playbook

Multifamily Passive House: Connecting Performance to Financing

How energy efficiency and operational savings can provide additional, ongoing cash flow.

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NYC ACCELERATOR

NYC Department of Housing Preservation & Development

MARCH 2021

Project Team

This study was conducted by a team from:

- New York City Department of Housing Preservation and Development (NYC HPD)
- Bright Power
- The Community Preservation Corporation (CPC)
- Steven Winter Associates (SWA)

The report was made possible by generous support from the NYC Accelerator. Visit nyc.gov/accelerator to learn more.

Executive Summary

The Passive House design standard reduces operational costs, which can offset incremental construction costs in the multifamily affordable housing sector. This playbook compares operational energy consumption and carbon emissions data from six multifamily Passive House case study buildings against their conventionally built peers.

Overview

From June 2019 to April 2020, the New York City Department of Housing Preservation and Development (NYC HPD), The Community Preservation Corporation (CPC), Bright Power, and Steven Winter Associates (SWA) collaborated on a study to assess the full costs and savings of constructing and operating Passive House multifamily housing developments, compared to conventionally built peers.

Findings show that the Passive House buildings use far less energy than typical multifamily buildings. These results translate into operational cost savings that can increase access to private debt and may also decrease reliance on public subsidies for certain types of affordable housing. Passive House buildings also emit significantly less carbon than conventional buildings, aligning them with long-term decarbonization goals set by New York City (NYC) and New York State (NYS).

The results of this study offer lenders assurance that projected Passive House energy savings translate into real operational cost reductions. Nevertheless, additional work is needed to spur more widespread adoption of the Passive House standard. In particular, future research examining a more extensive set of building data could support broader financing of such projects, thus accelerating adoption of Passive House.

Key Findings

There are several significant lessons learned from this study:

- The Passive House case study projects outperformed their peers in reducing energy use and utility costs, yielding substantial savings for building owners and tenants. These savings range from 28% to 68%, relative to their baselines.
- The Passive House case study group had substantially lower emissions than the control groups. All Passive House projects are projected to comply with NYC emissions limits for 2024 and 2030 and all but one would comply with the 2050 limits. For market rate buildings and certain types of affordable housing, this would enable them to avoid civil penalties.
- Across all metrics, projects that achieved Passive House certification and those that are electric-heated showed the best outcomes.
- Renewables can contribute to energy savings for Passive House projects. The best performing project incorporated a solar array and co-generation for hot water, achieving a 68% cost reduction relative to its baseline.
- Project performance tends to improve as building owners and tenants acclimate to new systems and adjust equipment settings.
- While first costs for Passive House construction can be higher than they are for conventional construction, costs tend to come down as the learning curve flattens and as the Passive House market grows.
- Non-energy benefits contribute to occupant health and safety and the well-being of the planet. While hard to quantify, these benefits could be incorporated into underwriting in the future.
- Operational savings can enable projects to leverage additional private debt and reduce reliance on public subsidies. For the Passive House projects included in this study, operational savings could unlock an additional $2 to $13/sf in debt.

Assessing Passive House Performance

Passive House is a high-performance, low energy use design and construction standard that has been well established in Europe and Canada since the 1970s. Interest in Passive House construction has grown rapidly in recent years and its adoption is notable in the NYC affordable housing market.

Making the Case for Passive House

Passive House design can save up to 85%[1] on heating and cooling costs and up to 60% on total energy use compared to conventional construction, presenting a compelling opportunity to improve cash flow in a market sector defined by lean operational budgets.

It can also reduce carbon emissions, providing a pathway to align with local, state, and international climate policies. These include goals set by the NYC Climate Mobilization Act (CMA), the NYS Climate Leadership and Community Protection Act (CLCPA), and the Intergovernmental Panel on Climate Change (IPCC).

Achieving High Performance

The 'Passive House standard' actually refers to two distinct standards from two separate organizations– Passive House Institute (PHI) and Passive House Institute United States (PHIUS). While there are differences between the two standards, this study focuses on their common goal of achieving high levels of energy use reduction.

The Passive House standard requires thoughtful design and stringent quality control during construction to attain quantifiable and rigorous levels of energy performance. The key principles and benefits of Passive House design are also common across both standards and are highlighted in Figure A.

Addressing Barriers to Adoption

Despite the known advantages and increasing demand for low carbon housing, Passive House design for multifamily affordable buildings has not yet been adopted widely. Of the various barriers to adoption, limited access to financing is one of the most significant.

Passive House project financing is often constrained by the following:

- Perceived first cost increase
- Limited data to prove the operational savings associated with Passive House performance
- Inability to recognize and quantify the value of non-energy benefits, such as enhanced resilience and occupant health.
- Lack of a methodology to underwrite to Passive House levels of energy performance.

Leveraging Data to Increase Lending

In order to accelerate adoption, lenders need a viable method for financing Passive House projects. This will require access to data that demonstrates how Passive House buildings compare to their conventionally-built peers across the project's life cycle, as well as guidance on how to underwrite to energy savings and non-energy benefits.

To that end, the research team selected the following areas of study for further analysis:

- First costs (design and construction)
- Operational costs (utilities and maintenance)
- Carbon emissions and penalties
- Non-energy benefits (resilience, improved health and comfort, risk reduction, etc).

