# Passive Building Design Guide

Passive House Institute US

## FOR DEVELOPERS, INVESTORS & CONSTRUCTION PROFESSIONALS

## COMMERCIAL CONSTRUCTION

# ACKNOWLEDGEMENTS

We would like to thank the Illinois Clean Energy Community Foundation for making this design guide and its associated website, the Commercial Construction Resource Center (www.commercial.phius.org) possible.

Through these new resources, the vital work they do to improve energy efficiency in Illinois will extend internationally. We thank them for their investment and commend them for acting locally on issues with global implications.

We would also like to thank all of the people who worked with us to put this guide together. Their help tracking down photos, photo credits, providing technical insight, and inside information was invaluable and has made this a better book. Among the people who dropped everything to help: Sam Rodell, Maren Longhurst, Jennifer Corson, Michael Wisniewski, Dylan Lamar, Laura Nettleton, Cara Carmichael, Kathy Berg, Christina Peay, Megan Kohlmiller, Sloan Ritchie, Steve Bluestone, Hammer and Hand, Ben Bogie, James Hartford, Hank Keating, and last—but not least— Keith Robertson.



PHIUS
Passive House Institute US

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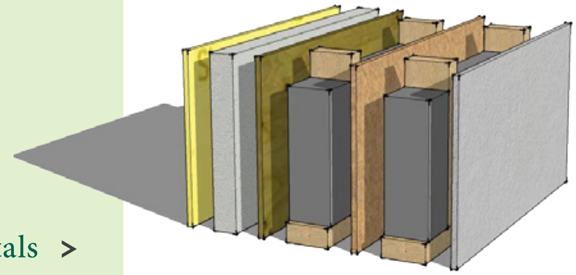

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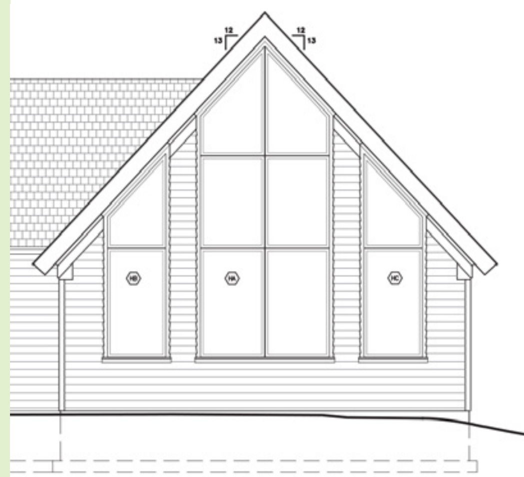

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# INTRODUCTION

## Welcome to the Passive Building Design Guide for Commercial Construction

When we began the Passive House Institute US in 2007, we focused primarily on houses, because that is primarily what we designed and built for a living. As we moved into commercial and multifamily projects, we realized that it works much better on larger projects, especially after closely tailoring the building to the climate it sits in. The 2015 Climate Specific Passive Building Standards are the result of deep research and improvements to the old passive-house model of construction. The standards represent the most cost-effective way to extremely low energy use.

This guide is loosely divided into three sections. Chapters 1 and 2, Passive Building Fundamentals and Passive Building Benefits, cover the basics. The second section explores real-world experience of developers, architects, and building owners. In Passive Building Works for All Building Types, we dispel some notions about whether passive building can scale to commercial (it can). Next, we look more closely at examples of PHIUS+ buildings in the real world: a conference center, a medical facility, and an office building. The last part of the guide walks you through the pathway to PHIUS+ certification (Six Steps to PHIUS+ Certification) and answers any of your lingering questions (in the conveniently titled Frequently Asked Questions). Of course, if your question is not answered in this guide, there is an easy way to get it answered: Contact us at commercial@passivehouse.us.

I hope you'll consider incorporating PHIUS+ into your next building project. As you'll learn in this guide, the result is a superior building for occupants and owners. And it does not necessarily need to cost more to develop and build.

Data that is coming in from completed projects shows the accuracy of the modeling software to be remarkable—energy use is frequently within about 10 percent of what the model predicts, which is substantially more accurate than other energy-use predictions that you may come across.

For more info on passive building, at the end of the guide is a substantial resource list, but don't stop there—you can also dig into the Commercial Construction Resource Center, the Multifamily Resource Center, and phius.org. In the meantime, subscribe to the PHIUS newsletter for breaking news, info, and new certified projects.

Thank you for your interest in PHIUS.

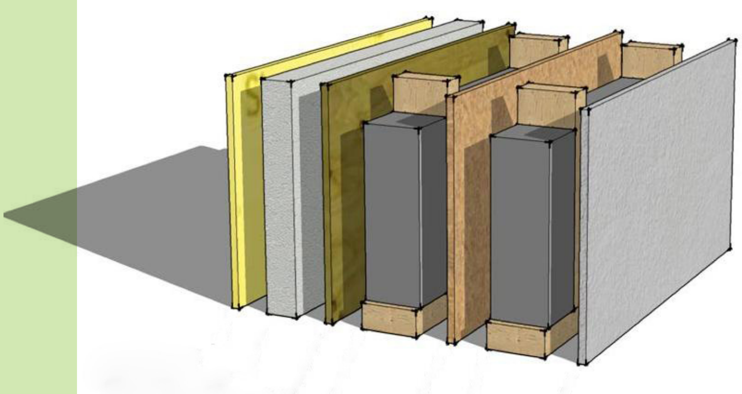
Sincerely,
Katrin Klingenberg
Executive Director, Passive House Institute US

Chapter 1

# PASSIVE BUILDING FUNDAMENTALS


## Passive building is based on science and experience

The building blocks of passive building come from the same building blocks as North American energy standards like Energy Star, LEED, and the Department of Energy's Zero Energy Ready Home designation, because you can't argue with physics. Those individual programs move buildings incrementally closer to energy efficiency. Passive building certification though PHIUS is a direct route to net-zero building that is substantially more comfortable, durable, healthful, and predictable than partial measures cobbled together. Fast-forwarding past the physics of passive building, it boils down to five building science principles:



**An indoor/outdoor approach to thicker walls.**
In this retrofit, Hammer and Hand added a stud wall inside the building and a layer of foam outside.

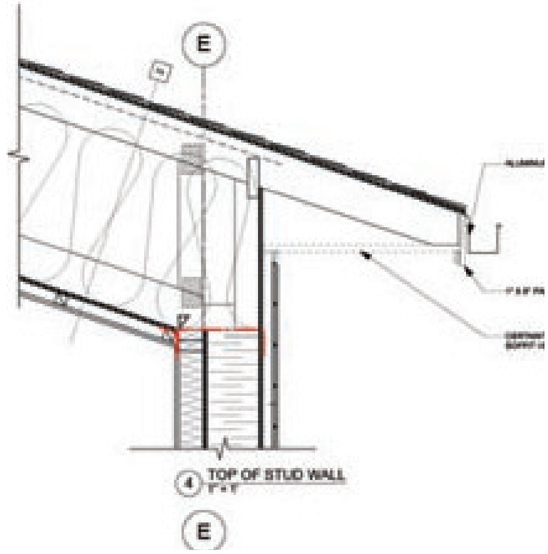
### 1 Continuous insulation interrupts thermal 'bridges' between inside and out

By completely wrapping a building with insulation, heat can no longer sneak out through framing, which has a lower R-value than the surrounding insulation. Masonry chimneys that connect inside and out are another often-overlooked thermal bridge. In multifamily housing, cantilevered concrete balconies inadvertently transform high-rise buildings into giant radiators. The simplest way to fix all of those energy sieves is to avoid building them in the first place. Continuous, thick, insulation on the outside of a building keeps heat flow to a minimum.

## 2 Airtight construction stops heat and moisture

While thick, continuous insulation can stop a significant amount of heat loss through conduction, plugging air leaks can slow heat flow, too. Because temperature drives air movement—think about convection loops—the air moving through buildings usually carries a lot of heat with it.

And here's the rub: Warm air can hold more moisture than cold air. So when warm air leaks through electrical outlets into exterior walls, it dumps moisture into wall cavities when the moist air hits the cold wall sheathing. It happens in winter and summer, only in reverse. Air-conditioned buildings are cooler and drier than outside air, so hot, humid outside air is sucked into walls, where it dumps moisture on the paper backing of the drywall. Paper backing on drywall makes terrific mold food, by the way. There are a lot of holes, gaps, and cracks in typical building that can add up to cause a lot of hidden rot problems while also wasting energy.




**Detail drawings eliminate weak links in logic.**
Plan sets that have extensive detail pages show tradespeople how to execute critical details in the field.

**Swinging windows are tighter.**
Casement and awning windows seal more tightly against air leaks than double-hung windows do. Triple-glazing and low-e coatings keep heat where you want it.

