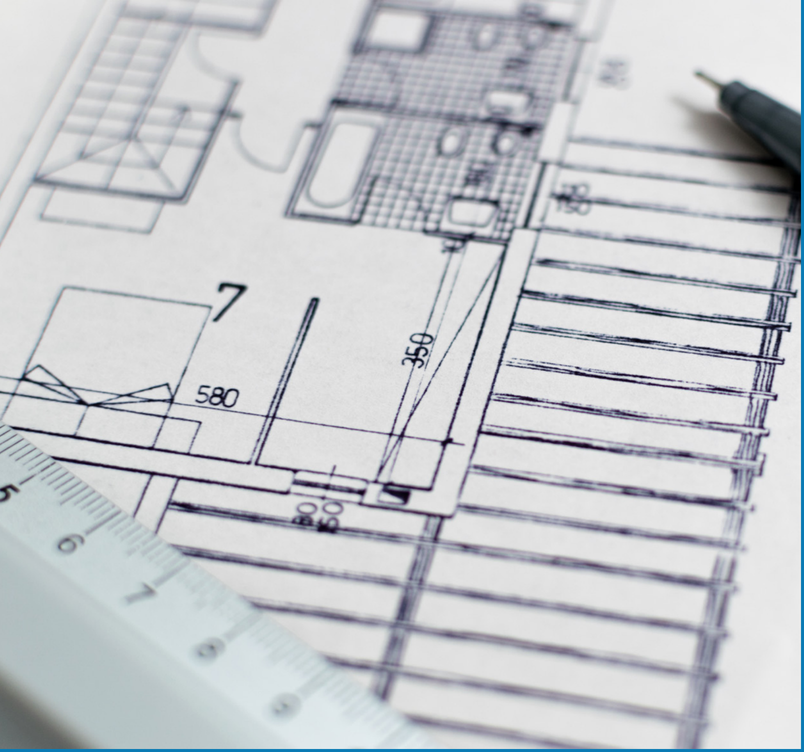

Passive House as Energy Code in the Midwest

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Abstract

Big strides are needed to reduce energy consumption of buildings. The Passive House Institute US (PHIUS+) standard provides strong energy conservation targets and a scalable solution as a baseline standard for net zero construction. Energy codes provide a policy mechanism for solid market penetration for new construction, but they are missing a lot of energy savings by not moving fast enough. This paper will explore how buildings built to the PHIUS+ standard in Illinois have demonstrated real energy use reduction that translates into long-term impacts. It will then provide the energy savings impacts for Illinois if PHIUS+ was adopted as its residential energy code and consider how the International Code Council could deliver a stepped approach to achieve this in the next three code cycles (by 2030). It will outline what that might look like and what the energy savings impact could be if these codes were adopted throughout the Midwest.

Introduction

Buildings generate nearly 40% of annual global GHG emissions. In 2018, the residential and commercial sectors accounted for about 40% (~ 40 quadrillion British thermal units) of total energy consumption in the United States (EIA 2020). On the current trajectory, the consumed energy will very likely grow. According to Architecture 2030, "The world is currently undergoing the largest wave of urban growth in human history…we expect to add 2.48 trillion square feet of new floor area to the global building stock, doubling it by 2060. This is the equivalent of adding an entire New York City every month for 40 years. This new building stock must be designed to meet zero-net-carbon standards." One of these such standards is Passive House Institute US (PHIUS+), and one of the ways to influence new building stock is through increasing the energy efficiency of energy codes. This paper will explore setting prescriptive incremental increases to the current national residential model energy code to meet PHIUS+ standard levels by 2030, so that a state like Illinois, whose adoption cycle follows the national model codes, could adopt them.

Climate Change and Energy Codes

More than 288 cities and counties and 10 states have signed on to the "We Are Still In" commitment supporting climate action to meet the goals of the Paris Climate Accord. Strong energy codes have proven to be instrumental to energy use and greenhouse gas reduction; energy code adoption in the Midwest has saved over 211.6 million MMBtu and more than 24.3 million tons of CO_2 emissions from 2009-2019. While some states and jurisdictions already can modify the model codes to meet their needs, many do not have the resources to develop code language needed to achieve their goals.

Development and Adoption of Energy Codes

Energy Code Development

In the United States, the most-adopted residential model energy code is the International Code Council's (ICC) International Energy Conservation Code (IECC). The IECC is updated every three years through an 18-month development process that involves code change proposal submissions, proposal debates, voting by ICC code change boards and finally voting by ICC members. As seen in Figure 1, the average energy use of the residential IECC remained relatively constant until the 2006 IECC. The next two code cycles saw a combined average jump in energy efficiency of around 30%. The code updates for 2015 IECC and 2018 IECC improved an average of 1% per cycle, not nearly enough to move the model codes to meet the climate and energy goals of Midwest states and cities if adopted. And although the 2021 IECC could potentially improve by as much as 10%, making future large strides through the IECC may prove challenging. Despite interest from states and cities for stronger model codes to mitigate climate change, the *New York Times* revealed how the ICC voting process is not moving fast enough to make big climate change impacts due to heavy influence of homebuilders and lack of voting participation by ICC members (Gillis 2019).