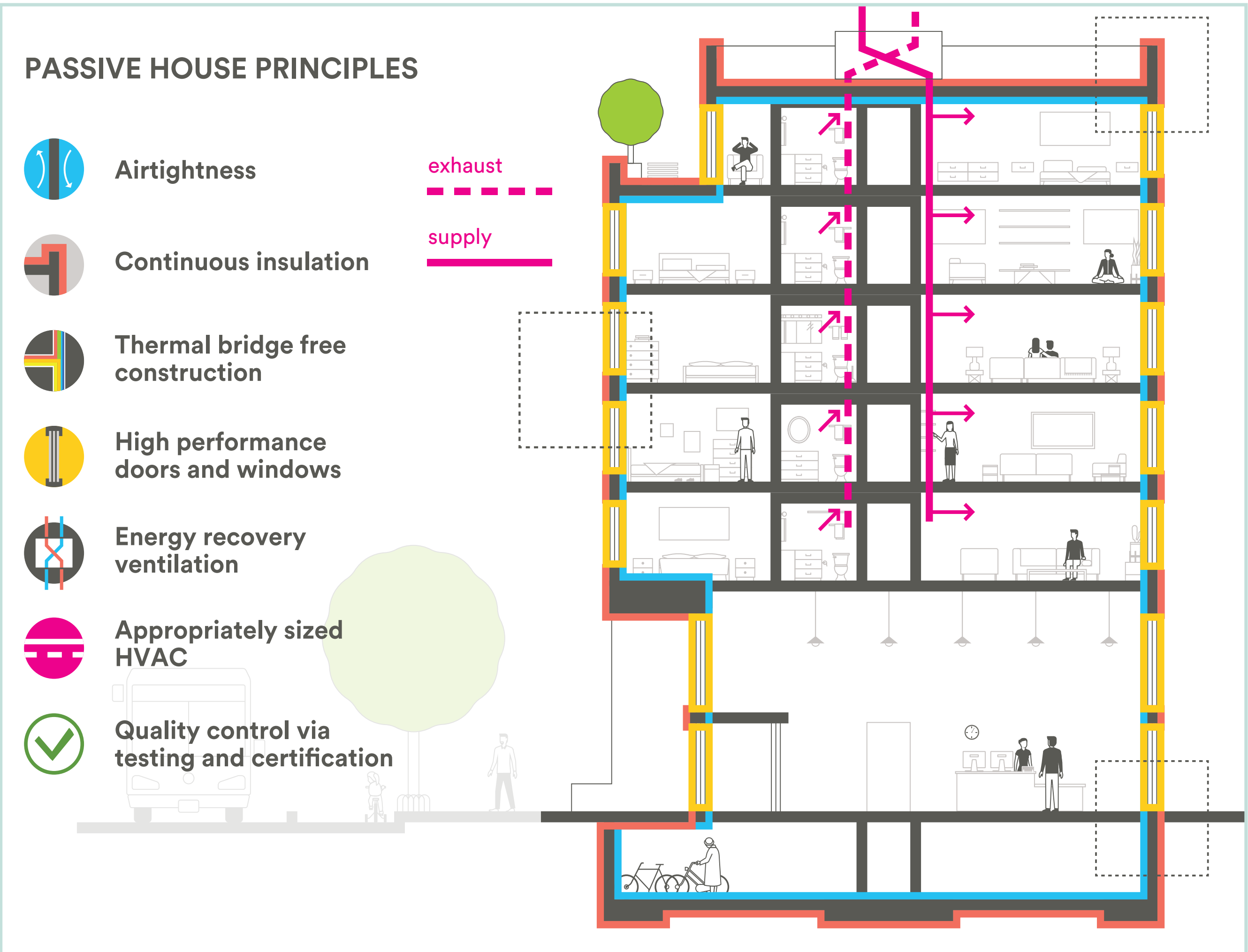
By understanding these metrics, lenders can develop more accurate and aggressive underwriting standards for Passive House projects. Better underwriting can help project owners and developers access additional private debt to overcome first cost barriers that currently hinder adoption in the affordable housing sector.

Navigating this Playbook

The following pages detail the project team's original research and analysis, which is organized according to the following objectives:

- **Objective 1:** Provide a framework to compare data from a study group and control groups.
- **Objective 2:** Compare site Energy Use Intensity between the study and control groups.
- **Objective 3:** Compare carbon emissions and financial implications of carbon regulations.
- **Objective 4:** Calculate operational cost savings.
- **Objective 5:** Demonstrate a methodology for underwriting incremental first costs.
- **Objective 6:** Demonstrate a methodology for underwriting operational cost savings.

Figure A. Buildings that meet the Passive House standard are designed and constructed according to a set of key principles. Occupants and owners enjoy a variety of benefits, including lower operating costs, improved health and comfort, and reduced risk. The figure below provides an overview of the fundamental strategies and outcomes of Passive House construction.



PASSIVE HOUSE BENEFITS

- Utility cost savings
- Avoidance of future carbon penalties
- Construction risk reduction
- Improved indoor air quality and occupant health
- Improved thermal comfort and acoustics
- Enhanced climate resilience and reliability

Establishing the Passive House Study Group and Control Groups

This study analyzed a group of Passive House multifamily buildings in NYC, looking at energy consumption, greenhouse gas (GHG) emissions, costs and savings, and compared their performance to a group of conventionally built peer buildings.

Objective 1: Provide a framework to compare data from a study group and control groups.

Establishing the Passive House Case Study Group

The research team began by collecting basic information on completed multifamily affordable housing developments in NYC designed to Passive House standards and available via Bright Power's energy benchmarking platform, EnergyScoreCards.[2]

In order to obtain the largest possible sample size, the team included projects that achieved Passive House certification, as well as those that were designed to the standard or included Passive House design elements but did not certify.

