why this discrepancy exists. A summary is shown in Table 1.

Table 1: Efficiency Vermont High-Performance (EVTHP) and Passive House (PH) Comparison

EVTHP	PH
Prescriptive checklist with one certification option	Performance standard, based on energy targets and verified by predictive energy modeling, with versions available for net-zero or existing construction
Customizable requirements and incentives to encourage action	Energy targets are fixed Customizable envelope and mechanical selections within target maximums for total energy demand
Efficiency Vermont staff involvement provides opportunity for desired technical assistance through experience and knowledge, included in program	Third-party consultants are hired by developer to provide energy modeling and verification services and to coordinate with design and construction team

No enrollment or participation fee	Fee for consultants and certification paid by owner/developer
Qualifies for EVTHP incentives Eligible for 45L tax credit, if pursued Eligible for additional Efficiency Vermont incentives if energy modeling or commissioning is pursued	Qualifies for EVTHP and additional energy modeling and commissioning incentives Qualifies for 45L tax credit, automatically due to the U.S. Department of Energy's Zero Energy Ready Home prerequisite Receives one checkmark for low-income housing tax credits (LIHTC)
Mid- and post-construction verification by Efficiency Vermont staff, included in program Internal Efficiency Vermont verification for savings claim	Mid- and post-construction verification by third-party consultant and commissioning agents Documentation submitted to Passive House certifying body for final verification

Efficiency Vermont High-Performance Track

Efficiency Vermont created this prescriptive EVTHP program to encourage multifamily new construction building performance to exceed Vermont state energy code requirements. Prior to July 1, 2024, there were two program tiers, the Efficiency Vermont Certified track and High-Performance track. With the 2024 Vermont energy code updates, it became impractical to maintain two tracks due to increased code requirements, so it was simplified to one track, EVTHP. Certification is based on meeting a checklist of efficiency measures, including thermal envelope values, airtightness, mechanical equipment efficiencies, water conservation, efficient domestic hot water (DHW) distribution, and efficient appliances and lighting. There is one checklist which applies to all multifamily projects of 5 units and larger, regardless of layout or design. At the completion of the project, Efficiency Vermont staff verify the checklist items on-site, through testing, and with documentation. Adjustments can be made to the incentive amount for checklist items that cannot be verified to meet requirements. The latest checklist can be found on the Efficiency Vermont website.

This program is only available for buildings constructed in Vermont and therefore is not perfectly aligned with "high-performance" standards outside of the state. Successful completion and verification of the checklist rewards projects with a per unit incentive; the amount has varied with checklist updates over the years. Add-on incentives are available for energy modeling, mechanical commissioning, and envelope commissioning. Another per-unit add-on incentive for PH certification was available in the past but was not continued with the most recent update.

For building owners and developers, a main strength of the program is the involvement of experienced energy consultants on each multifamily project. Efficiency Vermont consultants work with project teams, often from early design stage, to provide guidance, multiple reviews, and insights into energy efficient equipment and strategies. In addition, innovative research with completed projects is continually occurring through various means, which allows staff a deeper view into systems' performance through data and the potential for continuous improvement.

Passive House Certification for MFNC

The PH standard relies on a combination of energy efficiency, passive solar, and internal heat gains to dramatically reduce space heating demands. PH is founded on the concept of limiting annual and peak heating and cooling loads and overall source energy use. The concept is implemented through stringent performance thresholds for airtightness and energy consumption, and it is directed with energy modeling using approved tools.

The Passive House Standard is known by multiple names—Passive House, Passive Building, Passivhaus, and Phius—which are equivalent for purposes of this research. All certified projects in this study completed Phius (formerly Passive House Institute US) certification, so researchers have focused on the Phius standard for costs, requirements, and incentives.

The Phius standard was revised from the original European Passivhaus standard, including cost-optimization for North American climates and the addition of climate- and occupancy-specific targets for each project. The standard is achieved through implementation of the five core principles:

1. Continuous thermal insulation
2. Superior windows
3. Ventilation with highly efficient heat recovery
4. Airtightness
5. Absence of thermal bridges

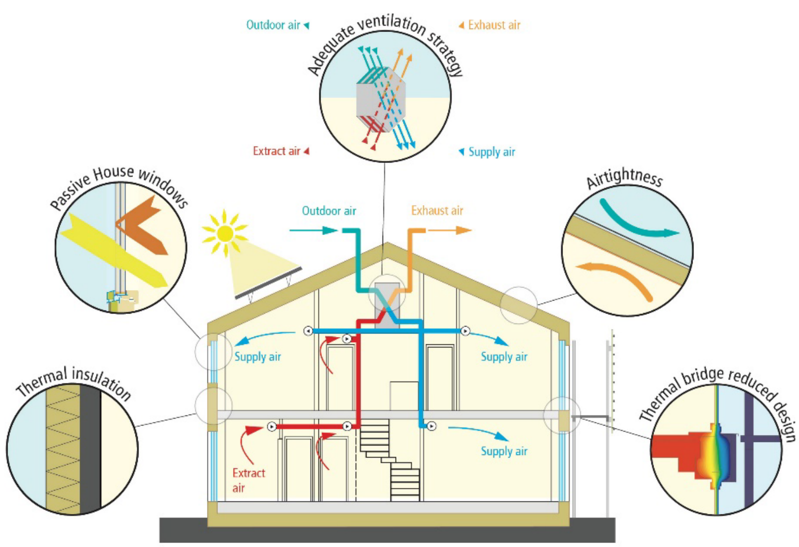

Figure 1. Illustration of passive house standards (Passive House Institute, www.passivehouse.com).

"The energy consumption limits are developed through extensive research on climate change imperatives, economic feasibility, building durability, occupant comfort, and indoor air quality."