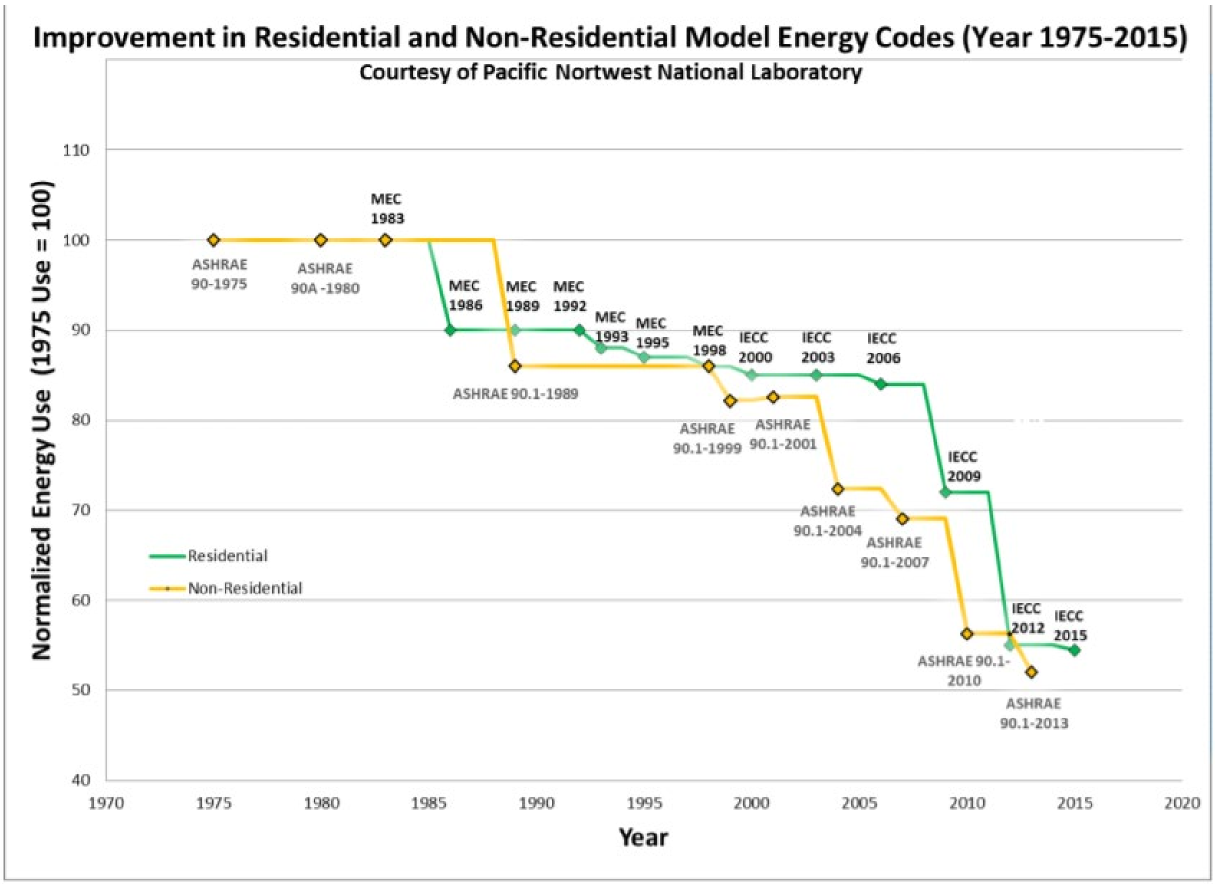

Figure 1. Model Code Energy Use Improvement through 2015. *Source:* Pacific Northwest National Laboratory

The slow energy code development has spurred cities and others to get involved in the development process. In June 2018, the United States Conference of Mayors passed "Cities to Accelerate Focus on the Economic and Climate Benefits of Boosting America's Building Energy Efficiency" resolution, urging mayors, NGOs and others to unite and maximize local government support to put the IECC on a glide path toward net zero building construction by 2050 (Britt 2019). However, at this time the ICC has not made any official declarations to move the model codes toward net zero building construction. In addition, many states and jurisdictions have climate change goals of 2030; net zero by 2050 is too late.

One large change is that the 2021 IECC will include for the first time an optional ZERO Code Renewable Energy Appendix, which can be adopted separately by jurisdictions (where allowed). The ZERO Code Renewable Energy Appendix is a proposed appendix to the 2021 IECC to require that new commercial, institutional and mid- to high-rise residential buildings install or procure enough renewable energy to achieve zero-net-energy on an annual basis. The appendix encourages onsite renewable energy systems when feasible, but also supports offsite procurement of renewable energy through a variety of methods. This appendix does not allow renewable energy to be traded off against the energy efficiency required by the 2021 IECC, but also does not advance the energy efficiency beyond the 2021 IECC.