Nevertheless, the sample size was limited, in part, by the fact that Passive House design is still relatively new in NYC and the development timeline for multifamily affordable housing can take upwards of three years to complete. The sample group was further winnowed to include only projects with at least 12 months of whole property energy consumption data.[3]

The resulting Passive House case study group includes six early-adopters, two of which achieved Passive House certification. The other four are either pursuing certification or implemented Passive House design strategies but did not certify.

For the purposes of the study, the team divided the study group buildings into two sub-groups, based on heating fuel source:

- **A gas-heated group** that includes two very early projects with gas hydronic heating and window unit air conditioners with custom covers (C-1 and C-2 in Figure C). Neither project is certified and both are small, affordable housing projects.
- **An electric-heated group** that includes two certified projects (C-5 and C-6), a project pursuing certification (C-4), and a “Passive House like" building that implemented Passive House design principles but did not certify (C-3). This group contains projects of all scales that use electric heating and cooling.

All projects across the two Passive House sub-groups use gas to heat domestic hot water.

Establishing the Control Groups

To establish a baseline for comparison, the team compiled data on multifamily properties with at least 12 months of whole building energy consumption data (tenant and owner paid) from Bright Power’s EnergyScoreCards.

The team established two control groups, representing two different points of comparison:

- **A pre-2003** existing building group comprised of benchmarking data from 1,633 NYC properties. 96% of the buildings are heated with gas and 4% use electric heating.
- **A post-2003** conventional new construction group made up of 315 NYC buildings built after 2003. 94% of these buildings are heated with gas and 6% use electric heating.

The control groups both align with the profile of buildings used to calculate the maintenance and operations standards that New York City affordable housing projects use for budgeting.

By including two control groups in the study, the team was able to assess how the case study group compared to conventionally constructed buildings of a similar vintage, as well as how the study group compared to a much broader set of existing buildings in New York City.

Analyzing Energy Consumption

Reducing energy use is a key motivator for pursuing Passive House. While there is abundant data on predicted levels of energy use, better data is needed to verify actual performance. The team's research confirmed that the Passive House case study group greatly outperforms the control groups.

Objective 2: Compare site Energy Use Intensity between the study and control groups.

Understanding Modeled vs. Measured Energy Use

The Passive House standard requires buildings to meet certain energy performance targets, which are predicted through energy models. Energy models account for multiple variables in multifamily buildings, such as occupant behavior, density, and apartment unit size.

An important question is whether the predictions of energy models are being actualized. To that end, the research team compared measured energy use in the Passive House study group against not only energy use in the control groups, but also against a modeled target for Passive House performance.[4]

Assessing Energy Performance

The team analyzed data to determine whole building, site energy use intensity (EUI) for weather-normalized operations. EUI is a metric for comparing energy use across different buildings. Site EUI is the annual energy consumed by a building on-site. The research team's findings demonstrate that building to the Passive House standard leads to far lower EUIs than conventional construction.

Figure B illustrates the following:

- The Passive House study group (C-1 through C-6) uses 32% to 58% less energy than the conventionally built post-2003 control group.
- The electric-heated Passive House group (C-3 through C-6) performs better than the gas-heated group (C-1 and C-2).
- Certified Passive House buildings (C-5 and C-6) consume the least energy of all the buildings.

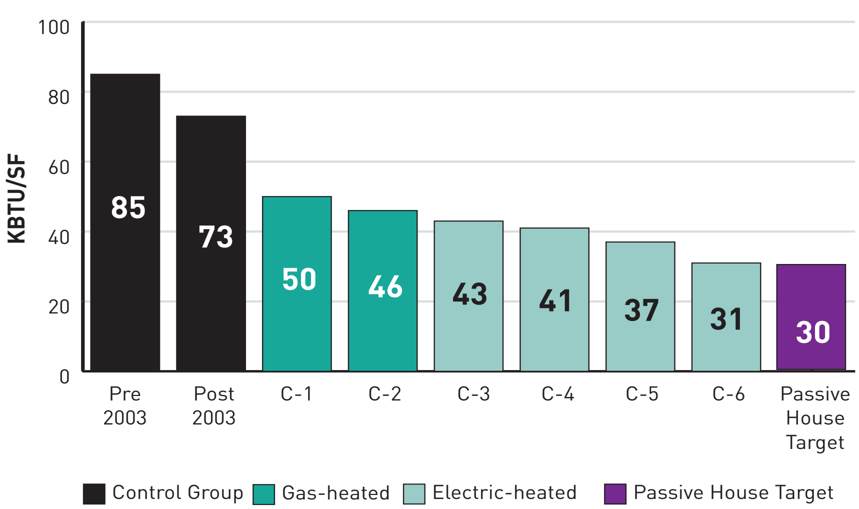


Figure B. Looking at Energy Use Intensity (EUI), the Passive House case study buildings consume 32-58% less energy than the buildings in the post-2003, conventionally-built control group.[5]

Analyzing Greenhouse Gas Emissions

Building to the Passive House standard can help owners meet climate legislation by reducing emissions, thereby avoiding costly retrofit projects that would otherwise be required for compliance.

Objective 3: Compare carbon emissions and financial implications of carbon regulations.