—New York Passive House

Phius has added requirements to the North American standard to ensure good vapor control design, durability of building assemblies, and indoor humidity management. There is an emphasis on minimizing overheating with exterior shading and daylighting design, which is integrated into the modeling software.

The performance-based standard, which requires early energy modeling to meet space conditioning load limits and source energy targets, leads to a systems-oriented approach where interactions between components of the building are simulated. This allows optimization of building systems and equipment and has been found to provide cost savings when compared with traditional design. For example, high-performance windows with appropriate shading can allow for a smaller heating, ventilation, and air conditioning (HVAC) system due to decreased space conditioning loads.

Phius certification for multifamily new construction projects requires ENERGY STAR®, U.S. Department of Energy (DOE) Zero Energy Ready Home (ZERH), and EPA Indoor airPLUS certification for eligible projects, to ensure best practices for quality elements such as healthy indoor air and water management. Due to alignment with these programs and the strict energy targets, requirements for lights, appliances, and plumbing fixtures are often the same as they are for the EVTHP program.

The verification process stands out against other programs and is a reason for PH's reputation as a highly rigorous path. In addition to the energy model completed by a Certified Passive House Consultant (CPHC) and pre-certification review by Phius, construction site verification must be performed by a third-party accredited Phius Rater or Verifier. This consultant often performs the required inspections for ENERGY STAR® and ZERH and is responsible for submitting all verification documentation at the end of the project for final certification.

Figure 1: Phius prerequisite requirements

Site verification requires:

- Comparison of installed components with the pre-certified or original design
- Visual inspection of insulation installation, air sealing, and thermal bridge avoidance strategies
- Testing and balancing of ventilation airflow at all outlets and verifying system power
- Testing of domestic hot water (DHW) distribution efficiency
- Air leakage testing for whole building and individual dwelling units (compartmentalization)
- Duct leakage testing where applicable
- Mechanical system commissioning per ENERGY STAR requirements

Some projects are designed and constructed per the PH standard or with passive house principles, but they do not complete certification. It is unknown how much of the standard or principles were adhered to without verification, therefore this research only includes certified projects. The latest Phius certification requirements are available at Phius.org.

Net Zero

Net zero, zero energy, or zero emissions in the building sector is most often defined as producing as much energy as it consumes in a year using renewable resources. (Office of Energy Efficiency & Renewable Energy, 2024) Net-zero-ready means that the building is optimally efficient, so clean renewable resources can be added on-site to cover its energy consumption. Multifamily buildings with efficient, compact layouts and multiple stories often struggle to fit enough renewable energy production on-site to cover their consumption, especially as photovoltaic arrays on roofs. Per this definition, the energy-use targets for the building should be as low as possible to have the greatest chance of fitting sufficient renewable energy on-site.

The National Renewable Energy Laboratory (NREL) has identified energy use intensity (EUI) targets for zero-energy multifamily buildings in different climate zones. A MF building in climate zone 6A has a site EUI target of 24 kilo–British thermal units (kBTU) per square foot per year and a target for photovoltaics of 24 percent of the total floor area. (Langner, et al., 2020, p. 7)

Methods

Building Selection

The research was conducted on representative projects completed within the past seven years that met certain criteria. Selected are six EVTHP projects and four certified PH multifamily projects, one in Vermont, two in New Hampshire, and one in Maine.

The selection criteria encompass the following:

- EVTHP or PH certified
- Located in ASHRAE climate zone 6A
- Double-loaded corridor layout – a more compact design and building massing, resulting in less heat loss than more spread-out designs
- Mid-size – 3 to 4 stories in height and 24 to 42 dwelling units
    - Conditioned floor area ranges from 21,000 to 44,000 square feet
- Low air leakage – 5 out of 6 of the EVTHP multifamily buildings studied were verified to have air leakage at or below PH maximum requirements (0.06 cfm50 per square foot of building envelope).

Including the low air leakage criteria for EVTHP buildings normalizes that metric across the sample of buildings studied. Verified air leakage in multifamily new construction has been trending lower over the time period studied, and it is more common to find projects meeting PH airtightness requirements which is a major component of reduced energy use.

Scope of Analysis

Efficiency Vermont researchers evaluated annual energy consumption, available cost data related to PH certification, and additional non-energy benefits of the selected buildings. Energy consumption data was gathered through available advanced metering infrastructure (AMI) data and utility bills provided by building owners and developers. Operational energy costs were not included in the scope of the research; when energy bills were provided, the team only considered energy consumption and not related costs. Estimated annual electric energy consumption for all EVTHP and PH buildings located within Vermont was determined by summing AMI data from the previous 12 months. Similarly, annual natural gas consumption was estimated using billing data provided by the gas utility and calculating the average of a rolling 12-month sum. Estimation of annual energy consumption of unregulated fuels, such as propane and oil, for all buildings evaluated varied based on the available data provided by building owners. To compare building performance, electric consumption and fuel use data is converted to kilo–British thermal units (kBTU) from which energy use intensity (EUI) in kBTU per square foot per year is calculated. The research team only evaluated site EUI, not source EUI.

While the cost to operate a building is of critical importance to the owner, researchers did not consider operational energy costs of the buildings in the study because current regulations, programs, and incentives for new construction are moving the industry toward all-electric buildings to meet Vermont's decarbonization goals. Comparing operating costs equates to comparing fuel and electricity cost per unit of delivered energy, and totals vary due to the variety of fuels and mechanical system efficiencies in the study buildings. Converting all energy consumption to EUI was a strategy used to normalize the data across buildings and find results that can be compared and are applicable to future projects.