Energy Code Adoption in the Midwest

Energy code adoption in the Midwest varies per state (Figure 2). In MEEA's territory, four states[1] do not have statewide energy codes; cities are responsible for adopting energy codes instead. Nine states do have statewide energy codes. Some states with a state code may also require that local jurisdictions go through the process of adopting the state-approved energy code on their own. Midwestern states typically do not allow local jurisdictions to adopt energy codes stronger or weaker than the state energy code, with a few exceptions[2]. Some communities have climate action plans that include advancing baseline codes or reach/stretch codes.

The adoption process itself can also vary by state and jurisdiction. Typically, the energy code adoption process includes the adopting entity's designated adoption board that oversees the process and meets to review the current nationally developed model code and offer amendments. In some cases, the public can participate and offer amendments as well. The public may also be allowed to offer comments on the draft code during the adoption process. The overseeing board may then give final recommendations to a higher authority, such as a city council, governor or administrative body, who may make more changes or give it final approval. The energy codes typically do not go into effect immediately following approval and may specify a lag time for the industry to adjust to changes. Specific details about the Illinois energy code adoption process can be found later in this paper.

Midwestern states do not update their energy codes at the same time or levels, as seen in the following figure. While some have adopted the currently available energy codes, many have amended the national model codes to be weaker, especially on the residential side.

1 North Dakota, South Dakota, Kansas and Missouri
2 Illinois, Nebraska. This does not include the ability to add optional energy components to appendices.

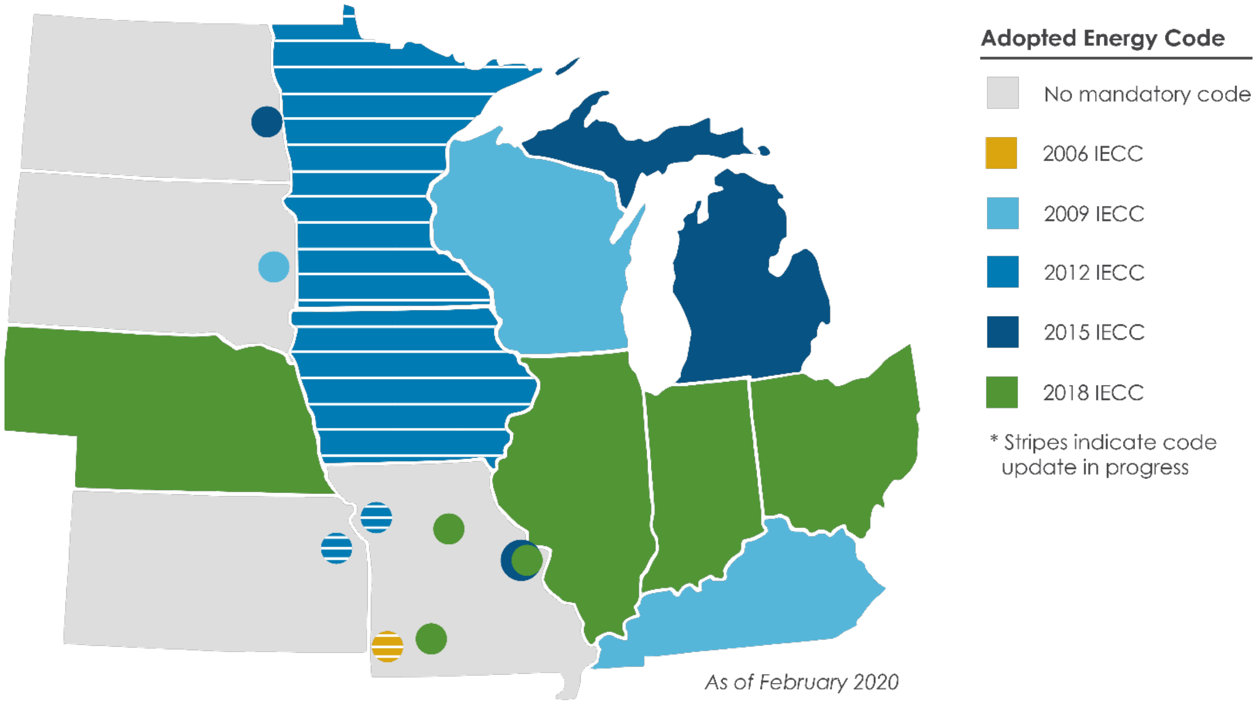

Figure 2. Residential energy code adoption in the Midwest. Image represents referenced model code; some adopted codes may have been amended. *Source:* Midwest Energy Efficiency Alliance.