## 3 Optimized windows keep heat in—and out

Windows have a terrible job description: Plug a hole in the wall; stop air, water, and heat; open and close; look good; and be transparent. Some are even supposed to be shatter-resistant. Of all these demands, stopping heat flow is the most difficult to achieve because glass has an extremely low R-value. Typical Energy Star windows do this with double-glazing and argon gas, but passive buildings usually use triple-glazing.

However, heat flow does not stop at conduction. A lot of heat can pass through windows by radiant transfer. Free heat in winter is welcome because it lowers the work a heating system must do. Free heat in the summer is the opposite: It makes the air-conditioning system work harder.

Low-e coatings applied to the surface of the glass can block radiant-heat transfer, keeping it in or out, depending on the temperature gradient. They can also be fine-tuned to allow a particular amount of heat gain. These coatings are categorized according to their solar heat gain coefficient (SHGC). High SHGC windows should be used on sides of the house where winter sun is wanted, generally on the east and south. Low SHGC windows should be used where summer sun will do the most harm, generally on west-facing windows.

The appropriate window depends on your climate zone; cold climates need well-insulated windows because the temperature extremes are significant. Hot-climate windows typically have strong radiant-heat blockage because the sun is intense in hot climates.

**A tight line of mechanical equipment.** When the money is spent overcoming the need for monstrous mechanical systems, the resulting systems fit in a corner of the basement and work as expected.

## 4 Balanced ventilation ensures fresh air—and controls moisture

Air-tightening means that dirty, moist air isn't leaking into the living space from basements and loading docks, which is good. It also means that stale indoor air is not leaking out, which is bad. Air changes must be controlled with some sort of high-tech fan. One option is an energy recovery ventilator (ERV), which pulls new air in and pushes old air out while transferring heat and moisture in the process.

A constant flow of fresh air flushes the living space without pulling in hot, cold, or wet air that the HVAC system must then condition.

## 5 Minimal mechanical is all a super-tight building needs

Because the building is super-tight, super insulated, and has super windows, a super-size heating and cooling system is unnecessary. The mechanical system is where the upfront investment begins to pay off because mechanical systems can get expensive. Some of the money that was spent upfront on insulation and windows can now be recouped with a much smaller mechanical system. In single family homes, this can add up to attractive savings, and in multifamily and commercial buildings, the savings compound quickly. In fact, a 58-bed long-term health care facility in Spokane, WA cost less to build ($132/square foot) than typical built-to-code construction (see example 2, page 24).

### LESSONS LEARNED *Oversize the insulation, not the HVAC*

Insulation is less expensive than mechanical equipment, and it has fewer moving parts, so it never really needs maintenance. Overinvesting in insulation means that the mechanical systems will have less work to do, so they can be smaller. Or nonexistent. The RMI heating system runs comfortably at capacity thanks to superinsulation.

*—Cara Carmichael, project manager,*
*Rocky Mountain Institute*

Chapter 2

# PASSIVE BUILDING BENEFITS

**A living example of achievable excellence.** The Innovation Center at Rocky Mountain Institute was designed to demonstrate thought leadership in construction and design. Superior energy performance in one of North America's coldest climate zones is not the only lesson: Comfort, health, and resiliency are key deliverables, too.

## A better building that's more predictable and affordable to operate—at little extra cost

Passive house certification is often cited as the most aggressive energy-efficiency standard available. That is correct. Passive building set out to define a rigorous energy-efficiency standard for buildings as a way to reduce the ecological footprint of the construction sector. This was achieved through superinsulation, super airtightness, super-efficient windows, meticulous control of plug and lighting loads, and some unconventional—and often overlooked—space heating (taking advantage of waste heat from lighting, appliances, and people).

All of this is great news for the people who pay the energy bills, but it's also a big plus for the planet: Buildings represent about 40% of carbon pollution, so buildings also represent about 40% of the solution. That's a lot of power in the hands of building professionals. PHIUS+ certification is the best way for building professionals to take control of the carbon footprint of their buildings.

### Passive buildings have clean indoor air

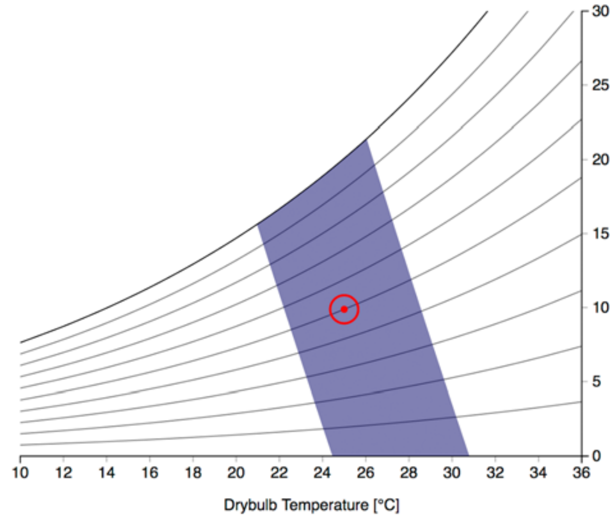
Beyond energy efficiency and carbon reduction, passive buildings also deliver superior living conditions via indoor-air quality and comfort. Because outdoor air doesn't leak in and indoor air doesn't leak out, building operators have much more control over the interior conditions. Because tight buildings have dramatically less air exchange with the outside, they are frequently blamed for causing mold or indoor-air pollution. "Buildings need to breathe" is a common refrain in conversations about sick buildings, but it is a bad analogy. The thought behind the phrase is that buildings need fresh air that can replace polluted or moist air that cannot escape a tight building. Actually, buildings don't need to breathe; people do. Buildings must be able to exchange old stale air for clean, fresh air so that the people inside can breathe.

Leaky buildings exchange air accidentally through random holes in the walls, roof, or basements, where there may be soil gases, musty air, or even dead rodents. Tight buildings control where the fresh air comes from and how much of it is drawn in, allowing building operators to dial in indoor-air quality (IAQ) for people who actually breathe inside the building.

## Superinsulation and tight construction make buildings comfortable to be in

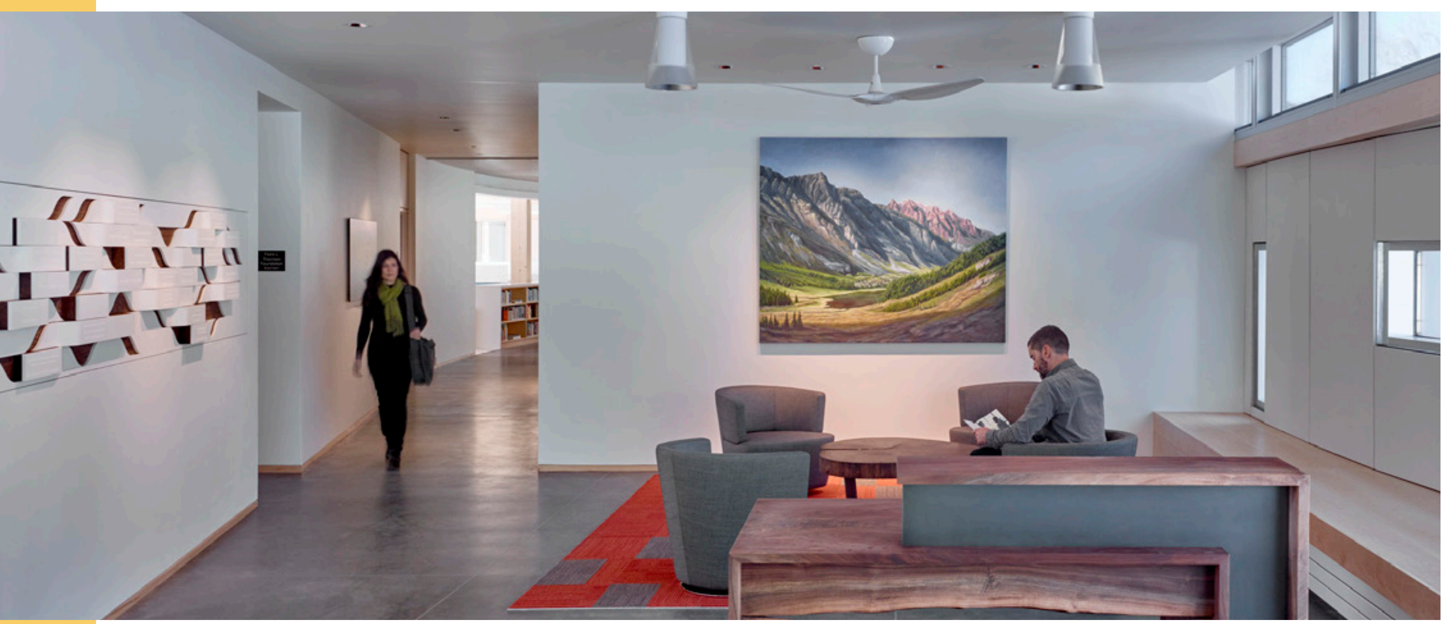
Comfort can seem like a vague term, but there is actually a way to measure it. Not surprisingly, the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) has a chart for it.