Evaluating the Impact of Carbon Emissions

Site EUI is not the only way to evaluate the case study group's performance, as it provides only a window into the amount of energy consumed by a building on-site. Understanding how buildings contribute to greenhouse gas emissions (GHG) is key to combating climate change. Failure to reduce emissions can have severe financial implications for building owners and developers.

Emissions from buildings are a major concern, particularly in cities. In NYC, buildings account for two-thirds of the city's total emissions. NYC Local Law 97 of 2019 (LL97) established limits on building-level emissions that go into effect in 2024 and become more stringent every five years until 2050. Special compliance pathways have been designated for various building typologies, including affordable housing.

Meeting Emissions Targets

How well do the base case groups and Passive House case study buildings perform? Figure D shows how they compare in terms of GHG emissions (GHG per gsf/year), as well as how they stack up against LL97 emissions caps mandated for 2024, 2030, and 2050.[6]

Figure D (p.9) illustrates the following:

- All of the Passive House case study group buildings, including those that use gas for heating and hot water, would easily comply with the 2024 emissions limit and the more stringent 2030 limit. Therefore, these buildings would not need to invest in measures to reduce their GHG emissions in the first two compliance periods.
- The Pre-2003 and Post-2003 control groups would require significant capital retrofit improvements to comply with the 2030 GHG limits or face civil penalties.

Looking ahead to the ambitious 2050 compliance target, Figure E (p.9) shows that:

- The Pre-2003 and Post-2003 control groups would require even more significant capital improvements to comply with the 2050 GHG limits.
- All but one of the Passive House study group projects would comply with the 2050 target.
- All electric-heated Passive House projects would be at or below the 2050 cap. For market rate buildings and certain types of affordable housing, this would enable them to avoid civil penalties.

Understanding the 2050 GHG Calculations

Each building's GHG budget is calculated using a "carbon intensity factor" that depends on the fuel type used. As we move towards 2050 and the State's deadline for transitioning the electric grid to 100% clean energy (solar, wind, etc), the carbon intensity factor for electricity will become zero. This changes the emissions budget calculations for each project in the 2050 compliance period and is reflected in Figure E.

Figure C. Energy models often do not reflect actual energy use. For instance, occupant behavior can lead to higher levels of energy use than is predicted by models.

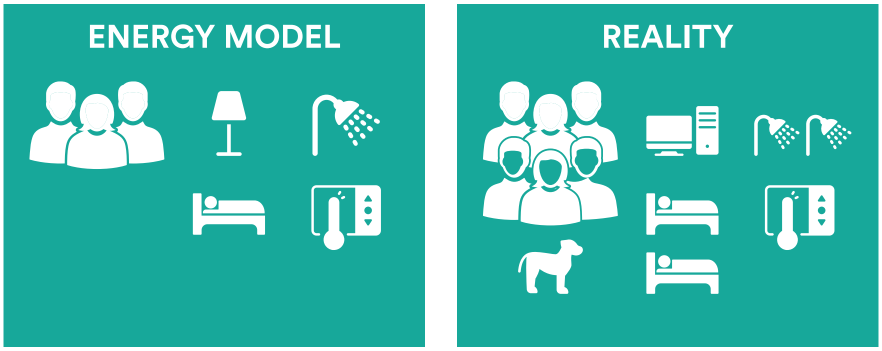
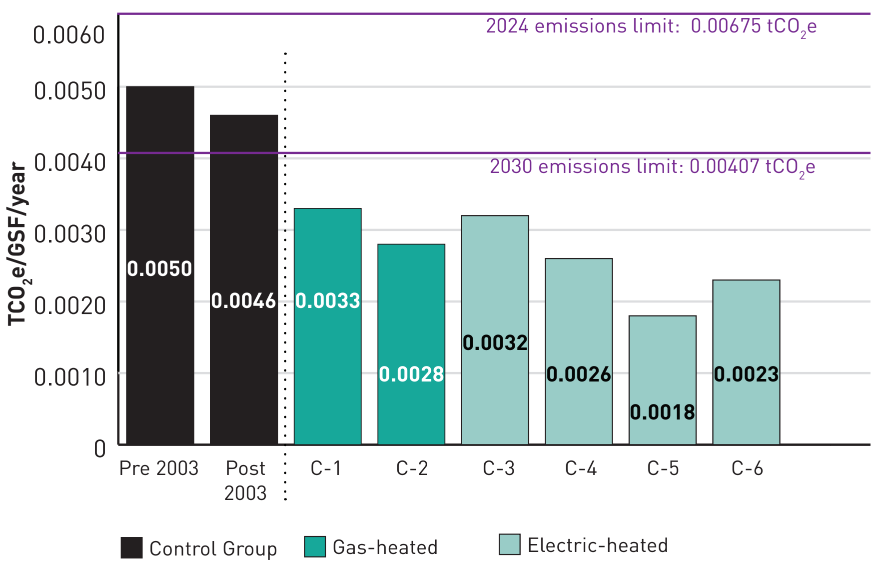


Figure D. The Passive House case study buildings would comply with 2024 and 2030 LL97 emissions caps. The control groups would need to invest in significant capital improvements to avoid civil penalties.



Closing the Predicted Performance Gap

Although they perform substantially better than the control groups, it is evident that the Passive House study group buildings are not quite meeting modeled predictions for the Passive House standard (purple bar, Figure B, p.7). However, it is critical to note that while the Passive House case study projects may not have met the standard's EUI target, they are some of the earliest adopters of Passive House at this scale.