Qualitative information on non-energy benefits was gathered through interviews with property owners and managers. Development team members and property owners shared their experiences and observed benefits of their Passive House buildings, as well as takeaways from the design and construction process.

Embodied or up-front carbon of construction materials or the construction process are not included within the research scope. Similarly, evaluation of carbon intensity and greenhouse gas (GHG) emissions are considered out of scope.

Results

Building Information

Ten multifamily buildings—six EVTHP certified (Buildings A-F) and four PH certified (Buildings G-K)—were selected. Information on building size, occupant type, and mechanical equipment of the buildings assessed is provided in Table 2 below. Occupancy includes either designated senior living or traditional family living. The buildings range in size from 21,308 square feet to 43,875 square feet. The number of units ranges from 24 to 45 while the number of total bedrooms, perhaps more indicative of the number of occupants, ranges from 28 to 62. Energy consumption is assessed on both an EUI and per-bedroom basis. Buildings B and H are all electric while the rest rely on natural gas, propane, or even oil for all or part of the heating and domestic hot water (DHW) loads. All buildings assessed have energy or heat recovery ventilation (E/HRV) and Building K is the only building without air-conditioning. For space heating, buildings A and F use natural gas boilers, buildings E and K use primarily electric resistance heat, and the remainder use heat pumps.

Table 2: Multifamily Building Metadata

Multifamily Building	Conditioned Area (sq. ft.)	Housing Type	No. Units	No. Bedrooms	Mechanicals
A	31,640	Family	30	43	Cooling: ASHP (Electric) Heating: Boiler (Natural Gas) DHW: Boiler (Natural Gas)
B	21,038	Family	24	28	Cooling: ASHP (Electric) Heating: ASHP (Electric) DHW: HPWH (Electric)
C	27,876	Family	30	42	Cooling: ASHP (Electric) Heating: ASHP (Electric/Oil Backup) DHW: Boiler (Oil)
D	25,914	Family	26	31	Cooling: ASHP (Electric) Heating: ASHP (Electric/Electric Resistance Backup) DHW: Boiler (Propane)
E	33,042	Family	30	45	Cooling: ERV (Electric) Heating: Electric Resistance (Electric), Propane backup in ERV DHW: Boiler (Propane)
F	43,875	Senior	39	45	Cooling: VRF (Electric) Heating: Boiler (Natural Gas) DHW: Boiler (Natural Gas)
G	29,350	Senior	30	30	Cooling: ASHP (Electric) Heating: ASHP (Electric/Natural Gas Backup) DHW: Boiler (Natural Gas)
H	27,700	Family	29	39	Cooling: ASHP (Electric) Heating: ASHP (Electric) DHW: Boiler (Electric)
J	30,970	Senior	42	42	Cooling: VRF (Electric) Heating: VRF (Electric) DHW: Boiler (Propane)
K	37,815	Family	45	62	Cooling: None Heating: Electric Resistance (Electric) DHW: Boiler (Natural Gas)[1]

Energy Use Comparison

Energy consumption and performance data for the ten multifamily buildings appear in Figure 2 and Figure 3 below. The research team evaluated two metrics to compare performance across

[1] Natural gas breakout was not available for building K. Of the PH projects with fuel, about 30% of total consumption was attributed to fuel use, so 30% was assumed and is shown in Figure 2 and Figure 3.

buildings: annual energy consumption per conditioned floor area and annual energy consumption per bedroom. Table 3 lists the average performance results and ranges.

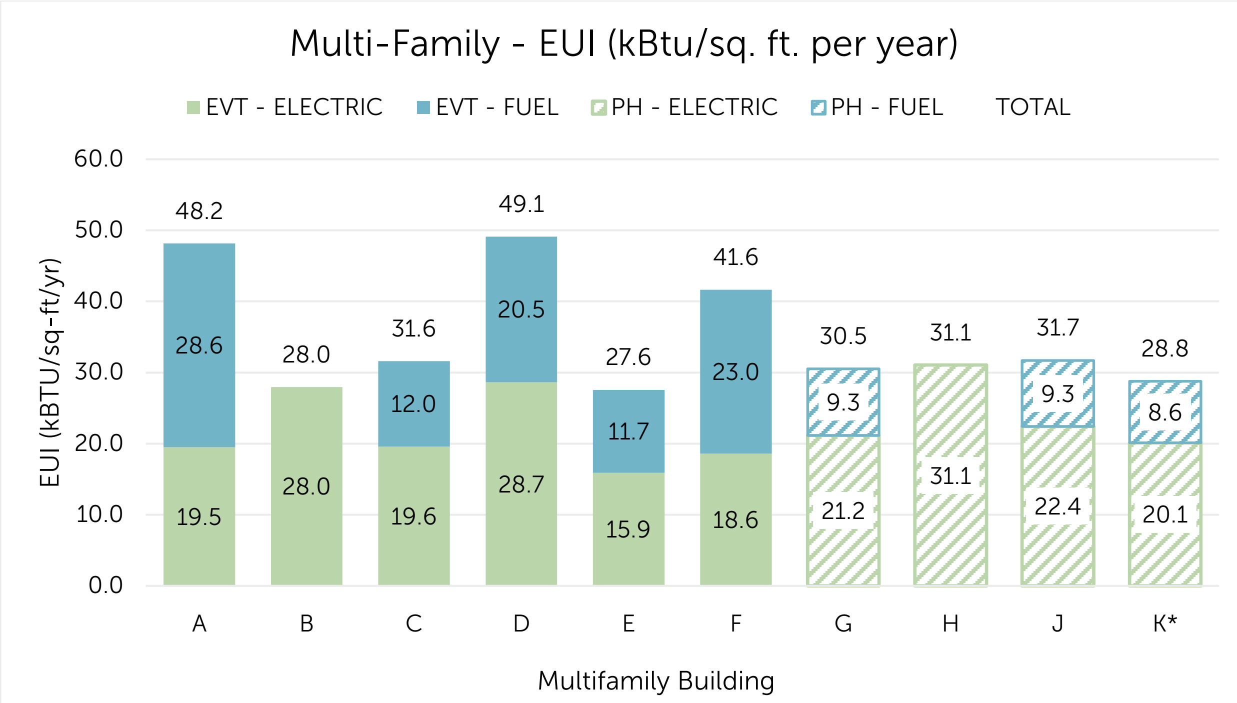

Figure 2: Annual energy use intensity (EUI) of EVTHP and PH buildings in kBTU/sq. ft., *see footnote 1.