Comfort is highly subjective because every individual has slightly (or drastically) different tastes. Personal comfort zones can vary seasonally as well. ASHRAE's chart plots temperature against humidity to isolate a zone within which most people will be comfortable.




**Comfort is relative, but not nebulous.** This chart illustrates what 90% of people find a comfortable balance between heat and humidity. As temperature increases, people find humidity less tolerable. The test method is defined in the ASHRAE 55 Standard.

One thing everyone can agree on, though, is that a passive building delivers superior comfort. It is not too hot, cool, drafty, clammy, or humid. Many occupants find that indoor temperatures well below what they think they need are surprisingly comfortable in a building that doesn't leak. Because people are accustomed to thermal striations and drafts, they think



**Gentle ventilation, automated.** Windows and circulation fans, such as this ceiling fan, automatically cool the space in summer and flush indoor air at night.

**Big air, no drafts.** Because the interior temperature in passive buildings is stable, there is no thermal stratification in large spaces.

65 degrees is too cool in winter and are accustomed to keeping the thermostat at 70 or 72 degrees. But when experiencing interior air in a passive building that is a consistent 65 degrees, they are surprised by how comfortable they are.

Passive buildings are extremely comfortable in all seasons, and yes, passive-building owners can open their doors and windows on spring days, just as they would in a conventional building.

### Mold is bad for buildings. It's a good thing passive buildings are mold-free.

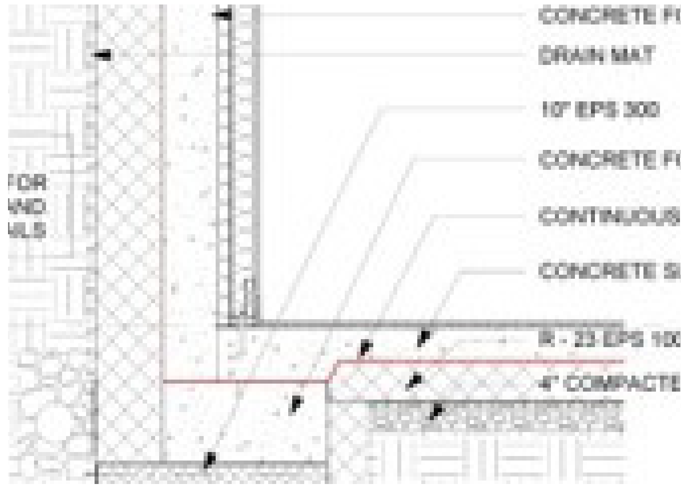
Many typical maintenance chores result from some sort of moisture damage—exterior painting or cleaning, bulk water leaks at windows and doors, high interior humidity that fosters mold or mildew growth—but floodwaters notwithstanding, it is not really liquid water that destroys buildings. It is the mold and decay fungi that follow it and deteriorate the building materials. Because of the careful hygrothermal (heat/moisture interaction) modeling and quality assurance and control that are central to PHIUS+ certification, moisture problems are never present in PHIUS+ buildings.

PHIUS+ certified builders understand the science behind the building, so bulk water problems from construction defects are equally rare. Buildings without water problems are more durable, require less maintenance, and last longer than conventionally built structures. This means lower operating costs, fewer disruptions for occupants, and fewer headaches in general for building owners and operators.

### The premium for PHIUS+ is negligible

Early in the passive-building movement, it did indeed cost more to build this way. Eight to 10 percent premiums were commonly reported. These higher prices were quickly qualified with lower operating costs as a way to recoup the initial investment in the passive-building process. Also, passive building was never developed as a way to save money in the construction process. It was developed as a way to minimize the ecological footprint of the construction sector.

PHIUS+ 2015 tailors construction details to the climate zone. That means not spending money on things that are not needed to achieve the desired performance. The result is a building that is cost-optimized for its climate. One cliche is about how much insulation to put under a slab. Just because it makes sense to put 10 inches of insulation under a slab in Chicago (heating demand: 6.2 kBtu/sf/yr, cooling demand 3.2 kBtu/sf/yr), it does not make sense to put that much insulation under a slab in Houston (heating demand: 2.1 kBtu/sf/yr, cooling demand 13.3 kBtu/sf/yr). Consequently, builders in Houston can spend less on subslab insulation and retarget the money to cooling strategies, which is much more important in that climate zone. Buildings certified under the German PHI standard , that has not been cost-optimized for North American climates, still still require the same amount of subslab insulation everywhere, so they cost about 8 percent more to build, while PHIUS has dropped to less than 3 percent.




**Subslab insulation is important, but...** Different winter clothing is needed in Minneapolis and Houston. People choose clothing based on climate, just like PHIUS+ decides insulation levels based on climate zone.

## Construction savings scale up extremely well in PHIUS buildings

Single-family homes tend to cost more to build to passive standards, but larger multifamily and commercial buildings can deliver much better results. The health-care facility mentioned earlier actually cost less to build to PHIUS+ than an equivalent built-to-code facility would have cost because of tremendous savings on HVAC equipment. “The payback,” architect Sam Rodell says, “is either spectacular or irrelevant, depending on how you look at it” because the term ‘payback’ implies some sort of extra investment.

Rodell is not alone. Many developers presenting at the 2017 North American Passive House Conference reported cost premiums in the 3 percent to 5 percent range, with some seasoned veterans coming in around 2 percent. A high-end 30-unit affordable senior living facility, Elm Place in Milton, VT, reported a 2 percent premium—mostly due to the fact that the construction team was very experienced in passive-building. Steve Bluestone, a developer in New York City who builds with insulating concrete forms (ICF), reports premiums of about 1.5 percent largely due to the intrinsic airtightness and continuous insulation of ICF construction.

Scaling efficiency is not just about magic products; it is also a product of simple math. As build-

**A thermal cushion for a building to sit on.** Six inches of insulation is installed along with plumbing rough-in before the slab is poured for Sunshine Health Facilities' new administration building in Spokane, WA.


**The best does not have to cost much more.** Elm Place won top honors at 2017 North American Passive House Conference yet the premium for PHIUS+ was only about 2%

ings get larger, surface-to-volume ratios decrease, and thermal envelope targets become easier to hit. Unintuitively, walls need less insulation in a large building than in a smaller one (if the insulation is continuous). Single-family homes built to Passive House standards often have R-40 walls, or higher. The previously mentioned ICF building in New York City (image next page) has wall insulation that is just a little higher than the code requirement (R-22).

### The best path to zero energy

The reason that code-specified R-values can deliver the performance of passive building is that continuous insulation—a thermal barrier that wraps all six sides of a building—is much more effective than intermittent insulation, which is interrupted by structural members, corners, and interior walls. This relatively simple concept, coupled with meticulous air-sealing and high-performance window glazing, means that PHIUS+ certified buildings are very close to net zero right out of the gate. Usually, adding a few solar panels can tip the scales to positive energy production.

In fact, through our work with the Department of Energy, all PHIUS+ houses qualify as net-zero ready homes (ZERH). The ZERH designation also converts to multifamily and commercial structures up to four stories. The bottom line is cost-optimized comfort and performance.

When the five passive-building principles are applied to buildings—apartment buildings, offices, skyscrapers, single-family homes—you get predictable performance. You also get unmatched comfort for the occupants, superb air quality, and resiliency in the face of power outages due to winter storms, summer blackouts, or extreme weather events.

**People see the finishes first.** Tailoring a building to the climate can make room in the budget for upgraded finishes. And when people are asked what they like about the apartment, you know they'll say the flooring, appliances, cabinets, tile, and so forth.

Chapter 3

# PASSIVE BUILDING WORKS FOR ALL BUILDING TYPES

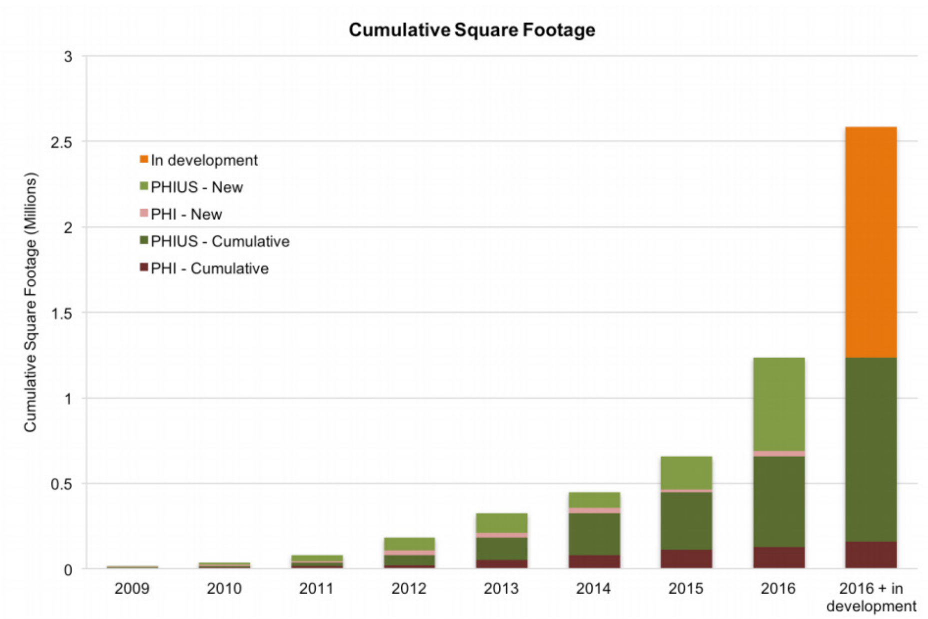
**There are many paths to high performance.** The 101-unit apartment building was built using insulating concrete forms (ICFs) for the foundation and the exterior walls. ICFs deliver continuous insulation and substantial airtightness along with structure.