Passive House Standard Elements

History

North American building scientists and builders with funding from the U.S. Department of Energy (DOE) and the Canadian government were the first to pioneer passive building principles in the 1970s. In the late 1980s, the German Passivhaus Institut (PHI) built on that research and those principles and developed a quantifiable performance standard that continues to work well in the Central European and similar climate zones.

However, in practice, the PHIUS Technical Committee and project teams in North America determined that a single standard for all North American climate zones is unworkable. In some climates, meeting the standard is cost prohibitive; in other milder zones, it is possible to hit the European standard while leaving substantial cost-effective energy savings unrealized.

As such, in cooperation with Building Science Corporation under a U.S. DOE Building America Grant, the PHIUS Technical Committee developed passive building standards that account for the broad range of climate conditions, market conditions and other variables in North American climate zones. The result was the PHIUS+ 2015 Passive Building Standard – North America, which was released in March of 2015. That standard has been updated to PHIUS+ 2018. The PHIUS Technical Committee will continue to periodically update the standard to reflect changing market, materials and climate conditions.

Passive Building Principles

Passive building comprises a set of design principles used to attain a quantifiable and rigorous level of energy efficiency within a specific quantifiable comfort level. Passive building principles can be applied to all building typologies – from single-family homes to multifamily apartment buildings, offices and skyscrapers. Passive design strategy carefully models and balances a comprehensive set of factors, including heat emissions from appliances and occupants, to keep the building at comfortable and consistent indoor temperatures throughout the heating and cooling seasons.

PHIUS+ 2018 is a pass/fail building standard. The standard has three pillars:

- Limit on overall source energy use
- Limits on heating/cooling loads (both peak and annual)
- Air-tightness and other prescriptive quality assurance requirements

Source Energy Targets

The PHIUS+ standard for residential buildings includes a maximum energy consumption limit per building occupant. The overall energy limit is based on source energy (rather than site energy). This is not a cap on total source energy, but rather on the annual net source energy after being offset by qualified on- and off-site renewable energy. There is no cap on total source energy use as long as the predicted annual net source energy use meets the target. Off-site options such as Virtual Power Purchase Agreements, community renewables, renewable energy credits and directly owned off-site renewable can be used to offset a project's source energy use under PHIUS+ 2018. The source energy limit is also not set based on cost optimization, but rather on the 'fair share' of carbon emissions allowed for each sector. To limit global warming and avoid many harmful impacts on society, emissions must go to zero overall and the energy system must go to 100% renewable (PHIUS 2018).

The PHIUS+ 2018 source energy targets are:

- Residential: 3840 kWh/person/yr.
- Non-Residential: 34.8 kBTU/ ft^2 yr. (110 kWh/ m^2 yr.)

An example of source energy reduction for a PHIUS+ 2018 building relative to the Building America 2009 benchmark can be seen in Figure 3.

Heating and Cooling Load Limits

One of the key components of passive building is to drastically minimize heating and cooling loads with the use of passive conservation strategies – continuous insulation, air-sealing, optimal glazing/shading and energy recovery ventilation. The PHIUS+ Passive Building Standard was developed as a guideline on "how far to go" with these passive conservation strategies. The design limits for heating and cooling loads were set based on economic optimization for buildings of different sizes and occupant density and are intended to guide the design to the optimal investment in passive conservation measures. The targets are project-specific and determined using three project factors: climate, envelope-to-floor-area ratio and occupant density.

Air-Tightness and Other Requirements

For the purposes of determining a prescriptive code path to get to PHIUS+ by 2030, we will use 1 ACH(50) as the ultimate air leakage requirement. The PHIUS+ 2018 air-tightness requirement is 0.060 cfm50/ft^2 of enclosure area for most buildings. For buildings 5 stories and above of noncombustible construction, the limit is increased to 0.080 cfm50/ft^2 of enclosure area. Other requirements include moisture design criteria for assemblies and details, quality-related prescriptive design elements, field quality assurance inspections, a contractor declaration and window comfort assessment. More information can be found in Section 3.1.2 of the PHIUS+ Certification Guidebook v2.1[3].

Passive House as Energy Code

Codes vs. Standards

Codes, like the IECC, are laws that set mandatory minimum requirements for a building. They are developed by the industry to follow market trends and updates in technology and building practices. They are rigid and intentionally hard to change. Codes have their own vernacular, which is interpreted by local code officials.

Standards, such as PHIUS+ and ASHRAE, are best practices developed by stakeholders and may be referenced in codes and rating systems. There is typically no enforcement or inspection for a standard, but third parties may offer certification or provide modeling software for reviewing that a project meets the standard.

It may be worth mentioning that when it is available, ASHRAE 227P (the ASHRAE Passive Building Standard currently under development) will have code adoptable language. However, this will not create a step code to bridge the gap and will instead set a target level for performance.