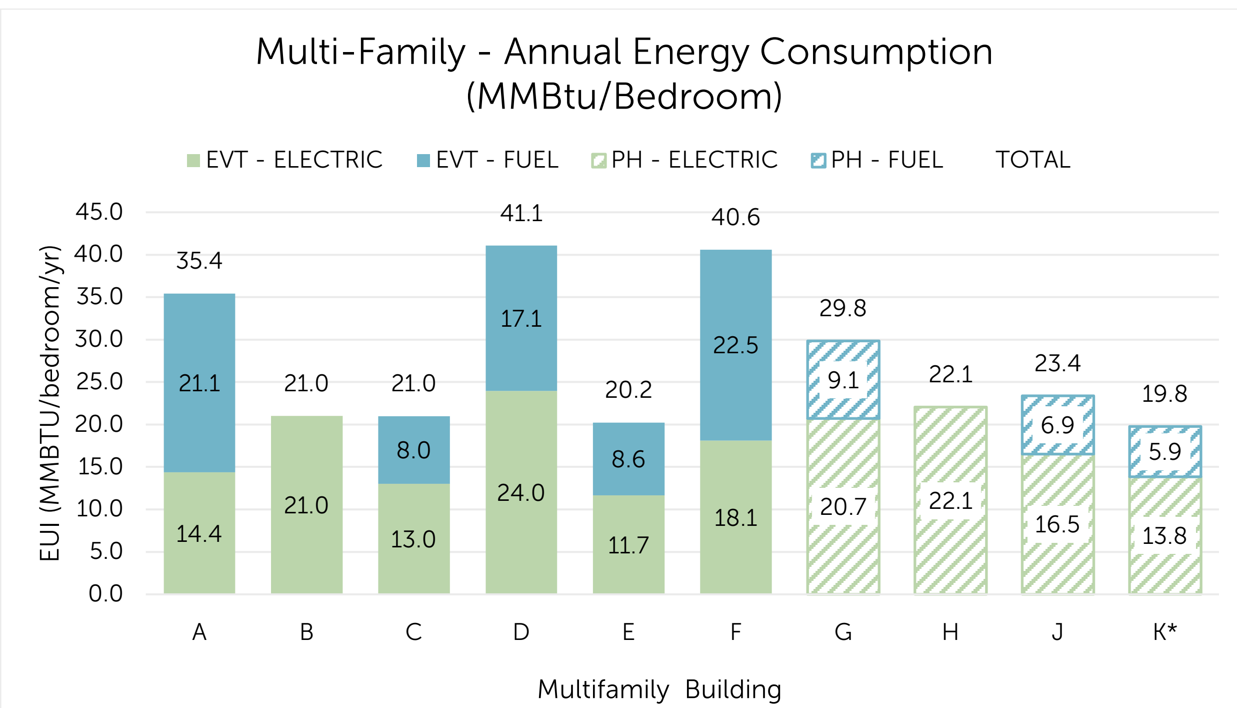

Figure 3: Annual energy consumption of EVTHP and PH buildings in MMBTU/bedroom, *see footnote 1.

Table 3: Summary of Energy Performance

Energy metric	EVTHP	PH	PH % Improvement
Average EUI (kBTU/sf/year)	37.7	30.5	19%
Average energy consumption (MMBTU/bedroom)	29.9	23.8	20%
Range highest to lowest EUI (kBTU/sf/year)	21.6	2.9	-
Range highest to lowest energy consumption (MMBTU/bedroom)	20.8	10.1	-

The PH buildings on average consume 19 to 20 percent less energy annually than the EVTHP buildings. Interestingly, the buildings with the lowest overall EUIs are EVTHP buildings (Buildings B and E). However, the range of EUIs for the EVTHP buildings is much higher than that of the PH buildings. This high variability in annual energy consumption of the EVTHP buildings leads to an appreciably higher average EUI.

The variety of combinations and efficiencies of mechanical equipment and unknowns of occupancy across all study buildings prevent perfectly equivalent comparisons. The total EUI of a building is lowered by using more efficient mechanical systems, like heat pumps, and PHs often include higher efficiency equipment due to strict source energy limits, which may influence the lower average EUI of the PH buildings.

Cost increases

Comparing costs between buildings that were constructed over the past eight years is challenging due to inflation, material price volatility, and supply chain issues. According to the Vermont Housing Finance Agency (VHFA), construction costs for new multifamily buildings in Vermont are currently trending high, especially for multifamily rental development, which has seen the per-unit cost increase 76 percent since 2018. (Vermont Housing Finance Agency, 2023, p. 4)

The additional cost to design and build to the PH standard can be divided into three categories: (1) soft costs, which include energy modeling, verification, and certification; (2) hard costs, which include the additional materials and higher-performing equipment needed to achieve the standard; and (3) design costs. Design costs cover the added time it takes the design team to integrate the requirements, which can vary widely depending on the team's experience with PH or the prerequisite programs. This research does not attempt to quantify design costs because they have been shown to diminish with increased experience.