## As buildings get bigger, efficiency scales along with it

Passive-building principles were originally developed for houses. After decades of experimentation, we have dialed in modeling tools to the point where observed energy use is within 10 percent of expected energy use over the course of a year. One of our first observations was that mechanical systems small enough to heat and cool these aggressive little structures barely existed in North America. Swedish and German mechanical appliances, called “magic boxes,” existed, but their capacities were designed for Germany and Sweden. Unfortunately, they didn’t have enough peak capacity for the more extreme North American climates—and they were blind to our dehumidification needs. Besides, who could read the label?

A passive-house paradox is that larger houses can achieve certification more easily than smaller ones.

**Old school update.** A turn-of-the-century resort cabin at a conference centerin Sharon, CT, was upgraded to PHIUS+ certification. The upgrade was done with off-the-shelf products. In this case, I-joists were used to overframe the walls and roof, making room for more insulation.




**Big growth from bigger buildings.** The Pembina Institute says, "The number and size of certified passive projects has seen a rapid increase in North America in the last five years, and we expect this growth to accelerate." The number of buildings is on a steady rise, but the area of the buildings is shooting up even faster—because bigger buildings are easier to build to PHIUS+ than smaller ones are. Source: Pembina Institute.

**Churches are notoriously drafty and uncomfortable.** Even with huge windows, this Seventh-day Adventist Church in Kinderhook, NY, is comfortable. Designed by Barlis Wedlick Architects, the building achieved PHIUS+ certification in 2017.

This seems unintuitive, but it explains why passive building scales up to commercial and industrial so well. The smaller surface-to-volume ratio of larger buildings makes insulating the space more efficient. Not only do small-enough mechanical systems exist on this side of the Atlantic, but the people occupying the building actually serve as space heaters. This can add up in office buildings and multifamily/hospitality applications.

Passive building has grown exponentially over the past decade, partly because of how powerful the WUFI Passive modeling software is, but to a larger extent, it has been new business attracted by the economies of scale in multifamily and commercial construction. The project database is full of examples of certified commercial, multifamily, and health-care facilities in all parts of North America.

## PHIUS+ works in all climates because it is tailored to each climate zone

PHIUS+ certification includes intricate hygrothermal (moisture/temperature) modeling, which is based on local climate and weather data. The models dial in the building envelope to include exactly what it needs to achieve its specific goals—no more, no less. And this leads to another happy paradox:

extreme energy efficiency does not always require extreme superinsulation. Many PHIUS+ commercial buildings have wall and roof R-values only slightly higher than code.

The reason that PHIUS+ buildings perform so much better with similar insulation is answered in chapter 1. Continuous airtight insulation with great windows allows a small and efficient mechanical system. It begins with 3D energy modeling to tailor assemblies to their site.

### Passive retrofitting is like regular retrofitting: messy and worth it

A fundamental truth of building—that new construction is easier and cleaner than remodeling—holds true for passive building too. New buildings are undeniably easier to make perfect than existing buildings because you start with a bare lot instead of a leaky building. Retrofits, however, are positively possible and profitable.

WUFI modeling software can help designers and builders identify issues and opportunities for the retrofit, just as it does on new builds. There are many examples of successful passive-house retrofits in the certified projects database from single-family homes to mixed use to medical boarding facilities.

Successful retrofitting just requires a dedicated—and experienced—team and the motivation to get it right. Because retrofitting is trickier than new construction, an experienced team is critical. It is best not to cut your teeth retrofitting to passive-building standards (though it has been done).

### Test the airtightness as construction progresses

The trickiest part of a PHIUS+ retrofit is making the existing building airtight. Multitasking materials, such as spray foam—which insulates and air-seals—can be valuable tools for tightening an envelope, which may be hard to define at first. Using a blower door as often as possible during construction lets you identify holes and leaks when sealing an old building. Blower-door-directed air-sealing drills can also help subcontractors stay focused on airtightness goals.


**The first multifamily retrofit to earn PHIUS+ certification.** The Harry and Jeanette Weinberg Commons, developed by Housing Up, completed in 2015, uses 75% less energy than a comparable code retrofit in the Washington, DC, area.

Adding insulation and airtightness to existing buildings changes the thermodynamics of how the building interacts with its environment. In other words, heat and moisture behave differently than they used to, and the consequences can be both surprising and unpleasant. For example, insulation added to the inside of an old masonry building can cause spalling, subfluorescence, and efflorescence because it changes how the masonry wall can dry after rain.

While retrofitting is more challenging than new construction, it can be rewarding (and tax advantageous) to restore old buildings. Because of the inherent risk involved with unknown thermodynamic changes, we believe the WUFI Passive modeling software is critical to success. In fact, it is central to PHIUS+'s quality-control and assurance guarantee.

**A historic landmark brought into the 21st century.** This iconic YMCA building in McKeesport, PA, was retrofitted into SRO housing for homeless people.

### PHIUS+ is already integrated into North American building codes and standards

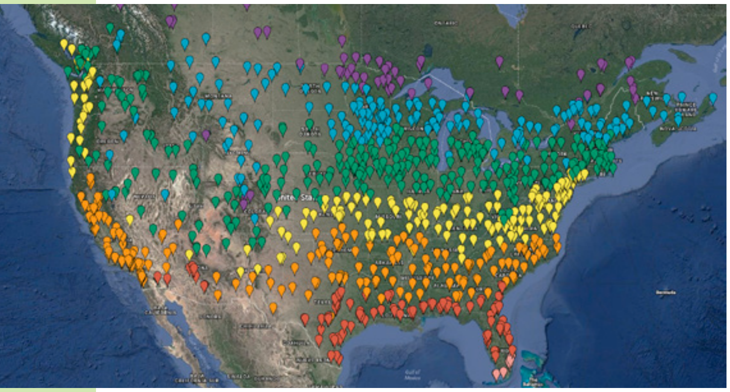
The move to tailoring PHIUS+ to North America's extreme climate zones led us to work with some of North America's leading engineers, architects, and policymakers. We partnered with Building Science Corporation, which had done extensive research through the U.S. Department of Energy's Building America program to identify affordable, effective energy-saving solutions for residential construction. BSC was excited to work with us on bringing affordability to extremely energy-efficient buildings that are also cost-effective, durable, reliable, and comfortable. This led to the climate map (next page) with data on more than 1,000 locations in North America. These data sets can be fed into the WUFI Passive modeling software.

A side effect of this collaboration and the evolution of climate-specific cost-effective energy solutions is that the PHIUS+ 2015 standard closely aligns with North American energy codes and energy efficiency certification programs like ENERGY STAR. Because the International Residential Code, the International

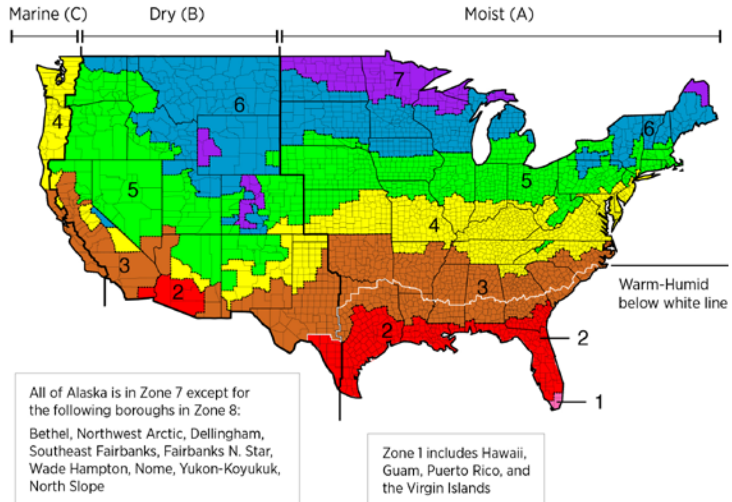
## LESSONS LEARNED *Oversize your way through the process*

Using a blower door to test during construction can help identify minor leaks before they become major headaches. Testing airtightness after windows and doors are installed—perhaps before and after rough-ins by trades—can identify air leaks before insulation and drywall are installed. The point of the blower door is not really to test airtightness as much as it is to find leaks by depressurizing the building and listening for whistles.