Additionally, energy models are only informed estimates and often fall short of predicting actual energy use and costs. For example, Passive House energy models do not necessarily align with the realities of tenant behaviour in the United States, occupancy patterns, or the small size of apartments in dense cities like NYC (see Figure C). In order to reduce the modeled versus measured performance gap, building owners will need to collect more granular energy use data.

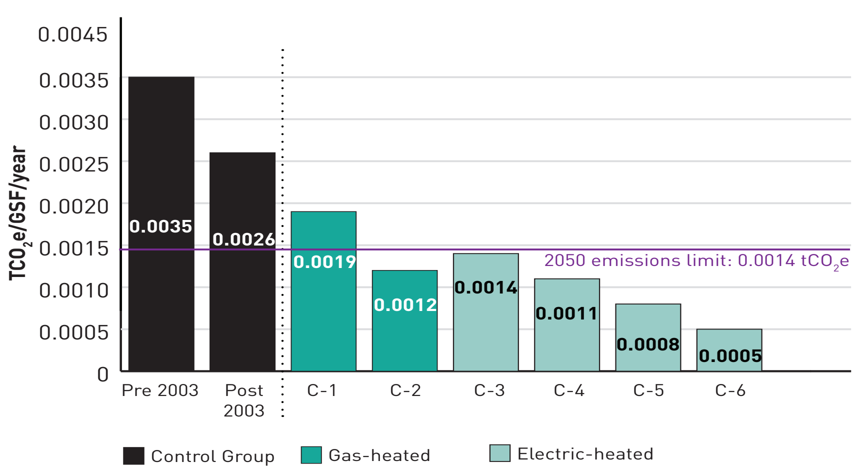


Figure E. All but one of the Passive House case study buildings would comply with the strict 2050 emissions limits, while the control groups would not.

Calculating Operational Cost Savings

Improved energy performance and reduced emissions in multifamily Passive House buildings can translate into operational savings, offering an advantage over conventional construction.

Objective 4: Calculate operational cost savings.

Determining Energy Cost Savings

To better understand energy cost savings, the research team analyzed each of the six Passive House case study projects in more detail. First, they assessed the performance of each Passive House project using whole-building utility data from the most recent year available. They then compared each case study's performance against that of a hypothetical, conventionally built affordable housing development of the same size and occupant density.[7]

Assessing Passive House Performance

The entire Passive House study group showed significant reductions in energy costs ranging from 28% to 68% relative to their baselines.[8]

A few key factors typically affect energy cost savings, and are evident in the case studies: [9]

- Energy costs scale less dramatically than energy savings. For instance, while the buildings with electric heating (C-3 to C-6) have lower GHG emissions and are more efficient than those with gas heating, electric rates are historically higher on a per-unit basis, making the difference in cost savings less substantial than might be expected.
- Project performance tends to improve as building owners and tenants acclimate to new systems and adjust equipment settings. This is reflected in the worst performing project, C-4, which had only a single year of operational data.
- Renewables can contribute to energy savings. The Passive House project with the greatest energy cost savings (C-5) incorporated a large solar array as well as co-generation for hot water, and achieved a 68% cost reduction relative to the baseline.

Figure F. Passive House case study group energy cost savings range from 28% to 68%. These savings can be leveraged to access additional private debt.

FUEL SOURCE	C-1	C-2	C-3	C-4	C-5	C-6
ELECTRIC COST REDUCTION	52%	40%	41%	12%	62%	30%
GAS COST REDUCTION	62%	70%	65%	60%	80%	85%
TOTAL ENERGY COST REDUCTION	55%	50%	48%	28%	68%	47%
DEBT THAT COULD BE LEVERAGED ($/SF)	$9-$13	$7-$10	$7-$11	$2-$4	$9-$13	$6-$9

Appraising Non-Energy Benefits

While externalities are not currently factored into a project's underwriting, there are are significant non-energy benefits (NEBs) associated with Passive House design and construction.

According to the Fannie Mae, special energy saving items must be recognized in the appraisal process and noted on the appraisal report form. While not directly calculated and captured in the first mortgage, the following factors contribute to overall asset health and value of high-performance buildings.[10]

- **Occupant Comfort:** Residents of Passive House buildings enjoy more consistent interior temperatures and humidity levels and higher acoustical comfort than residents of traditional buildings.

- **Indoor Air Quality & Health:** This feature of Passive House design has become even more critical given the outsized impacts of poor health and air quality on COVID-19 outcomes. For affordable housing tenants subject to multiple stressors and increased health challenges, and often living in areas with polluted outdoor air quality, these benefits are even more impactful.

- **Resiliency:** Passive House design features increase a building's resilience to climate and weather-related risks. In the coldest weather or during a power outage, a Passive House building can achieve a safe interior temperature equilibrium of approximately 55° Farenheit indefinitely, allowing residents to shelter in place. Passive House buildings also use less energy for cooling during heatwaves, essential for vulnerable populations with limited resources.

Using Savings to Unlock Financing

Reductions in energy use lower operating costs and utility bills, a major advantage for owners of Passive House buildings. For affordable housing, the ability to underwrite operational savings and NEBs is critical to unlocking additional private debt that can be used to offset the incremental first costs of higher performing buildings.