Passive House Standard Use in Codes

Currently there are no examples of PHIUS+ being used as a baseline energy code. However, there are many examples of Passive House standards being used as an alternative compliance path to a code, or as a stretch code that could eventually be adopted into a baseline code. Below are two examples.

Massachusetts Residential Stretch Code

Massachusetts has had a stretch code since 2009 – the first of its kind in the country – and for the last eight years has allowed a PHIUS+ certification to be an alternative compliance path to this stretch code. This means that a project that achieves PHIUS+ certification automatically complies with the stretch code, and thus can receive incentives where applicable. The stretch code was expected to update from PHIUS+2015 to PHIUS+2018 on August 8, 2020. It also will allow for PHIUS+ pre-design modeling to demonstrate compliance in the same manner that architectural drawings can help show compliance. While PHIUS+ is recognized as complying

[3] https://www.phius.org/PHIUS+2018/PHIUS+%20Certification%20Guidebook%20v2.1.pdf

with the stretch code, the actual PHIUS+ requirements are not written into the stretch code or base code language beyond in reference. It is possible that Massachusetts will eventually move to PHIUS+ sometime in the future (Elnecave 2020).

Vancouver and British Columbia Step Energy Code

In 2016, the Vancouver City Council adopted the Zero Emissions New Building Plan[4], which articulates the path for new construction and includes aspects from Passive House such as better envelopes, lower heating energy and less use of fossil fuels. The city has also established energy efficiency regulations for their city energy code that took effect in June 2019. It sets limits for three components: greenhouse gas emissions, net heat loss and total energy use.

Vancouver also approved 2021 requirements to reduce GHG emissions from new multifamily and commercial buildings by more than 70% over ASHRAE 90.1-2010 and established a maximum net heat loss of 30 kWh/m^2. This net heat loss is equivalent to the Passive House Institute (PHI)[5] Low Energy Building Standard and EnerPHit (NAPHN, 2019). The PHI Low Energy Building Standard is not as stringent as the PHI "passive house" criteria. EnerPHit is the PHI retrofit standard.

The province of British Columbia has a goal of all new buildings meeting net-zero-energy-ready by 2032. The province created the BC Energy Step Code to help meet this goal, which provides cities with a code structure at varying steps of performance that they can choose to adopt. Cities that adopt it will now have the BC Energy Step Code (at their designed step) as their baseline energy code. In a non-step code city, builders can choose to build to the step code and achieve compliance with the regular baseline energy code and (sometimes) receive incentives. As of March 6, 2020, 64 cities have either adopted the BC Energy Step Code into their bylaws or have begun the process to do so.

The BC Energy Step Code is a performance standard with either four or five steps (depending on construction complexity) that reach toward net-zero-energy-ready; meeting the PHI Passive House standard is the final step. By 2032, the BC Building Code will move toward the higher steps of the BC Energy Step Code as a minimum requirement. The National Building Code of Canada is similarly moving towards similar steps by 2030 (NAPHN).

Passive House as Step Code in Illinois

This section will discuss what a stepped approach to a PHIUS+ energy code by 2030 could look like for the state of Illinois. Illinois has two climate zones: CZ 4 and CZ 5, with most of the new construction occurring in CZ 5. The Illinois adoption process coincides with the national model code development schedule, so it is a good example of a state that could follow this approach if it were implemented into the IECC.

[4] https:// council.vancouver.ca/20160712/documents/rr2. pdf

[5] PHIUS and PHI represent the U.S. and Europe, respectively, and while having similar principles, have different requirements.

Residential, Prescriptive and Stepped Approach

This report focuses on residential energy codes, which tend to have the most opposition to efficiency improvements during the development and adoption phases. Support from the homebuilding industry could lead to adoption of stronger residential energy codes in the Midwest.

A prescriptive approach was explored as a possible way to achieve PHIUS+ by 2030 in Illinois. The residential IECC has an Energy Rating Index (ERI) compliance pathway that could potentially coincide with PHIUS+ modeling, but a prescriptive pathway could help provide more specific guidance on the exact measures needed to achieve super-efficient construction. The homebuilding industry is resistant to adopting performance-based solutions and understanding prescriptive measures could help during the development and adoption process. Prescriptive measures could also be more easily enforced by code officials. That is not to say that a performance-based approach is not feasible or desirable in other ways[6]; this paper simply chooses to explore a prescriptive approach for the reasons mentioned above.

The homebuilding industry does not like to move quickly, so an incremental stepped adoption structure was explored in this paper. By setting these prescriptive requirements to incrementally step up from the IECC to PHIUS+ by 2030, we can look at what changes need to be made every three years and evaluate their impacts. These changes could occur either on the national level and be integrated into the IECC, or by a state (like Illinois) through their own adoption process, with the option for individual cities to choose which step to adopt. A stepped approach helps the industry plan and adjust to upcoming energy code changes before they happen.