*—RMI Design Team*



**PHIUS climate data overlay IECC climate zones.** Data points for over a thousand locations are coordinated to the climate zone map on page 14. When inspectors, planning commissions, or investors ask about codes and standards, you can tell them that PHIUS+ fits.




**Seven zones of separation.** From Miami—which gets its own climate zone— to California—which has five—there is a lot of climate variation in North America. Even within the climate zones, there are three humidity categories (dry, moist, marine).

Building Code, and the International Energy Conservation Code are based on Department of Energy research, the solutions we developed in the PHIUS+ 2015 Passive Building Standards are used for model codes. PHIUS+ 2015 integrates into building codes because the language—and climate-specific science—is consistent.

For example, the German Passivhaus standard may bump up against city or state ventilation requirements. A similar situation arose in a recent high-profile construction project in New York. The ventilation system did not align with what the building officials expected, so project managers had to obtain a variance from the city. This took multiple weeks and tacked cost onto the project. In such cases, you may need to obtain variances from city or county officials. PHIUS is aligned with ASHRAE standards and ICC requirements, so getting buy in from local building officials is a much more predictable process.

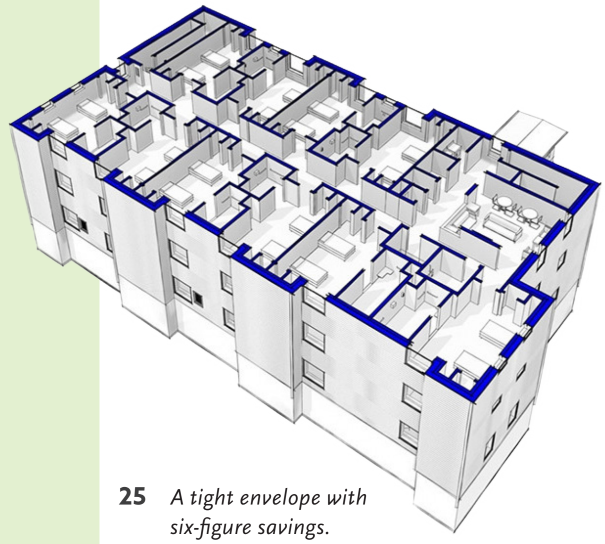
**Ventilation requirements can vary vastly by region.** Because PHIUS+ aligns with North American ventilation codes and standards, there are no construction delays or variances needed.

Chapter 4

# THREE EXAMPLES OF PASSIVE BUILDING



**21** *Exterior materials that are beautiful, sustainable, and durable.*



**25** *A tight envelope with six-figure savings.*

**31** *A waste management company that leads by example*

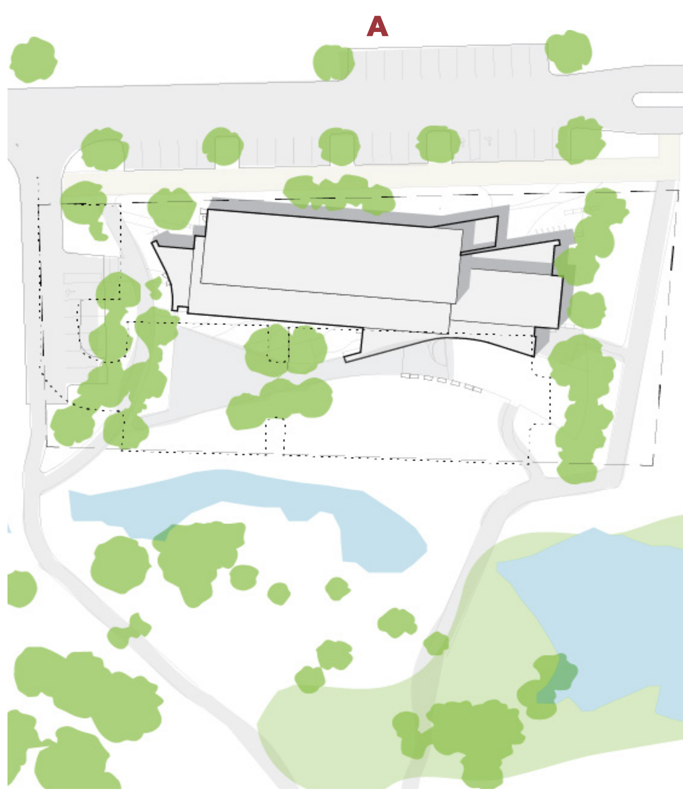
Chapter 4: Example 1

# ROCKY MOUNTAIN INSTITUTE INNOVATION CENTER

**With a view like this, it's hard to not invest in great windows.** Fortunately, the view at RMI faces south, so it is also a heat source during much of the year. Windows on the northern side of the building (photo above) are smaller. Fast-growing trees and shrubs were planted in the parking lot to break the Arctic winds blasting down from Canada each winter. Photo above taken at A on site plan.

## The most energy-efficient building in a very cold climate zone

Located in Basalt, Colorado, Rocky Mountain Institute's Innovation Center is built to demonstrate how deep green buildings are designed, contracted, constructed, and occupied. The office building and state-of-the-art convening center go beyond net-zero energy use and actually produce more energy than they consume—one of only 200 buildings in the U.S. to achieve this net-positive distinction. It is also the largest PHIUS+ certified office in the U.S. and one of the first to add PHIUS+ Source Zero certification to its list of credentials.




### A 15,000-sq.-ft. overachiever

This extreme efficiency—the building uses 74 percent less energy than the average office building in this climate—making RMI's Innovation Center the most energy-efficient building in the two coldest climate zones. The aggressive design meant that the team could eliminate mechanical cooling and drastically reduce the mechanical heating system to a small, distributed system equivalent to that found

## PROJECT SPECS

**LOCATION** *Basalt, Colorado (Climate Zone 7B)*

**BUILDER** *JE Dunn Construction*

**QA/QC RATER** *Francisco Reina, PIE Consulting and Engineering*

**ARCHITECTURE** *ZGF Architects*

**MECHANICAL DESIGNER** *PAE Engineers*

**BUILDING TYPE, FUNCTION** *New construction, commercial office and convening space*

**SIZE, LEVELS** *15,610 sq. ft., two levels*

**COST** *$569/sq. ft.*

**CONSTRUCTION** *Timber frame with structural insulated panel (SIP) walls and roof (R-50 and R-67, respectively)*

**WINDOWS** *Alpen QuadPane with SHGC coatings tuned per window elevation*

**HEATING** *Hyperchair direct-occupant heating wi- thelectric resistance backup*

**COOLING** *Natural ventilation, night flush, ceiling, desk and Hyperchair fans to extend the thermal comfort range*

**VENTILATION** *Two dedicated outdoor-air ventilation units (Tempeff RGSP 2700 and 600) with demand control ventilation, oversize ducts, high-efficiency filters, and 89 percent heat recovery to bring in a lot of clean air with little friction*

**The high window-to-wall ratio in the south wall weaves together the view and the energy strategy.** The high-performance windows let in heat during winter, and the insulated concrete floors hold onto it. Photo taken at B on floor plan.


**The floor plan is part of the ventilation strategy.** Wide stairways and open-to-below balconies at the ends of the building—with few walls in between—make it easy for air to circulate.

in an average-size home—even though the building is six times larger than the average-size home. Eliminating the central heating system in such a large building nestled high in the Rocky Mountains is indeed a thermodynamic big deal.

Beyond the multiple PHIUS certifications, the RMI Innovation Center meets the Architecture 2030 goal of a 70 percent energy reduction even before the 83-kW solar-electric system is accounted for. The photovoltaic system will produce around 114,000 kWh annually, which significantly exceeds the power demands of the building (estimated at 77,000 kWh). That extra energy powers six electric vehicles. A 40-kW battery storage system reduces the building's peak energy demand, which helps RMI stay below a peak demand of 50 kW and keeps them in the small-commercial electricity rate class.

### Design solutions: great windows, exterior shading, and automation

At an elevation of 6,600 feet, Basalt has views worth looking at. The site also has great solar access because few large trees can grow at a mile and a quarter above sea level. To build a net-zero office building in such a cold climate in the U.S. broke down to a

**Open plan lets light penetrate and air circulate.** Airflow is automated at the Innovation Center, meaning that nighttime flushes of stale air make the morning air fresh. Windows and exterior shading are automated for daytime cooling, heat gain, and ventilation. Photo taken at C on floor plan.