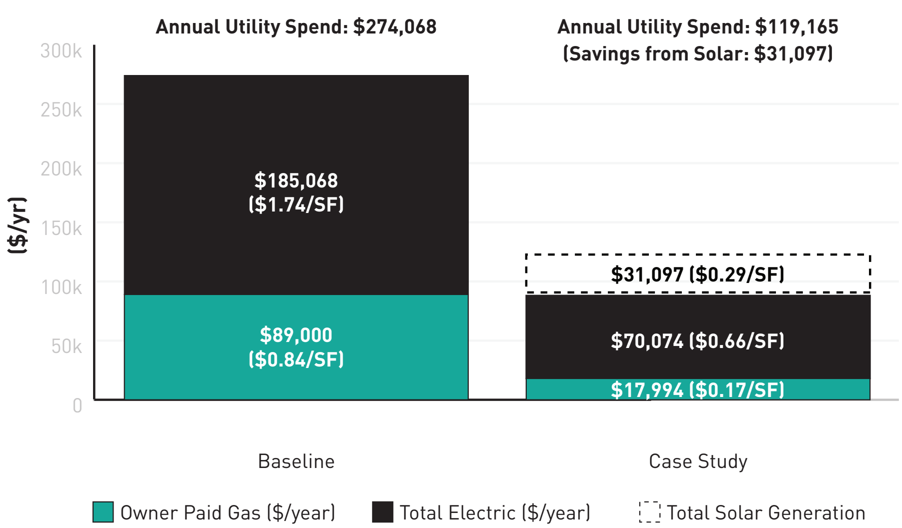


Figure G. Case study C-5 is a certified, large multifamily Passive House with electric heating and cooling plus onsite solar and co-generation.

The case study project's annual utility costs, based on energy consumption, is $119,165, or a 56% operational energy cost savings over the baseline cost of $274,068. After accounting for solar savings of $31,097, annual utility costs are only $88,068, reflecting a 68% total cost savings.

Putting a Price on Carbon

LL97 stipulates that an owner of a covered building that has exceeded its annual emissions limit shall be liable for a civil penalty of $268/ton carbon, every year that they are non-compliant. Penalties for exceeding carbon targets could negatively affect a building's operational expenses and return on investment.

Figure H shows potential avoided penalties relative to the 2030 and 2050 targets, illustrating the reduced financial risk for Passive House buildings as a result of carbon regulation. While the base case buildings could face significant fines, all of the Passive House study group buildings would be in compliance in 2030 and all but one in 2050.

If carbon trading is introduced in NYC, building owners may be able to capitalize on their carbon savings by selling those savings to a building owner who has emissions above the cap. These potential revenues could be significant for building owners. For instance, in 2030, the Passive House study group buildings could earn $5,000 to $132,000.[11]

Figure H. Translating carbon savings into dollars and cents helps to illustrate the reduced financial risk the Passive House study group faces as a result of carbon regulation, compared to the control groups.

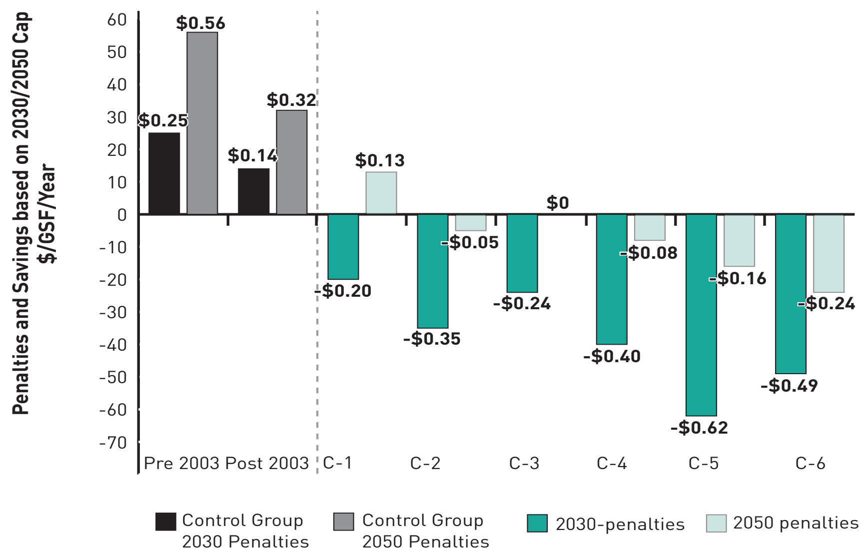
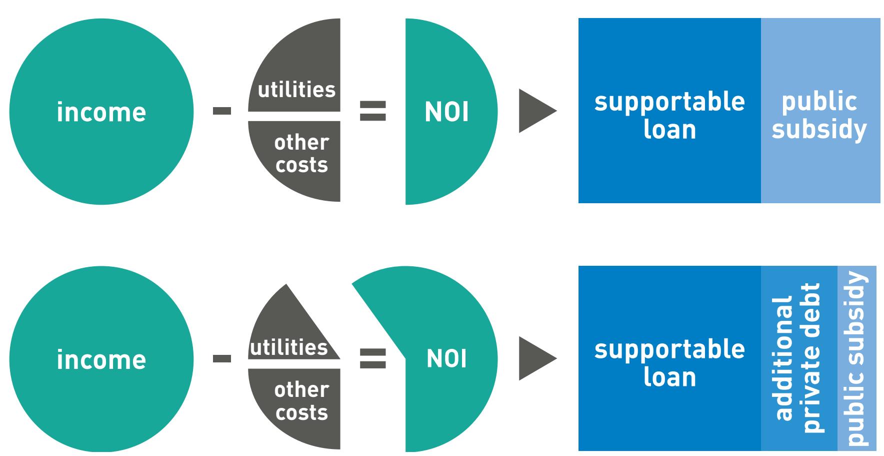


Figure I. Improved performance and utility cost savings associated with Passive House construction increase NOI, which supports additional private debt and can also reduce reliance on public subsidies for certain types of buildings.



