



From: Isaac Elnecave

Date: September 1, 2022

Re: Summary of Cost Data Research on Multi-Family buildings built to the Phius Standard.

The following memo will summarize cost data collected in two- states where a sizable number of multi-family buildings have been built to the Phius standard: Massachusetts and Pennsylvania. This data is available because agencies have incentivized Phius level construction through direct utility/state incentives or through the use of low-income housing tax credits. Agencies managing these policies often track cost information along with energy use data providing important data on two important questions:

- Is the actual energy use of Phius certified buildings lower than comparable buildings built to the energy code?
- What are the actual incremental costs of building to the Phius standard versus the energy code? Are there any directional trends in cost-effectiveness over time?

Typically, multi-family buildings built to the Phius standard use significantly higher levels of insulation, have more efficient HVAC equipment, and achieve higher levels of air sealing than a code-compliant building. A review of benchmarking data collected through the Environmental Protection Agency (EPA) Energy Portfolio Manager by the Massachusetts Department of Energy Resources found that buildings built to the Phius standard used, on average, 40% less energy than similar code compliant buildings. A similar study of buildings in Philadelphia found a similar result although it only consisted of two buildings. The next sections will:

1. Explore Reasons Why Multi-Family Construction Built to the Phius Standard is Cost-Effective
2. Review Cost Data
 - 2A: Massachusetts
 - 2.A.1: Boston Department of Neighborhood Net Zero Cost Study
 - 2.A.2: Massachusetts Clean Energy Center- Passive House Challenge
 - 2B. Pennsylvania
 - 2.B.1. Pennsylvania Housing Finance Agency
3. Effect of Inflation Reduction Act on cost-effectiveness.
4. Describe implications of the cost-effectiveness of multi-family buildings built to the Phius standard.

1. Why is Multi-Family Construction to the Phius standard cost-effective?

People perceive (correctly) projects built to the Phius standard as both high-quality, extremely energy efficient due to both the standard itself and the review process which includes both design and construction phases. People also perceive (this time incorrectly) that the quality and energy efficiency come at a significant cost. There are two specific reasons why the assumption of higher cost is incorrect.

The first factor relates the surface area to volume ratio of a given building. Heat and air infiltration are a function of the surface area of a building. The high surface area to volume ratio of multi-family buildings reduces the amount of insulation per square foot needed to meet the Phius standard for a given climate. The high ratio also makes it easier to achieve the stringent air tightness requirement prescribed by Phius.

Second, practice makes cost-effective. A key tenet of building high performance buildings rests on the fact that as the design and construction professionals familiarize themselves with Phius design/construction principles, the costs will decrease.

The incentive programs in both states have been successful in encouraging the construction of Phius projects as well as increasing the number of professionals proficient in the design, construction, and inspection of Phius projects. For example, in Massachusetts alone, since 2018 43 multi-family projects have either been completed or are in progress. Related to this, there has been the increase in the number of design and construction professionals proficient in the development of Phius projects (almost two hundred Certified Passive House Consultants in Massachusetts) The sizable number of Phius related projects in Massachusetts have given project teams valuable experience on building to the Phius standard and establishing the most cost-effective construction methods. Related to this, construction teams get practice at meeting key benchmarks such as the air sealing standard. On a related note, in Pennsylvania there are 98 CPHCs and fifty-five multi-family projects have been completed or are in progress.

2. Review of Cost Data:

2.A Massachusetts

There are two sources of cost information pointing to the fact that building to the Phius standard results in minimal incremental cost: The Boston Department of Neighborhood Development Study and the Massachusetts Clean Energy Center Passive House Challenge.

2.A.1 Boston Department of Neighborhood Development:

The City of Boston, Department of Neighborhood Development¹ commissioned a study on the cost of building a multi-family to a net-zero standard (ZEB). This modeling study using actual cost data from the growing number of passive house (and other net-zero energy) projects in Boston compared the costs of building a zero-emission building to the current energy code in Boston. The study found that the incremental cost was typically less than 1% with an incremental costs ceiling of 2.2%. The table below details the cost differences between the net zero emissions buildings and the current code in Boston.