**Exterior materials are beautiful, sustainable, and durable.** Sandstone walls reflect the surrounding Rocky Mountains, their battered ledges catching snowdrifts. Juniper accents the exterior, lending extreme durability and longevity to the building.

couple of key challenges: windows and automation. The window demands went beyond typical measures of airtight and energy efficient. Because the windows play a central role in ventilation, they must open and close automatically. Night flushing of indoor pollutants, natural ventilation, and passive cooling are all automated.

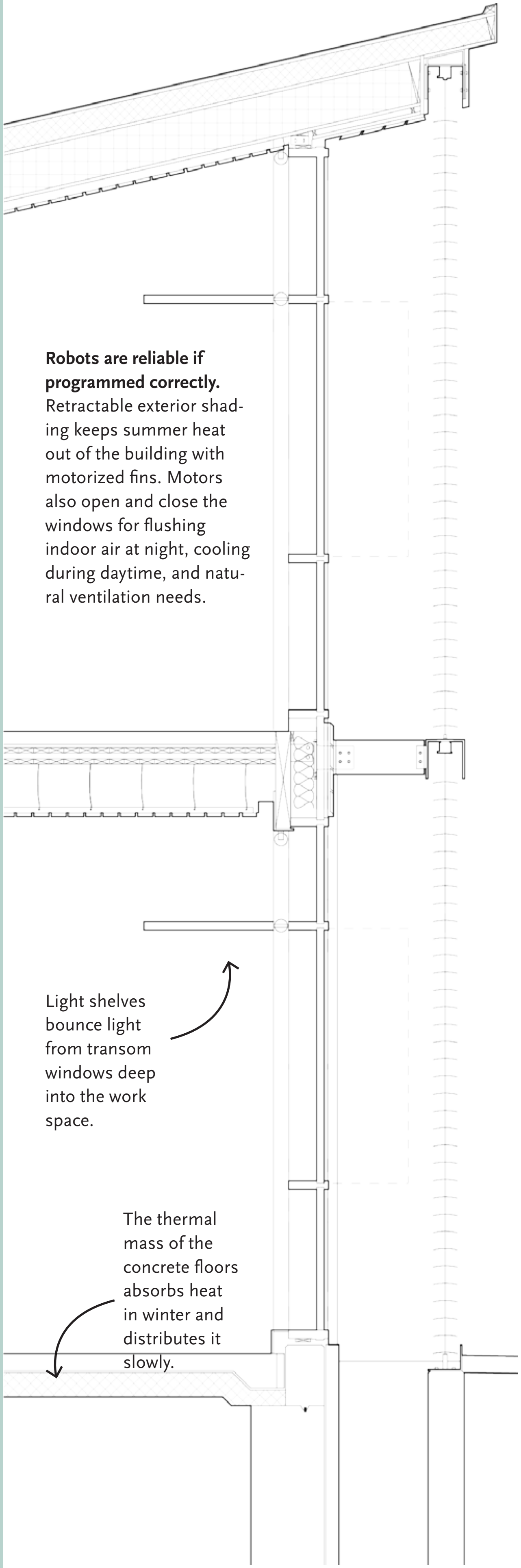
The design team converted the site's wonderful solar access into heating, daylighting, and beautiful views by using a lot of windows in the south wall. Design professionals call it a high window-to-wall ratio. But windows also have a dark side. They can also cause overheating in summer. Selective low-e coatings can exclude or allow radiant heat to enter.

Exterior shading can also keep out unwanted heat. The shading on this building is automated so that energy performance doesn't rely on a person to keep track of the solar calendar and daily weather conditions. Because robots can be more efficient than people, the other key challenge was to make sure that the automatic controls were reliable. It was important that active and passive strategies—motorized exterior shading, automated operable windows, night flushing, and backup electric-resistance heating—worked as intended.

## Benefits to the building owner: positive energy flow on display

Rocky Mountain Institute is the owner of this building and wanted to achieve net-zero energy use from the start of the project because it aligns with their mission. PHIUS+ certification was the best and most cost-effective path to net zero because it tailors design, construction, and operations to the building's extreme climate.

The Innovation Center is similarly sized to 90 percent of U.S. commercial office buildings. Over half of commercial buildings are owner-occupied, and office




**Exterior shading lets indirect light into the space** while blocking unwanted direct sun, which can cause reflection and glare on screens. Photo taken at E on floor plan.

space is the largest use type. In this way, the Innovation Center achieves its goal of being a living lab by sharing how the building was contracted, designed, constructed, and commissioned, and how it operates.

To learn more about this project, go to www.rmi.org for a digital book and a microsite dedicated to the mission, strategy, accomplishments, and vision of the Innovation Center.

## LESSONS LEARNED

***You can do this***
Net-zero energy construction on a commercial scale is cost effective and easy to achieve, if you do the upfront planning.

***Getting HVAC right is key***
Commissioning and monitoring comfort and indoor-air quality systems is absolutely critical. The design team's advice is to involve a commissioning agent or controls expert from the start of the design process to check specifications, provide input, tackle system interoperability issues, and overcome scope gaps.

***Smart buildings need smart people***
While automation can take a lot of responsibility off the people in the building, tenant engagement and education are still required to meet net-zero energy goals. If people don't understand how the building works, they can sabotage its efficiency.

***Project management is an art***
Integrated project delivery is useful to help manage cost, contracts, and risk.

*—Innovation Center design team*


**Designed for physics and nature.** Turns out that natural ventilation, light, and heat storage feel more natural than artificial ventilation, light, and heat. The three systems work together using operable windows, shading, and thermal-mass storage. Photo taken at F on floor plan.

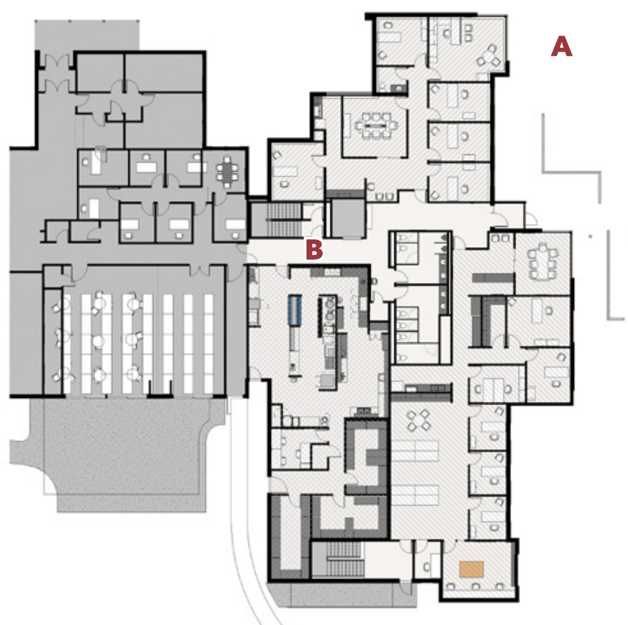
Chapter 4: Example 2

# SUNSHINE HEALTH FACILITIES

**Three buildings under one roof.** Rather than try to bring an old building up to PHIUS+ performance, the design team compartmentalized the new buildings under a common roof. The kitchen and laundry are inside the PHIUS zone; halls and stairs are outside the zone, acting as a buffer to the old building. Image above at A on floor plan.

## Extreme energy savings fuel a higher standard of care

When it was time to build a new administration building at Sunshine Health Facilities, the construction choice was a no-brainer: PHIUS+ certification through Passive House Institute US—not because the CEO of Sunshine Health Facilities is tree-hugger, but because of past experience on a 58-bed PHIUS+ certified addition to a state-licensed boarding home a few years earlier. It was cheaper to build and cheaper to operate, and it delivers superior comfort and healthy indoor air to the occupants.




Founded in 1949, Sunshine Health Facilities was built on the site of one of Spokane's first universities, Spokane University, which closed in 1933. The historic campus brought with it significant problems, including aging housing susceptible to temperature extremes, which is a problem for medically fragile residents. The campus includes a nursing home, the aforementioned boarding home and several cottages.