More than five years ago, soft costs were an average of $1,500 per dwelling unit, all included, or about $45,000 for a 30-unit building. Estimates from the past few years have revealed a substantial increase: soft costs are now $90,000–$100,000, or about $3,000 per unit, for an average mid-rise multifamily project. The steep increase can be attributed to inflation and higher demand for PH consultants in the Northeast, particularly verifiers. The increase could be attributed to greater requirements and more testing for the prerequisite standards for PH certification: ENERGY STAR® and ZERH. The verification work is typically about half or more of the total soft costs due to time and travel involved. The cost for a PH verifier would displace some of the cost borne by Efficiency Vermont for on-site energy savings verification, currently completed by Efficiency Vermont staff.

In addition to third-party fees, Phius certification fees, which are based on interior conditioned floor area (iCFA), have increased substantially. In 2019, multifamily projects with 50,000 square feet had an estimated Phius certification fee of $11,875. (Phius, 2019, p. 58) For 2024, multifamily projects with 50,000 square feet have an estimated certification fee of $19,250. (Phius, 2024, p. 24) These incorporate costs for the full certification process but do not include optional feasibility studies. Cost studies listed in Table 4 have shown the increased cost of Passive House certification for multifamily projects over standard development costs is an additional 1–4 percent on average.

Table 4: Multifamily Passive House Incremental Cost Studies

Sponsor/ Author	Source and Reference	Incremental cost of building to the Passive House standard and other findings.
NYSERDA (New York State Energy Research and Development Authority)	June 2024 Buildings of Excellence Construction Cost Data (NYSERDA, 2024)	• Passive House projects in rounds 1-4, beyond early design stage, showed average of **2.7%** higher cost without incentives. • 67% of those projects had a net gain in costs after credits and incentives were applied. • 71% of projects in MF competition followed Passive House.
Massachusetts Clean Energy Center	*Scaling Up Passive House Multifamily: The Massachusetts Story* (Simmons, Craig, McKneally, & Lino, 2022)	• Passive House Design Challenge demonstrated average increase of **2.3%** over energy code with a sample size of 7 MF projects. • Projects received incentives in milestone payments which are not included in incremental cost. • The report also demonstrates PH energy savings of 52% over non-PH MF projects.
Phius	Memo: Summary of Cost Data Research on Multi-Family buildings built to the Phius Standard (Elnecave, 2022)	• Increase of **1–4%** over energy code was demonstrated in Massachusetts. • Pennsylvania MF PH projects started at 5.8% average increase in 2015, 1.6% in 2016, and by 2018 they showed average **3.3% savings** over conventional construction. • Federal tax credits can lower cost additionally.
The Passive House Network (PHN)	*Is Cost the Barrier to Passive House Performance* (Bronwyn Barry, 2021)	• NAPHN demonstrated increase of 1–8% over standard costs with a sample size of 16 MF buildings, with an average of **4%** increase. • The higher increases were attributed to teams with less or no PH experience.

Vermont Architectural Firm	NESEA Building Energy Boston Presentation on MF PH in NH, March 2019	• Architects demonstrated increase of $8 more per square foot or less than 3% over standard costs.

A three percent increase equates to over $400,000 for a 15-million-dollar project, still a considerable amount for the projects studied. Notable study findings include decreased cost with experience—as construction professionals familiarize themselves with Passive House design and construction principles, each subsequent project's incremental costs decrease. With increasing energy code requirements, the cost difference between PH and baseline decreases.

Researchers separated the additional elements of the PH buildings that were above what was required for EVTHP which would result in higher incremental first costs. It's important to note that these items will not increase maintenance costs. These include:

- Higher levels of insulation in exterior walls, floor slab, and roof
- Triple-glazed windows in place of double-glazed
- Higher levels of air sealing (not applicable for this study)
- More efficient HVAC equipment, notably ventilation systems
    - Greater distribution (more ductwork) for the ventilation system

The original intent of the research was to use the RSMeans database to estimate a current 2024 incremental cost for the above items, but researchers discovered multiple challenges with accurate accounting for differences in labor and variations in projects. Researchers completed an incremental cost study for upgrading from double-glazed (2 layers of glass) to triple-glazed (3 layers of glass) windows. Comparing that to other pre-existing cost estimates and studies can provide general conclusions about the scale of hard-cost additions required for PH certification.

Using the RSMeans database, researchers estimate the incremental cost for upgrading windows is approximately $13.20 per square foot of window area. (Gordian, 2024) This estimate is significantly higher than another study indicating an incremental cost of $4-7 per square foot (Selkowitz, 2023, p. 15) and may be due to substantial inflation in recent years. For the evaluated buildings located in Vermont, the RSMeans estimate gives an incremental cost ranging from roughly $28,000 to $70,000, based on the total window area. This also gives an example of how cost estimating is challenging in accuracy.

Available Incentives

State requirements and incentives for energy efficient multifamily new construction vary widely across the United States. Efficient multifamily construction for affordable housing is incentivized through state and federal programs and points in state Qualified Allocation Plans (QAPs) at different levels in different states. Among the more advanced, Massachusetts now requires PH certification for all multifamily buildings over 12,000 square feet in approximately 40 cities and towns across Massachusetts that have opted into the state's new Specialized Energy Code. Massachusetts achieved that level of code acceptance through a Passive House Design Challenge which provided substantial incentives and training for a limited time to study the effectiveness (Simmons, Craig, McKneally, & Lino, 2022). See Appendix A for more information on state incentives outside of Vermont for PH certification.

The higher cost of EVTHP and PH certification can be offset by available incentives in Vermont. The incentives shown in Table 5 are available for either EVTHP or PH construction for multifamily new construction.