Underwriting to Incremental Costs and Passive House Savings

Incremental first construction costs of Passive House projects are likely to decrease as components become more widely available and cost-efficient, increasing demand for high-performance buildings.

Objectives 5 & 6: Demonstrate a methodology for underwriting incremental first costs and operational savings.

Offsetting Incremental First Costs

Information reviewed as part this study—including experience from other Northeast states employing Passive House to address climate goals – indicates that it is possible to construct Passive House multifamily buildings at minimal additional cost, ranging from 0- 5% for experienced project teams. Incremental costs are strongly correlated with the baseline of comparison, and are expected to approach zero as code requirements and market demand increase, and as products become more widely available and cost-competitive.[12]

Incremental costs for Passive House construction often include the following:

- **Soft cost increases** for Passive House include certification, consulting, verification, and performance testing, typically ranging from $100K to $200K for multifamily projects. This varies with building size and team experience.
- **Hard cost increases** for Passive House are primarily related to higher performing HVAC equipment, particularly variable refrigerant flow (VRF) and energy recovery ventilation (ERV). Building envelopes also contribute to costs –primarily triple-glazed windows– which are required for many projects.
- **Maintenance & operating (M&O) costs** can run up to $200/apartment per year for ERV and VRF filter changes. This would be less for centralized systems and does not take into account the M&O costs of base case systems, like boilers and A/C units.
- **The learning curve and "fear of the unknown"** among contractors and subcontracts can increase costs for teams new to Passive House.

Translating Savings into Additional Private Debt

One way to cover incremental costs of Passive House construction is to factor energy performance cost savings into the first mortgage. Net operating income (NOI) is calculated based on the difference between rental and other income and M&O expenses. If lenders can prove some measure of cost reduction for certified Passive House and Passive House-like buildings, they can increase the supportable loan by reducing expenses and increasing NOI. This could also decrease the amount of subsidy often required from city and state agencies.

Underwriting to Improved Performance

Underwriting Passive House performance and cost reduction into a first mortgage takes into account the financial stability of the project. Below are key recommendations for lenders to consider:

1. Compare projected energy costs to conventional M&O standards to assess potential energy cost savings.
    a. Confirm what portion of the energy cost savings will accrue to the owner. Those savings can be underwritten by the lender.
    b. Ensure that renewables, if included, are factored into energy cost savings.
    c. If applicable, factor in avoided costs (e.g. future carbon penalties, reduced vacancies) over the project’s life cycle.

2. Collect relevant project information and relevant comparables (“comps”) to assess risk.
    a. How does the projected performance compare to available Passive House comps?
    b. Has the team (e.g. architect, contractor, etc.) built to a Passive House standard before?
    c. Does the team plan to certify to a Passive House standard?

3. Determine the NOI.

4. Determine a reasonable percentage of energy cost savings that can be underwritten, and use that to assess the additional debt that the project can leverage.

Looking Ahead

The research team's findings support Passive House as an effective standard to attain a high level of energy efficiency, cost and carbon savings, and a series of value-added benefits, which can be leveraged to increase financing. These findings have already proved valuable for Passive House affordable housing, but more data is needed. The next phase of research will include a deeper dive into building data to support even wider adoption of Passive House.

Conclusion

This study demonstrates that Passive House-levels of performance can yield savings that increase NOI and unlock access to additional private debt. This can offset incremental first costs of construction, making Passive House buildings cost-competitive to build and operate, of particular value to the affordable housing sector.

However, this first-of-its-kind analysis is limited by the small size of its dataset. Additional research is needed to help underwriters develop standards that accurately reflect the real performance of Passive House projects, increase lender confidence, and encourage broader financing of projects.

What's Next

This analysis of multifamily Passive House buildings is just a starting point. The research team seeks to expand and deepen this research in three key areas:

1. **Conduct a deep dive into energy performance** to better understand the implications of building design, operation, systems choices, and tenant behavior. This will help the industry better understand the differences between Passive House models and actual performance.

2. **Collect data from more buildings** in NYC and similar climate regions. A capstone team from the City College of New York (CUNY) Sustainability in the Urban Environment program is currently working on a multifamily Passive House database that will collect data from projects in North American climates similar to New York's. The database includes an online survey that collects the granular information needed for future research and asks that participants share benchmarking data through the EPA's free Portfolio Manager tool.

   This survey will be distributed among multifamily Passive House professionals through many channels, including future NAPHN conferences. The database will be hosted through CUNY's site as part of our Phase II efforts. Learn more at: openpassivehouse.commons.gc.cuny.edu/

3. **Provide better data and tools for lenders** to more accurately underwrite to energy savings and the non-energy benefits of Passive House, and create a Passive House comps database that grows as more multifamily projects share data.

   As demonstrated in this study, the case study projects did not meet the modeled Passive House EUI targets for their building type, despite being significantly closer than their non-Passive peers. It is critical to reconcile this performance gap in the future. The original standards were based on single family occupancy and do not account for multifamily end-uses like elevators and corridor lighting, or for occupant density. These standards are currently evolving.

   Investing in collecting, curating, and analyzing both utility and systems-level data is critical to improving building performance over the long-term and the ability to underwrite the energy savings at scale.