## PROJECT SPECS

**LOCATION** *Spokane Valley, WA (Zone 5B)*

**BUILDER** *Jon Hawley, Tamarack Ridge Construction*

**QA/QC RATER** *Peter Anderson*

**ARCHITECTURE** *Sam Rodell Architects*

**MECHANICAL DESIGNER** *Jonathan Iams Consulting*

**BUILDING TYPE, FUNCTION** *New construction, commercial administrative and boarding*

**SIZE/LEVELS** *17,852 sq. ft, 3 levels*

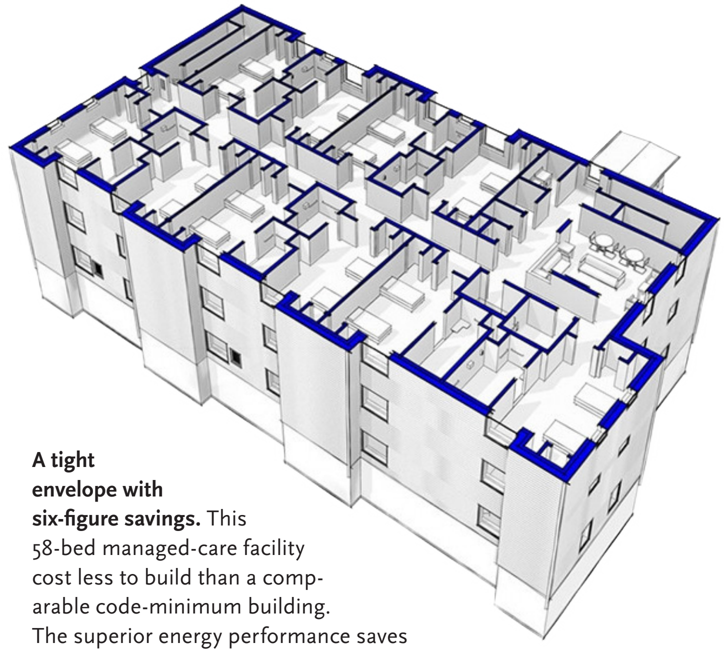
**COST** *$134/sq. ft.*

**CONSTRUCTION** *Walls: 9½-inch engineered I-joist Larsen-Truss wall, 2x6 structural wall. Roof: Truss roof with R-88 blown-in cellulose.*

**WINDOWS** *Zola Thermo uPVC U 0.16*

**HEATING/COOLING** *Panasonic multi-zone VRF heat pump system*

**VENTILATION** *UltimateAir 2000DX heat recovery ventilator*



**A tight envelope with six-figure savings.** This 58-bed managed-care facility cost less to build than a comparable code-minimum building. The superior energy performance saves Sunshine Health $120,000 in annual utility costs versus a code building.

**Natural light bathes the space.** The living space has large triple-glazed windows that are comfortable to sit next to in all seasons.

### Less expensive to build, less expensive to operate, better place to live

The new administration building, which shares a common atmosphere with the nursing home, aims to solve an interesting mix of needs that have cropped up as the company has grown over the past couple of decades. Chief among the needed solutions were office space, commercial kitchen space, and a commercial laundry facility.

The architect of the project, Sam Rodell, and his partner, Calla Kirkwood, have a long history with Sunshine Health, having built, remodeled, or added to all of the buildings over a span of three decades. But before the boarding-house addition, design and construction were done the old-fashioned way: built to code.

After dipping his toe—and eventually jumping—into the passive-building pool, Rodell suggested modeling the boarding house with WUFI Passive 3D energy software that can work side-by-side with Revit, their BIM software. “Revit has been transformational to our shop, and being able to put the PHIUS approved design and verification software on top of it really puts a lot of power in your hands as a designer.”

Despite the superior comfort and indoor-air quality, the project’s design process was primarily cost driven. Sunshine Health's income potential is limited and established largely by outside agencies. Profit margins are extremely narrow, so the design must be as economical as possible—both initial construction and operating costs over time. Because Sunshine Health Facilities' business model is based on fixed reimbursements, squeezing utility and value out of capital expenses represents their best opportunity to affect the bottom line. The four-story, 58-bed, 25,000-sq.-ft. boarding home—if built to code minimum—would spend at least $120,000 more each year on utility costs. Building a net-zero facility represented tremendous low-hanging fruit because it could be done using current construction technology, so Sunshine went for it. The building is pre-wired for solar roof panels, which will make the building net positive when the owner installs photovoltaic panels them after funding becomes available.

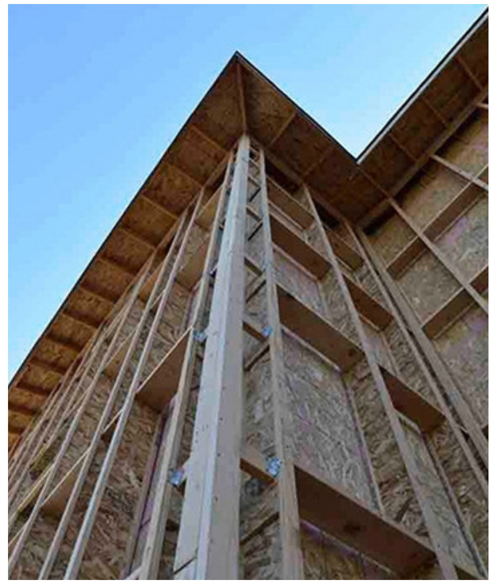
Even better for the bottom line was what it cost to get to PHIUS+: just $134 per sq. ft., including soft costs. PHIUS+ construction cost less to build than comparable mainstream construction. Less.

## It's all about the residents

Beyond the financial benefits and energy savings, passive house construction improves the quality of care and living conditions for the people who live there. Passive house elements "make a much more comfortable, quieter building ... with purified air that eases respiratory problems for our clients," reports Dr. Nathan Dikes, CEO of Sunshine Health Services.

Additionally, "the company is very mission-driven," Rodell remarks. "There is more involved than just finances; there are quality-of-life issues at play." Sunshine has a history of investing in innovative quality-of-life enhancements, so Rodell was not surprised when they embraced passive building.

To manage expectations, Rodell didn't oversell it initially. The design team modeled a building in WUFI passive and then modeled it built to code to show the owner the differences. Passive House Institute US provided a cost-benefit analysis spreadsheet to paint a more sophisticated financial portrait of the savings over time. In addition to the hard costs



**Off-the-shelf high-performance walls.** At Sunshine Health, low technology is the backbone of affordable performance. Standard I-joists screwed vertically into walls add depth for insulation and a layer to the air barrier—a low-tech no-brainer.

**Higher quality of life for patients.** The company is mission-driven, with the welfare of patients top of mind. Superior indoor-air quality, comfort, and resiliency improve the patients' well-being.

**Commercial kitchens are afterburners for energy use.** Grills, dishwashers, and ovens use a lot of power and create indoor pollution. Range hoods and dishwasher hoods quickly remove moisture and pollutants along with thousands of cubic feet of air. Dedicated makeup-air equipment is needed to balance this heavy exhaust. Photo taken at B on floor plan.

of construction and daily operations, the analysis accounts for inflation, interest rates, and rate of change in the cost of energy over time (in Spokane, it is about +2% annually).

"We look at bracketed scenarios, worst case to best case, and they can see without needing to have a crystal ball what the range of possibilities looks like," Rodell says. The predicted savings were in the six figures, and the project has delivered more than promised.

After getting so much building for their construction budget; after not paying utility bills for the building; and after experiencing the comfort and indoor environmental quality of the facility, there was never a question as to how they'd design the administration building: PHIUS+.

## Return on investment implies an upfront investment, but...

One of the first questions architects and designers ask about this kind of construction relates to payback, or return on investment. But return on investment presumes an initial investment. Because there was no additional investment beyond what was in the budget, the return on investment is either spectacular or irrelevant, depending on how you think about it.

The extra costs of the building envelope (thicker walls, better windows, and meticulous detailing) lowered other costs moving forward—particularly with things like firewalls. After the trade-offs, the finished cost of the project was lower than a comparable built-to-code building. One reason costs were lower was that after the envelope was complete, the rest of the project went faster than usual because of simplified mechanical systems, ductwork, and fire dampers.

"This particular company is not a nonprofit, but they act like it," Rodell says. "So that wash of funding has allowed them to improve the services they offer their residents."

## Design challenges and solutions

The main design challenges for the administration building were the commercial kitchen and the commercial laundry facility. Rodell calls commercial kitchens "afterburners for energy use"—mostly because of the exhaust hoods—"but commercial laundry facilities are even worse." The solution for large kitchen range hoods is dedicated makeup-air fans calibrated to the exhaust fans. Maintaining consistent pressure and controlling airflow are keys to passive building. In the laundry, ozone cold water washing eliminates heating water from the process and also eliminates chemicals from the waste stream.

Another pretty big challenge was that the new admin building had to share a common atmosphere with the vast nursing home, and “there’s no way in the world it can ever be made airtight,” Rodell says before revealing the solution: Compartmentalize the air barrier.Rodell let the corridors, the circulation systems, and the stairwells become part of the common atmosphere of the nursing home. They built three different buildings under a single roof. “You don’t know it, but when you step from the hall into the administrative offices, you are actually stepping into a different environment,” he says.

The kitchen and laundry facilities are in a self-contained building, and the administrative offices are in another. Additional offices for a home health business are the third building under the common roof. All three share a thermal envelope and a roof, but the interior buildings are compartmentalized with an air-barrier system. “That allowed us to add a passive-house facility onto a non-passive-house facility” Rodell explains.

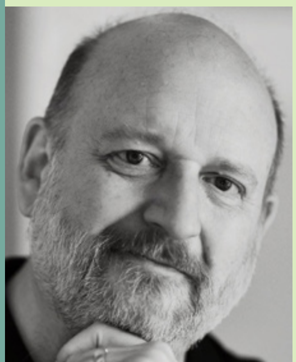

**Makeup air balances exhaust.** This heat-recovery ventilator tempers incoming air with outgoing air to recoup a lot of the waste heat exhausted from the kitchen and clothes dryers.