Table 5: Vermont Multifamily Incentives

Incentive	EVTHP qualifies	PH qualifies	Amount per dwelling unit or total
EVT per unit program incentive	✓	✓	$2700, (2020 – 2024) $3700, (2024+)
EVT: energy modeling	optional	✓	50% up to $5,000 total
EVT: building envelope commissioning	optional	✓	50% up to $5,000 total
EVT: mechanical commissioning	optional	✓	50% up to $5,000 total
45L federal tax credit	optional	✓	Up to $5000 per unit, if prevailing wage requirements are met
VHFA Low Income Housing Tax Credit (LIHTC) Qualified Allocation Plan (QAP)	X	✓	One checkmark or point for PH or Net Zero certification can be advantageous for 9 percent tax credits, affordable development only
Vermont Passive House (VTPH) training grant	X	✓	$500 cost reimbursement towards Phius and Passive House Institute (PHI) accreditation training

The current total that can be achieved for either certification is $8,700 per unit plus an additional $15,000 per project, which equates to $276,000 for a 30-unit building. There is currently no additional incentive available for PH certification except the QAP point, which only applies to affordable development. The VHFA LIHTC QAP system does not translate to QAPs in other states since there are fewer points total, more flexibility in how they are allocated, and no cost caps. The PH point can help a project to qualify for the upper level of 9 percent tax credits, but due to the high level of competition, it is not guaranteed.

Market rate MF projects are subject to different cost pressures, but several case studies have shown PH certification to be cost-competitive with code-level construction due to advantageous financing options, low operational energy costs with related increased access to private debt, and rent pricing strategies.

Partner Feedback

Discussions were conducted with the owners and operators of the multifamily PH buildings to obtain feedback about the design and construction process, the certification, and how the buildings are performing. There was a general feeling among all interviewed that the PH buildings seem well-constructed and quiet, with consistent indoor temperatures. The perception among all interviewed is that a PH building is among the most energy-efficient buildings that can be built, which contributed to their decision to pursue PH. None mentioned any major power outages, weather events, or other resilience tests of their buildings thus far.

Certain themes came up in all the conversations, like the cost to build and operate the buildings which is the primary concern. Affordable housing partners typically own and operate their buildings for their lifetimes, so they are especially concerned about operational energy costs since heating and hot water are not usually included in the rent and are paid by the owner. Minimizing energy costs benefits them and their residents, but most questioned whether PH is worth the expense and complexity of certification. Some saw EVTHP as a simpler and more achievable standard, while still providing the same incentives. Those with less PH experience mentioned the added time involved and felt the certification did not justify the extra time and cost required because it prevented homes from being built as quickly. However, having special accolades and awards that PH has brought helps with their corporate image.

Affordable housing partners noted they are trying to find the balance between building the best building possible and building it affordably, especially with the staggering cost increases of recent years. Developers feel they need to seek funding opportunities that have the potential to have the greatest impact. There has not been any additional funding or significant incentives available for PH in Vermont since the first project in 2017, so interest in multifamily PH certification has waned in the state. The current QAP checkmark for PH is somewhat minor among all the points that an affordable multifamily project needs to qualify for—location, access to transportation, etc. And there are additional cost burdens which are consistently being added—inflation, increasing standards, and requirements for funding like the Build America Buy America Act (BABA). The consensus among the interviewees is that there would need to be more financial incentives for PH to achieve the certification.

One developer who has more experience with multifamily PH certification mentioned that they are now building close to the standard but not certifying due to increasing cost and lack of incentives. They feel that most of what PH requires is worth the effort, and since their experience has raised their collective team's knowledge base and introduced expertise to the market, they are able to use the PH standard as a tool to achieve high-performance or net zero consistently and for less cost than certifying as a PH. These developers also mentioned aspects of the PH standard that they have adopted and now apply to all new buildings. These include air tightness (with building envelope commissioning), triple glazed windows, continuous insulation, balanced ventilation, and photovoltaics.

Another theme that came up in all conversations was regarding the operation of the building after occupancy – maintenance and monitoring of mechanical systems and controls is critical to realize energy savings over the long term. Despite the requirements for mechanical commissioning in a PH, there were often issues that showed up post occupancy that caused unnecessary excess energy consumption over what was predicted. These issues tend to become apparent when systems are being monitored and there is a predicted energy usage to compare with, as in a PH, and otherwise they go unnoticed. Developers felt that monitoring energy usage for the first year is especially important to ensure that systems and controls are optimized, and they can troubleshoot issues with equipment while still under warranty. Direct digital controls (DDC) allow owners to do most of this troubleshooting remotely and is seen as a desired feature to include if possible. Knowledgeable building maintenance and management staff is also critical to success with realizing predicted energy savings over time.

Discussion

Opportunities and Barriers for Passive Buildings

The EVTHP tier for multifamily new construction provides a simple, lower-cost path to low EUI buildings, but the data shows that it is not a guarantee of reaching zero emissions level of efficiency or net zero ready. The PH standard guarantees a level of energy savings due to energy limits and verification requirements. Table 6 highlights additional opportunities and barriers for PH in Vermont.

Table 6: Opportunities and Barriers for Passive Buildings

Opportunities	Barriers
Early energy modeling leads to optimized envelope and mechanical systems which can lead to cost savings (example: smaller mechanical systems due to envelope upgrades).	Higher cost—hard costs for construction and soft costs for consulting and certification.
Performance standard allows for more flexibility.	Alternative path of EVTHP provides a simple, low-cost option to achieving savings and earning equivalent incentives.
Limits value engineering during bidding and change orders during construction, which prevents compromise of performance.	Lack of PH education and knowledge base exists in community due to few completed projects.
Allows outsourcing of some current Efficiency Vermont work to third-party raters and consultants with extensive oversight due to rigor of certification.	Lack of PH certified professionals in Vermont.
Training opportunities for third-party consultants and professional development of design and construction team members would lead to market transformation.	Limited additional financial incentives for PH currently exist.