Endnotes

1 **Passive House Energy Saving:** The energy efficiency industry touts that buildings designed to Passive House standards consume 60-85% less energy than a comparable conventional building. when compared to a 2009 IECC code-compliant building, depending on climate zone and building type

2 **Establishing Case Study Groups:**
- Data from Bright Power's energy benchmarking database, EnergyScoreCards, was used. It is a comprehensive cloud-based energy and water analysis platform and benchmarking service.
- This study used data from early Passive House adopters that was readily available to the research team at the time of the study, without external funding.

3 **Data Collection Methodolgy:**
- Where possible, the most recent year's data was used to account for adjustments made during the first year of operation, when the building was stabilized. All case study buildings were confirmed for accurate gross square footage, mechanical systems and fuel type, and metering configuration
- To account for annual variations in weather, weather normalized metrics were used and cost-normalized pricing was used for consistency. Weather normalized energy is the energy buildings would have used under average conditions and removes weather related anomalies allowing for more accurate evaluations over time.

4 **Energy Consumption & Passive House Target:** While it is impossible to define a single Passive House target number for all projects in study, certified Passive House building targets can be in the upper 20s to low 30s when properly commissioned. This target is based on a 25% gas and 75% electric fuel mix, which is typical of buildings with gas water heaters and electric heat.

5 **Figure B:** See endnote 4, above.

6 **GHG Analysis:**
- GHG consist of carbon dioxide (CO2), methane (CH4), nitrous oxide (N20) and other gases and they are measured in carbon dioxide equivalents for simplicity's sake.
- Each fuel type has a different "carbon intensity factor" depending on how much GHG is emitted. When the electricity grid relies on 100% renewable energy (ex. solar or wind),the emission intensity factor for electricity will be zero.
- LL97 stipulates that an owner of a covered building that has exceeded its annual building emissions limit shall be liable for a civil penalty of $268 per metric ton of CO2e over the established limit.
- GHG were measured using the 2024-2029 emissions coefficients for gas and electricity for Figure D. Figure E uses the same factors for gas and an emissions factor of zero for electricity, predicated on the goals of the Climate Leadership and Community Protection Act (CLCPLA) which states that New York State will have an emissions-free electric grid by 2040.

7 **Energy Cost Calculations:** All numbers represent whole-building energy use. Cost reductions shown are estimates of whole building impact - including owner and tenant costs. The baseline underwriting cost estimate includes both M&O standard expenses (owner) and utility allowance (tenant). Savings from onsite generation are included in cost reductions shown here. Estimate of additional debt that could be leveraged assumes lender underwrites 50% of savings.

8 **Baseline Building Assumptions**
- Baseline building assumes same building size and unit distributions as the Case Study
- Owner costs, which typically cover heating, hot water, and common area electric, were generated using Housing Development Corporation's (HDC) 2020 Maintenance & Operations Standards for gas & electric
- Tenant electric costs were generated using New York City Housing Authority's (NYCHA) 2020 utility allowances

9 **Case Study Assumptions:**
- Utility costs are based on benchmarked utility data from the most recent year available.
- Rates are based on standardized National Grid rates for gas ($1.10/therm) and Con Edison rates for electricity ($0.20/kWh)
- Comparison: baseline was then compared to the property's actual performance using the most recent year's available utility data, multiplied by standard costs for gas and electricity to ensure consistent comparison.

10 **Appraising Non-energy Benefits:** According to the Fannie Mae Selling Guide Section B4-1.3-05 "special energy-saving items must be recognized in the appraisal process and noted on the appraisal report form ." The Appraisal Institute, an international association of professional real estate appraisers with 99 chapters in the U.S. and Canada has produced a companion document, The Residential Green and Energy Efficient Addendum, which is an extension of the new construction builder's specification sheet and the Fannie Mae Form 1004/ Freddie Mac Form 70, used by the mortgage lending industry. The Addendum specifically recognizes both PHI and PHIUS certified buildings as low energy buildings and collects information on Passive House specific design features including triple-glazing and Energy and Heat Recovery Ventilators. While this study did not assess the appraisal values in the study group, there is an approved method for recognizing the long term value of Passive House.

11 **Carbon Trading:** Calculations assume that the price of carbon is equal to the penalty of 268/ton, as stated in NYC Local Law 97. While it has not yet been decided whether NYC will establish a carbon trading initiative, and few details exist on what the plan will look like if it is adopted i.e., price of carbon, how the commodity will be traded, considering avoided penalties and potential revenues highlights the importance of taking a lifecycle approach when evaluating the costs and savings of high-performance buildings.

12 **Offsetting Incremental Costs:** Passive House experts with experience on multifamily Passive House projects suggest that the typical range is between 3% -5% depending on the baseline for comparison (e.g. LEED vs. code minimum) . It is difficult to tease out the actual incremental costs because projects are rarely bid both ways, however a feasibility study by FX Collaborative did just that. The study analyzed what the cost would be to upgrade a completed LEED Silver project to Passive House and found that it would have added 2.4% to the capital cost.

The NYC Accelerator offers free, personalized advisory services to streamline the process of making energy efficiency improvements to your building that will reduce operating costs, enhance tenant comfort, and improve our environment.

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The Building Energy Exchange (BE-Ex) is a center of excellence dedicated to reducing the effects of climate change by improving the built environment. BE-Ex accelerates the transition to healthy, comfortable, and energy efficient buildings by serving as a resource and trusted expert to the building industry.

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