Illinois Adoption Process

Illinois is directed by statute to update the Illinois Energy Conservation Code every three years. The adoption process takes place through the Illinois Capital Development Board (CDB), who reviews the latest IECC and makes recommendations for amendments if necessary. The process is open for the public to provide input, although only the members of the CDB have voting power. The CDB recommendations proceed to the Joint Committee on Administrative Rules for final approval.

The Illinois Energy Conservation Code is a statewide code. Once approved, local governments are free to adopt stricter (not weaker) energy conservation laws for commercial buildings. Codes for residential buildings cannot be either less or more energy efficient than the Illinois Energy Conservation Code. There are three exceptions[7] to this rule, enabling the City of Chicago to enact a stricter residential energy code than the state energy code if it chooses. Chicago has not adopted a stronger than state residential energy code; the example in this

[6] Performance-based approaches and pathways exist and have been successful in many energy codes, including the IECC and California's Title 24.

[7] A unit of local government that on or before May 15, 2009 adopted or incorporated by reference energy efficient building standards for residential building that are equivalent to or more energy efficient than the 2006 International Energy Conservation Code; a unit of local government that on or before May 15, 2009 provided to the CDB identification of an energy efficient building code or amendment that is equivalent to or more energy efficient than the 2006 International Energy Conservation Code; and/or a municipality with a population of 1,000,000 or more.

paper would be an available option to the city today without statewide adoption or stretch code approval. In order for other cities to have this option, the CDB would need to adopt PHIUS+ as a step code for the state's baseline code, the state would need a legislative directive to allow adoption of a residential stretch code (or code stronger than the state energy code), or the state would need to develop PHIUS+ as an optional Appendix Chapter to the Illinois State Code to be voluntarily adopted by jurisdiction.

Illinois typically adopts the new commercial model code with little weakening amendments. Conversely, the residential state energy code historically contains weakening amendments to basement insulation, wall insulation and envelope air tightness over the model code. The latest energy code adoption weakened the envelope air tightness from the model code (2018 IECC) but improved it from the previous state energy code. The CDB has signaled interest in improving the envelope air tightness to the model code level in the next adoption cycle.[8]

Stepping the IECC to PHIUS+ by 2030

Table 1 below outlines a possible prescriptive pathway of the main energy code components of the residential energy code to reach PHIUS+ standards by the year 2030. PHIUS+ generally exceeds code in items like insulation, window efficiency and air sealing, but some techniques may be the opposite of a typical code pathway (e.g., SHGC for southern windows could in some cases be higher to maximize passive heating). The values were determined by first considering a scenario of evenly distributing the necessary progress for each component across the three code change cycles to 2030. The values were then reviewed and reorganized to reflect product availability, cost, change in construction practices and adoption feasibility. For example, if the largest changes occurred in the same code cycle, the feasibility of approval for adoption would diminish because the industry is resistant to large code changes; the same is true for cost. Large construction practice changes need time and education to ensure proper technique but making updates every code cycle can create learning fatigue. Some products that meet the PHIUS+ requirements might not yet be widely available and should be stepped up incrementally to handle demand and ultimately assure success with the energy code.

[8] The 2012, 2015, and 2018 IECC all have an envelope air tightness requirement of 3 ACH(50) which IL has weakened to 5 ACH(50), 5 ACH(50), and 4 ACH(50), respectively.

Table 1. Recommended Residential Energy Code Step Structure for PHIUS+ by 2030 for CZ 5.

	PROPOSED		**RECOMMENDED to get to PHIUS+**			
Climate Zone 5 - Illinois	2018 IECC	2021 IECC	2024 IECC	2027 IECC	2030 IECC	PHIUS +
Wall insulation	R-20 or R-13+5	R-21 or R-13+5	R-30 or R-13+17 or R-19+11	R-35 or R-13+22 or R-19+16	R-40 or R-13+27 or R-19+21	R-31 to R-43
Ceiling insulation	R-49	R-60	R-60	R-70	R-70	R-60 to R-70
Slab insulation R-value	R-10, 2ft	R-10, 2ft	R-15, 3 ft	R-15, 4 ft	R-20, 4 ft	4ft R-20 vertical perim; or whole-slab R-20
Window U-factors	0.30	0.28	0.24	0.20	0.14	U-value 0.14
Window SHGC	n/a	n/a	SHGC (glass only) to be between 0.3-0.5	SHGC (glass only) to be between 0.3-0.5	SHGC (glass only) to be between 0.3-0.5	SHGC (glass only) to be between 0.3-0.5
Air leakage	3 ACH(50)	3 ACH(50)	2 ACH(50)	1 ACH(50)	1 ACH(50)	0.060 CFM50/ft2 enclosure, ACH50 varies with building size
Duct leakage	4 cfm/ft² in unconditioned space	4 cfm/ft² in unconditioned space	4 cfm/ft² in conditioned space	4 cfm/ft² in conditioned space	4 cfm/ft² in conditioned space	All space conditioning equipment is to be located within conditioned space. ·Duct Leakage to outdoors shall not exceed 4CFM25 per 100 sq ft of CFA.
HVAC efficiencies	80 AFUE/13 SEER; 8.2 HSPF (Btu/Wh)	80 AFUE/13 SEER; 8.2 HSPF (Btu/Wh)	National Standards (hopefully to 12 HSPF, 21 SEER for heat pumps)	National Standards (hopefully to 12 HSPF, 21 SEER for heat pumps)	National Standards (hopefully to 12 HSPF, 21 SEER for heat pumps)	Very efficient heat pumps are popular (12 HSPF, 21 SEER)
Ventilation			Balanced <=10%	Balanced <=10%	Balanced <=10%	Balanced <=10% with heat recovery (~75%+)