Phius standard requires and aligns with what is currently encouraged in EVTHP—early energy modeling, envelope and mechanical commissioning, site verification, compartmentalization, DHW distribution efficiency, and decarbonization.	Stigma exists around PH standard and challenges with first multifamily PH building.
Independent review of all building systems is provided, satisfying regulatory requirements. Durable assemblies are verified providing assurance for project team.	Additional design time and support is needed for a team's first PH project.

Resilience Benefits

"The time constant of Passive Buildings might be the most untapped resource."
- Graham Wright

Studies have shown through the robust envelope and ultra-low air tightness of a Passive Building, PHs have the potential for load flexibility with space conditioning loads – the ability to shift loads to different times to influence total power demand on the grid at a specific time. (Wright & Mitchell, 2023) This is due to the ability of the interior temperatures of the building to be maintained in times of loss of power or heating/cooling source. With grid-interactive controls, a PH building or group of buildings have the ability to shed load at peak hours therefore offsetting costly peak resources, which is becoming increasingly valuable as a strategy in demand response programs. (White, 2023)

Energy Modeling Benefits

One of the primary differences between PH and EVTHP for multifamily buildings is the energy model that is required to be created to verify energy limits for PH certification. This allows for multiple benefits including:

- Optimization of the building envelope features with each other, allowing trade-offs
- Optimization of the thermal envelope with the mechanical systems within a total predicted energy use which can result in construction cost savings.
    - Ability to include lesser used building elements like exterior shading devices and daylighting to offset mechanical loads
- A predicted energy performance value which allows for post-occupancy comparison of actual usage to the model and can be used for a performance guarantee.

Phius requires the use of proprietary software, WUFI Passive or METr, which can be an obstacle due to the cost and limited conversion to other software. For energy savings analyses, a common strategy has been to create a separate baseline energy model using the same software to determine savings, and PH consultants have reported this process does not add significant time or cost. ASHRAE is developing a Passive Building standard, ASHRAE 227, which will help clear additional adoption hurdles.

Prediction vs. Reality

The predicted energy value that a model provides can also bring additional scrutiny when predictions don't match actual consumption of a building. Discrepancies in real-world usage are common for buildings with pre-construction energy modeling due to the many factors affecting energy usage and historical shortcomings in the accuracy of modeling analyses or inputs, which can create further issues when predicted energy performance is assumed or guaranteed. However, software is continually improving accuracy and has provided modeling process improvements over what was available at the design of the first building in this study.

Through energy monitoring and comparison with predicted energy use, several PH buildings in this study discovered issues with their mechanical systems that were resulting in higher-than-expected energy consumption. Interviewees mentioned several instances of buildings not performing as predicted and either existing monitoring was used, or investigative metering was deployed to find the issues, resulting in measurable savings. Despite the issues, these PH buildings are still lower energy than most of the HP buildings in the study, but these uncovered issues can at least partly explain the EUIs that are higher than the pre-construction energy model. It is likely that other non-PH buildings have similar issues resulting in higher energy use, but they are not as closely observed so the issues remain hidden. An additional benefit of rigorous PH on-site verification is when energy usage issues arise in a PH building, thermal envelope shortcomings can be ruled out.

Conclusion

Passive House as a Reach Goal for Vermont

As Vermont approaches net-zero-ready goals for new construction in 2030 and energy savings diminish for the Efficiency Vermont High-Performance standard (EVTHP) for MFNC, Efficiency Vermont researchers recommend that Efficiency Vermont support Passive House (PH) certification as a new reach goal for the Efficiency Vermont MFNC program, as an optional add-on to its well-established EVTHP offering. Years of success with EVTHP and increasing requirements have minimized the difficulty in a once-significant step upward to PH. The many benefits of PH include design flexibility of a performance standard, optimized and integrated building systems, independent review of design and construction, modeled predicted energy use, and a higher level of reliable energy savings.

This study demonstrates that PH buildings save an average of about 19 percent of total energy consumption over EVTHP buildings, and performance results are more predictable with less variability due to the required modeled energy targets, detailed oversight, and rigorous verification. This positions the PH reach goal to still garner savings as Vermont code continues to evolve, while not disrupting a proven and popular EVTHP program. Currently available incentives are significant, but PH certification carries higher total costs for design, construction, and verification which will require additional incentives and implementation support for successful adoption. With the lack of certified PH professionals in Vermont, there is an opportunity to support PH training which, with its relevance to high performance regardless of the standard sought, will encourage market transformation. Energy modeling and site verification by certified PH professionals will offset some work performed by Efficiency Vermont staff, saving time and resources that can be directed elsewhere.

Stakeholder feedback highlighted the need for additional incentives and support to cover the increased cost and complexity of PH certification, especially for first-time projects. However, evidence shows that PH certification gets easier, and design costs decrease with increased experience of the entire project team. With greater adoption of PH in energy codes and incentive programs throughout the northeast, there are many current multifamily PH examples to guide project teams. The predicted energy consumption that PH modeling provides has been useful in post-occupancy energy comparisons, but advancements in modeling software and more accurate inputs will continue to make energy modeling an essential tool for increasing energy savings.