Table 1: Cost differential between ZEB and Code Building

Multi-Family Building Type	Incremental Cost to Build NZEB against a Building Built to Code
Small Multi-Family (6-unit building)	0.88%
3-Story Multi-Family (14 Unit Building)	0.60%
4-5 Story Multi-Family (50 Unit Building)	0.91%
6 Story Multi-Family (51 Unit Building)	2.21%

2.A.2 Massachusetts Clean Energy Center:

Massachusetts, through both its QAP and a robust incentive program has seen a sharp rise in the number of multi-family buildings meeting the Phius standard. The Massachusetts Clean Energy Center funded a challenge to better understand the cost and energy savings of Phius projects. The agency provided incentives aimed at building eight low-income multi-family to the Phius standard. It collected cost data in order to determine the incremental cost of building to the Phius standard as compared to the energy code. The agency found that the incremental costs for projects ranged between 1% and 4%. Following is a chart showing the individual incremental costs²

¹ City of Boston- Department of Neighborhood Development 2020; Guidebook for Zero Emission Buildings.

² <https://www.masscec.com/emerging-initiatives/passive-house>

Craig Beverly: *At the Finish Line: How Two Affordable Passive Projects Crossed the Hardest Hurdles (Slide 3); BuildingEnergy Boston Conference, February 28, 2022.*

Table 2: Summary of Incremental Cost of Multi-Family Buildings Built to the Phius Standard

Project	Number of Units	Incremental Cost
Old Colony; Phase 3C	55	2.8%
North Commons	53	4.3%
Depot Village/Hanson Village	48	4.1%
Finch Cambridge	98	1.4%
Harbor Village	30	1.8%
Mattapan Station	135	2.0%
Bartlett Station/Kinzie	52	1.0%

Cost parity between Phius and conventional construction, as seen above, comes from the factors detailed above. The construction industry has adapted to the increased demand for Phius buildings.

2B. Pennsylvania

2.B.1 Pennsylvania Housing Finance Agency

The Phius standard is designed to achieve deep energy savings and at a cost savings both from a first cost and across the building’s life cycle. Recent experience of the Pennsylvania Housing Finance Agency (PHFA) demonstrates that building an affordable, multi-family home to Phius standards does not result, on average, in a higher construction first cost per square foot once there is significant market adoption. Moreover, due to the sharply reduced energy costs, the energy burden for low-income residents living in Phius housing is also dramatically reduced.

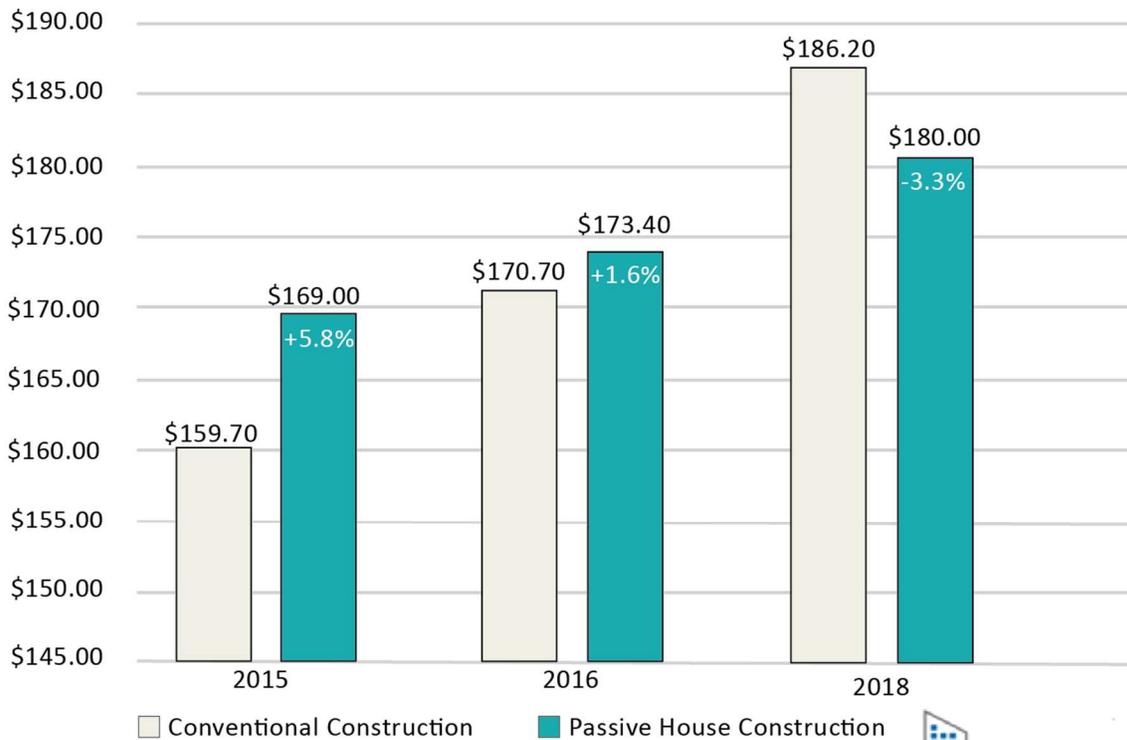
The first few passive house projects, under the PHFA tax credit program were slightly more expensive than conventional construction. By the third round of projects (in 2018), Phius projects were, on average, less expensive than conventional construction. See Appendix A for a project-by-project breakdown of costs.