Envelope R-values

Illinois' current building practices of 2"x4" framed construction with fiberglass batts in cavity would not meet PHIUS+ requirements. PHIUS+ guidance suggests meeting a certain sheathing to cavity ratio for wall insulation when using insulation within the cavity and outboard rigid. This ratio is the R-value of the sheathing (exterior insulation) divided by the cavity insulation R-value. For example, if there was R-13 in the cavity and R-5 outboard, this ratio is (5/13)= 0.38. For climate zone 5, the rule of thumb is to be above 0.35; R13+5 would meet the ratio but not the insulation requirement (PHIUS 2019). See Table 2 below of different options when targeting the stepped R-values in Table 1.

Table 2. Wall R-values Sheeting to Cavity Ratio.

Wall R-value	Cavity (2x4)	Exterior	Sheathing to Cavity Ratio
18	13	5	0.38
20	13	7	0.54
21	13	8	0.62
30	13	17	1.31
35	13	22	1.69
40	13	27	2.08
43	13	30	2.31

Wall R-value	Cavity (2x6)	Exterior	Sheathing to Cavity Ratio
30	19	11	0.58
35	19	16	0.84
40	19	21	1.11
43	19	24	1.26

HVAC Efficiencies

Model energy codes must follow national heating and cooling standards[9], and cannot specify more stringent requirements. Most PHIUS+ homes use an electric air source heat pump for heating and cooling needs. A typical heat pump is around 8 HSPF. Although not absolutely necessary, most heat pumps for PHIUS+ homes are around 12 HSPF and 21 SEER. This is reflected in Table 1; while the IECC cannot make changes, Illinois could consider legislating stronger statewide standards or championing changes to national standards.

What may become most critical for Illinois is the operation range or the cold temperature cutoff; they must be able to retain capacity and efficiency during cold weather.

Ventilation[10]

A whole-building mechanical ventilation system is required to be installed, and a balanced ventilation approach must be used in PHIUS+. Typically, the balanced ventilation approach is achieved by using an energy recovery ventilator (ERV), which has both heat and moisture recovery. It is required that fresh air is supplied directly to bedrooms and often fresh air is also supplied to shared living spaces. The fresh air supply must come directly from outside and pass through a minimum of MERV 8 filtration (MERV 12 or higher recommended). Continuous exhaust is used in bathrooms and kitchens, maybe also laundry and mechanical rooms. The total

[9] The current requirements in CZ 5 are 80 AFUE for furnaces and 13/14 SEER for air conditioning.
[10] Refer to Section 3.5.3.3 of the PHIUS+ Certification Guidebook v2.1 for ventilation information.

continuous ventilation airflow rate is determined by one of the two requirements below, whichever is higher.

1. Supply Air Requirement: 18 cfm continuous per person (people is determined by bedrooms+1)
2. Exhaust Air Requirement: Continuous exhaust rates in the kitchen >=25 cfm, and continuous exhaust rates in the bathroom >=20 cfm.

There are alternative compliance targets for intermittent exhaust in bathrooms (50 cfm) and kitchens (100 cfm) but most often the continuous ventilation approach is taken. Intermittent kitchen cooktop exhaust and dryer exhaust is permitted, given that there is a provision for makeup air if the direct exhaust causes more than 5 pascals of depressurization in the building[11]. It is common to use both intermittent/cooktop exhaust and continuous exhaust in the kitchen. This general approach of a continuous low-flow balanced ventilation with heat/moisture recovery and filtration provides great indoor air quality while also minimizing the impact on space conditioning loads.

Quality Control

Quality workmanship is key to achieving high-performance with PHIUS+ philosophy. These building science principles would also need to be worked into code language. If PHIUS+ were integrated into code, quality control would need to be addressed (see section on Compliance). Residential PHIUS+ projects are required to meet nationally accepted programs as pre-requisites for certification: Energy Star, DOE Zero Energy Ready Home and EPA Indoor airPLUS. These programs ensure best practices are followed for quality construction by having protocols for testing and verification, certification and/or commissioning.