Efficiency Vermont researchers were not able to include all topics of interest in the limited scope of the current research. Additional investigations could include:

- Whole building lifecycle analysis and carbon impact comparisons
- Enhancements to Efficiency Vermont incentive structures to support PH certification
- Evolution of EVTHP requirements
- Operational cost comparisons between standards and systems, with the option to break-out costs for heating, cooling, ventilation and hot water systems to gain a full understanding of how the buildings are operating
- A detailed and current construction cost analysis

To retain relevance, due to recent energy code updates and price volatility, it is recommended that a construction cost study be done for a future project, to evaluate the capital cost difference between achieving Vermont energy code baseline, EVTHP, Zero Energy Ready Home (ZERH), and PH certification. A current cost study could reveal a reduced scale of upgrades for PH due to recent code updates.

Alternative Applications

It is the position of the researchers that the entire PH standard and certification be adopted as a reach goal because of the many integrated benefits listed. Based on conversations with affordable housing developers and financers, researchers conclude that, in the absence of full PH certification, the following elements could be cost-effectively added to the list of HP requirements in future updates, without adding to on-going maintenance costs:

- Whole building air leakage targets at the Passive House level
- Higher efficiency ventilation equipment
- Triple-glazed windows
- Higher R-value assemblies – walls, roof/ ceiling, and floor/ slab
- More rigorous Quality Assurance/ Quality Control (QA/QC)
- Mechanical commissioning – monitoring for first year and subsequent controls adjustments to align with predicted energy use

Although full mechanical commissioning is not required in either program, it has shown up in this research as a significant energy-savings opportunity. These above listed items could be implemented individually, but since the multifamily buildings in Vermont represent significant state assets, the integrated approach of Passive House certification would better guarantee long term savings over the life of the building.

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Appendix A

Northeastern States Passive House Incentives and Requirements

State	Incentive agency or state body	Source and Reference	Details
CT	Eversource, sponsor of Energize CT	Residential New Construction Passive House Incentives (Energize CT, 2022)	Pre-construction and post-construction incentives for multifamily (MF) Passive House (PH) certification can add up to $110,000.
	Energize CT, CT Passive House	Passive House and All-Electric Home Initiative (Energize CT, 2024)	75% cost reimbursement for professionals who successfully complete PH accreditation trainings and exams.
	CT Housing Finance Authority	Low-Income Housing Tax Credit (LIHTC) 2024 and 2025 Qualified Allocation Plan (Connecticut Housing Finance Authority, 2023)	Qualified Allocation Plan (QAP) awards four points for tier 3 which includes PH certification.
MA	Stretch Energy Code	225 CMR 22: Massachusetts Residential Stretch Energy Code and Municipal Opt-In Specialized Code 2023 (Massachusetts Department of Energy Resources, 2022)https://www.mass.gov/regulations/780-CMR-chapter-115-aa-stretch-energy-code	2023 Opt-in Stretch Code requires PH certification for MF projects above 12,000 square feet. 22 municipalities have adopted it as of Jan. 1, 2024.
	Mass Save	Passive House Multifamily Incentives (Mass Save, 2024)	Incentives for PH feasibility study (up to $5,000), energy modeling (up to $20,000), PH pre-certification ($750 per unit), and final PH certification ($3,000 per unit).
	Massachusetts Clean Energy Center (CEC)	Passive House Design Challenge (Massachusetts Clean Energy Center, 2022)https://www.masscec.com/emerging-initiatives/passive-house	Awarded up to $4,000 per unit for eight MF affordable housing developments and informed Mass Save's incentives for PH MFNC.

	Massachusetts Department of Housing and Community Development (DHCD)	LIHTC Program, 2023-2024 Qualified Allocation Plan (Massachusetts DHCD, 2022)	QAP awards eight points for NC or retrofit PH certification with five additional points available for innovative characteristics and PH consultant on team.
NY	NYSERDA	Buildings of Excellence Competition (NYSERDA, 2024) https://www.nyserda.ny.gov/all-programs/programs/multifamily-buildings-of-excellence	Competition recognizes best in class buildings, with prizes of up to $1 million for demonstration projects and up to $100,000 in funding for Early Design Support.
	NYSERDA	Building Better Homes Program (NYSERDA, 2025)	Building Better Homes program provides incentives of up to $2,000 per person for PH training. Additional incentives for projects meeting zero emission standards.
	NYSERDA	NYStretch Energy Code – 2020 (NYSERDA, 2019)	Part 3, section R408 includes Passive House certification as a compliance path.
RI	National Grid	Rhode Island Residential New Construction (RNC) Program & Zero Energy Homes (Rhode Island Energy, 2023)https://energy.ri.gov/sites/g/files/xkgbur741/files/2023-09/ri-energy-rn_zero-energy-ready-program-description.pdf	PH is one option for eligibility for Residential and New Construction & Zero Energy Homes program; incentives are based on number of units. An 11 – 30-unit building can receive up to $2,750 per unit.
	RI Housing	State of Rhode Island 2024 Qualified Allocation Plan (Rhode Island Housing, 2024)	QAP awards up to three points for meeting PH standards.
States with only low-income housing tax credits (LIHTC) for incentives			
ME	Maine Housing	2023 - 2024 LIHTC Qualified Allocation Plan (MaineHousing, 2022)	QAP allows a greater Total Development Cost (TDC) per unit for PH certification.
NH	NH Housing Finance Agency	New Hampshire Qualified Allocation Plan (New Hampshire Housing, 2024)	QAP awards eight points for PH certification and allows a greater TDC per unit.

PA	PA Housing Finance Agency	Pennsylvania Housing Finance Agency Allocation Plan for Program Year 2024 (Pennsylvania Housing Finance Agency, 2023)https://www.phfa.org/forms/multifamily_news/news/2023/2024-lihtc-allocation-plan.pdf	QAP awards ten points for PH certification.