Figure 1: Cost Comparison, Across Three Years, Between Passive House and Non-Passive House Projects in Pennsylvania ³

³ “How a PA Affordable Housing Agency is Making Ultra-Efficient Buildings Mainstream” Pittsburgh Post-Gazette, December 31, 2016 & Pennsylvania Housing Finance Agency

Passive House Costs Less with Experience

(Cost per Square Foot)



Note: Low-income housing tax credits were not awarded in 2017

Source: "How a PA affordable housing agency is molding ultra-efficient buildings mainstream"
Pittsburgh Post-Gazette December 31, 2018 & Pennsylvania Housing Finance Agency (PHFA)



3. Effect of Inflation Reduction Act on cost-effectiveness.

The Inflation Reduction Act (IRA), enacted in August 2022 contains a couple of specific amendments that strongly affect the cost-effectiveness of Phius projects. The law amends the requirements behind the awarding of tax credits under Section 45L of the tax code.

Under this amendment, single family homes, duplexes and townhouses are eligible for a \$2500 tax credit if they are built to Energy Star specifications. The total rises to \$5,000 for projects achieving DOE ZERH. Since all Phius single family projects must reach these benchmarks, it means that all Phius projects are eligible for this tax credit. Reducing the cost of a Phius project by \$5,000 can have a strong effect on its affordability.

We are still trying to figure out the multifamily requirements. However, the preliminary understanding is that for multifamily buildings eligible for the Energy Star Multifamily New Construction program a builder can receive \$500/unit for projects achieving Energy Star and \$1,000/unit for units achieving ZERH. These number rise to \$2,500/unit and \$5,000/unit respectively for projects subject to prevailing wage requirements. Phius is working to clarify these requirements.

Finally, the law adds an important technical change in that it explicitly states that energy efficiency tax credits do not count against a low-income housing tax credit (LIHTC) award.

4.Implications of the Cost-Effectiveness of Multi-Family Buildings Built to the Phius standard.

The cost-effectiveness of meeting the Phius standard shows that with smart policy development, there does not have to be a trade-off between high performance buildings and cost. This indicates that utilities and state energy offices from around the country should incorporate these policies with an eye to accelerating the construction of high-performance buildings such as Phius. Moreover, as it becomes increasingly clear that building to the Phius standard does not involve cost increases, this information will help in the incorporating of Phius into energy codes so that Phius and other high-performance building standard becomes the minimum level of energy efficient construction.

Appendix A: List of Pennsylvania Projects

The PHFA first included PHIUS in its 2015 QAP, establishing a considerable number of points for passive house in the evaluation criteria (10 of 130 points). That year 39 multi-family projects received funding of which eight were PHIUS projects (26 projects were completed, of which seven were passive house projects). Table 1 shows a cost comparison between the completed passive house and non-passive house projects funded by the PHFA in 2015.

Table 1: COST COMPARISON BETWEEN PASSIVE HOUSE AND NON-PASSIVE HOUSE PROJECTS ⁴

Average Cost/sq. Ft of the Non-Passive House Projects (\$176 (+/-)\$36)			Average Cost/sq. Ft of the Passive House Projects (\$168 (+/-)\$45)		
Non-Passive House Projects			Passive House Projects		
Number of Units	Building Area (Sq. ft)	Cost/sq. ft	Number of Units	Building Area (Sq. ft)	Cost/sq. ft
45	53,021	\$128	54	70,128	\$111
53	82,070	\$129	34	39,447	\$145
40	53,52	\$144	49	54,287	\$151
35	61,504	\$149	66	70,689	\$155
45	63,458	\$154	61	63,949	\$157
40	40,959	\$157	50	55,099	\$226
24	36,064	\$160	52	50,275	\$233
31	43,868	\$162			
53	51,690	\$163			
44	49,406	\$169			
56	56,250	\$176			
28	45,434	\$178			
12	16,796	\$181			
43	55,832	\$185			
51	62,509	\$189			
23	28,205	\$193			
37	48,767	\$199			
88	79,560	\$228			
52	43,868	\$287			

⁴ Source Pennsylvania Housing Finance Agency. <https://passivehouseaccelerator.com/articles/2019-new-gravity-housing-conference-july-1st-2nd>