Cost

Currently, constructing a building to meet PHIUS+ may cost about 5-10% more than a conventional home[12]. Larger projects benefit from the economy of scale: a multifamily passive building typically only costs 0-3% more than a building built to an energy star baseline. In general, the larger the building the less of a cost difference there is. PHIUS has a cost calculator tool that can estimate both cost per square foot as well as source energy percentage. An example of a home in CZ5 in Illinois is below. Using the average additional cost per square foot from Figure 3 and a median Midwest cost of $104.15 per square foot[13], the PHIUS+ home would cost $118.15 per square foot. As more large-scale window and door manufacturers bring high-performance products to market, economies of scale are expected to drive down costs (PHIUS 2020).

[11] https://www.phius.org/Tools-Resources/TechCorner/Makeup%20Air%20Requirements%20for%20Direct%20Kitchen%20Hood%20Exhaust%20.pdf
[12] https://www.phius.org/what-is-passive-building/passive-house-faqs
[13] According to the Census Bureau, the median sale price per square foot of new single-family homes in 2017 was $148.45 in the Northeast, $126.43 in the West, $95.35 in the South and $104.15 in the Midwest.

PHIUS+ 2018 Initial Cost Premium & Source Energy Savings Estimator v1

Building Floor Area (ft2)	2,386.00
Method:	CITY DATA
State:	ILLINOIS
City:	AURORA MUNICIPAL
HDD65 [F.days]	6537
Electricity Cost [$/kWh]	0.1144

Estimated Initial Cost Upgrade
over BA benchmark (2009)

$/sf	$14.00
+ / -	$2.39
Low ($/sf)	$11.50
High ($/sf)	$16.00

Estimated % Source Energy Savings
over BA benchmark (2009)

% per year	59
+ / -	5.76
Low (%)	53
High (%)	65

Figure 3. PHIUS+ 2018 Initial Cost Premium & Source Energy Savings Estimator v1 for a 2,386 sq.ft.[14] home in Aurora, IL (CZ5). *Source:* Passive House Institute U.S.

Compliance

As with all policies, true energy savings are only realized with implementation. PHIUS+ in an energy code will likely have the typical energy code compliance challenges, with additional challenges due to the learning curve associated with new requirements and building techniques, as well as potential increased costs. Compliance review would need to occur at the design phase, during construction and post-construction to assure quality control at any step level. The quality control built into the PHIUS+ standard includes on-site inspections throughout construction to ensure that the built product is what was specified in the design and is installed well (i.e. quality insulation installation, verifying ventilation airflows are as planned and meet requirements, etc). PHIUS+ projects receive a certificate after completion, which could assist jurisdictions with proving compliance if a jurisdiction adopts to that step level. Utilities could offer programs that increase education and provide incentives that address compliance barriers. This could include workforce development training that would properly equip builders and designers on the latest best practices for these types of buildings.

Massachusetts offers one example of compliance support. The National Grid MassSave program uses utility funding to provide training and incentives to increase compliance with the base energy code and the stretch energy code. National Grid also claims savings for energy code adoption efforts. Illinois could consider a similar support structure with the PHIUS+ to Zero Step

[14] 2,386 sq.ft. is the national median newly constructed home in 2018 according to U.S. Census data.

approach, which might include claiming savings from providing advocacy for the state to adopt energy codes above the model code (as outlined in this paper), promoting step code adoption in individual cities, and then creating programs that provide technical assistance, incentives and training to all step code levels, from the state baseline energy code to the 2030 PHIUS+ level.

Potential Benefits

Illinois has already cumulatively saved almost $834 million dollars and over 5.7 million tons of CO_2 emissions from base energy code adoption[15] from 2009-2019. If the state of Illinois were to follow the stepped approach to PHIUS+ by 2030 for residential energy code adoption, the savings would be much greater than if the state continued to adopt and amend the IECC. Moving the residential energy code to PHIUS+ by 2030 would provide benefits beyond just monetary savings and CO_2 emissions reduction. Super-efficient building construction also helps to "flatten the curve" of peak electricity demand. As our world is beginning to understand the importance of resilience due to natural disasters and pandemics like COVID-19, "grid reliability" and "sheltering in place" are common vocabulary. PHIUS+ uses the EPA Indoor airPLUS (IAP) program as one prerequisite for all single-family projects, ensuring a cleaner indoor air environment for their occupants.

Summary

Big strides are needed to reduce energy consumption of buildings. The PHIUS+ standard provides strong energy conservation targets, and energy codes provide a straightforward mechanism to have an impact. Considering exactly how energy or stretch code adoption in Illinois would look stepping to PHIUS+ offers a scalable solution to move the needle by 2030, and sets up a framework for national energy code development as well as a replicable pathway for other Midwestern states and municipalities. Utilities can help to support high-efficiency energy codes through energy savings programs, helping to make the grid and the communities in the Midwest become more resilient.

[15] Residential and commercial

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