**Hot air, high pressure.** In tight buildings, the effect of commercial laundry facilities goes beyond massive water and energy consumption. Because commercial clothes dryers exhaust a massive amount of air, a massive pressure imbalance must be accounted for in the ventilation system with makeup-air units.

## A curveball most designs will never see

Rodell uses a design scenario from this building that serves as an excellent example of not knowing what you don’t know and the deeply ingrained inertia that litters the path to high-performance building. In the basement of the boarding home is a space where heat-pump water heaters use warm air to heat water. Cool air is a by-product. In an adjacent space, computer servers hum along, heating the space and powering their internal fans to cool themselves.

The design team initially missed the synergy because “it is hard to acclimate yourself to understanding how significant little things are inside a high-performance building—like how the distribution of water lines can challenge you with cooling—or help you with heating.” Intuition, Rodell says, can act like a mask “before you recognize that those computers can be heating the water, and those showers can be cooling the computers.”



## LESSONS LEARNED

### *A great team is critical*

Bring in a certified PHIUS builder as early as possible. As the design progresses, they bring in subcontractors and get to a granular level of planning and trade-offs through 3D energy models.

### *Modeling is powerful*

Sam Rodell Architects is a Revit shop—BIM software—and Rodell says that they are heavily into it. “We build the site before we do any design work, and then we do all of the design work in a three-dimensional context, in Revit. We have been doing that for years. We now export our Revit models into WUFI Passive (PHIUS+ software) to get 3D energy models.”

“We have the information we need—in real time—to see how things we do affect the design as it progresses.”

### *Passive building improves many bottom lines*

The initial sell to build through PHIUS+ was 100% financial. The company runs a tight ship financially, and the first building overdelivers financially.

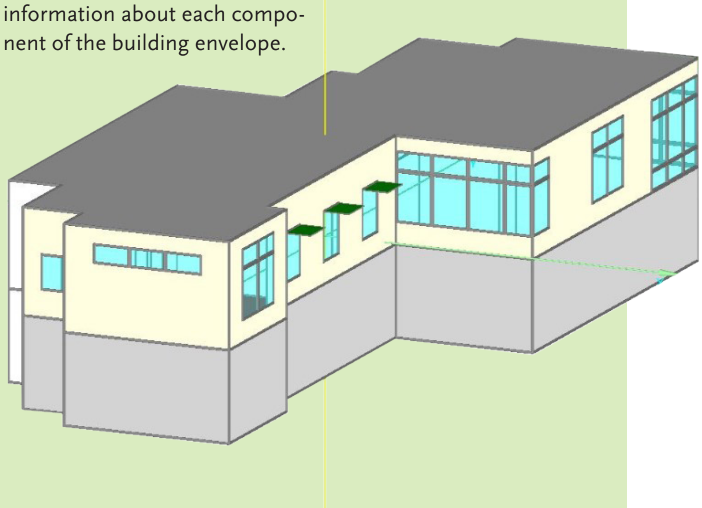
### *Look out for little things*

“When you take care of the big things, the little things get bigger. Parts of a design that used to be invisible come into focus through high performance construction. Even with all of that attention to detail, we missed the simple synergy mentioned earlier about the heat-pump water heaters and the computer servers working against each other. It is very hard to be intuitive about these things, and that’s one of the things I love about passive building—that intuition has been replaced by physics.”

*—Sam Rodell, Sam Rodell Architects*

**A different kind of thermal bridge.** The connection from the original boarding home to the new PHIUS+ building is isolated with exterior doors at each end.

**A peek into the possibilities.** The WUFI Passive energy model analyzes buildings in many contexts including climate and internal loads (like people and computers). It delivers granular information about each component of the building envelope.

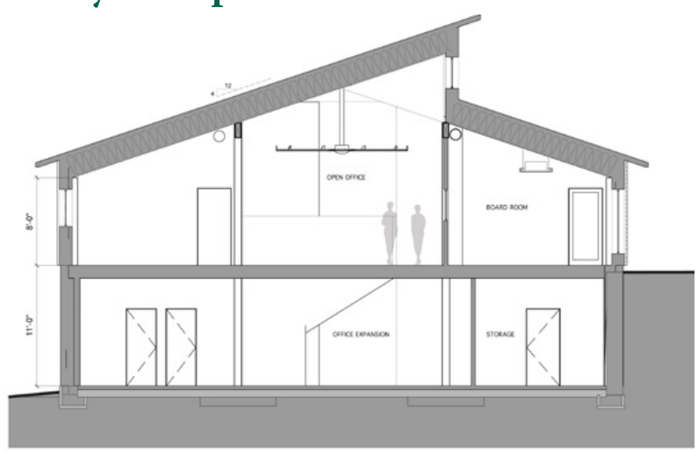


Chapter 4: Example 3

# VALLEY WASTE MANAGEMENT

**Daylighting done right.** A sun scoop funnels daylight deep into the building from the sunny south side. Smaller windows on the north side add balance with soft indirect light. Photo above taken at A on floor plan.

## A waste-management company that leads by example




"Waste management" is almost literally Valley Waste Resource Management Authority's middle name—with "resource" bumping in the middle. Because VWRMA is in the business of managing the resource of waste, their new building had to reflect their commitment to reducing waste, reusing where possible, and recycling the rest. This is especially important to them because construction debris accounts for a large percentage of the resources that VWRMA manages.

### An example of how to get more by using less

The new office building is a living demonstration of efficient construction, featuring superinsulation, a high-efficiency mechanical system, state-of-the-art lighting, and water-conserving design and products. Solterre Design used recycled and salvaged materials wherever possible, and Roscoe Construction worked consciously to divert construction waste from the landfill. The main offices feature salvaged interior finishes from dismantled buildings and a recycled glass aggregate in a polished concrete floor—the first of its kind in Nova Scotia.

Completed in 2013, this passive-building pioneer has a five-year track record of being among the most energy-efficient office buildings in Canada and the first commercial building in Canada to be certified under PHIUS.

## PROJECT SPECS

**LOCATION** *Kentville, NS (Zone 6A)*

**ARCHITECTURE** *Solterre Design: Jennifer Corson, David Gallaugher, Matt Parks, Keith Robertson*

**CPHC PROFESSIONAL** *Natalie Leonard*

**QA/QC** *Rater Jordan MacDonald*

**MECHANICAL DESIGNER** *CBCL Limited*

**BUILDER** *Roscoe Construction*

**BUILDING TYPE, FUNCTION** *New construction, commercial office and administrative*

**SIZE/LEVELS** *8,106 sq. ft. (gross); 7,524 sq.ft. (finished); 2 levels*

**COST (CANADIAN)** *$195/sq. ft. (gross), $210/sq. ft. (finished) per sq. ft.*

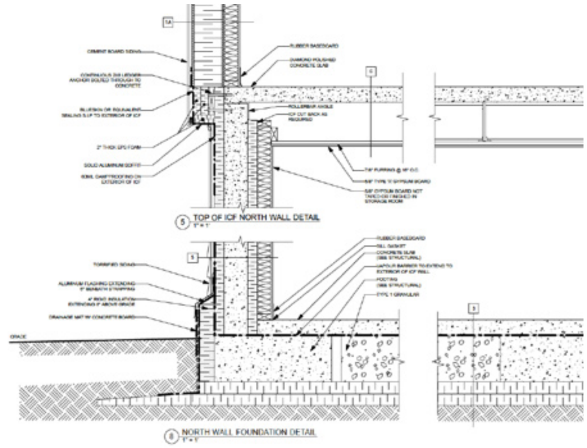
**CONSTRUCTION** *Lower walls: ICF and 2x4 service wall with Rockwool batt insulation (R-48). Upper walls: SIP and 2x4 service wall with Rockwool batt insulation (R-34). Floor: Concrete slab with EPS sub-slab (R-27). Roof: Wood truss with blown in cellulose (R-93).*

**WINDOWS** *TAFG triple-pane, argon-filled Comfort E2 and TiAC40 coatings, insulated fiberglass frames*

**HEATING** *Heat pump, baseboard heaters*

**COOLING** *Heat pump*

**VENTILATION** *Tempeff Cross Flow HR*




**A concrete wall with continuous insulation.** Insulating concrete forms are an off-the-shelf product that has continuous insulation and airtightness built in. A 2x4 service wall brings plumbing and electrical inside the envelope.

### A chance to combine two high-performance design teams

The project was exciting to Solterre Design because it was the first time they were able to combine their commercial LEED consulting experience and their green architecture practice into a truly integrated design team aiming for a really high design standard.

Truly integrated design includes all people who use the building in the design process. Not all people in every step and every decision, but all people who work on or use the building are included in the design decisions that affect them because each has

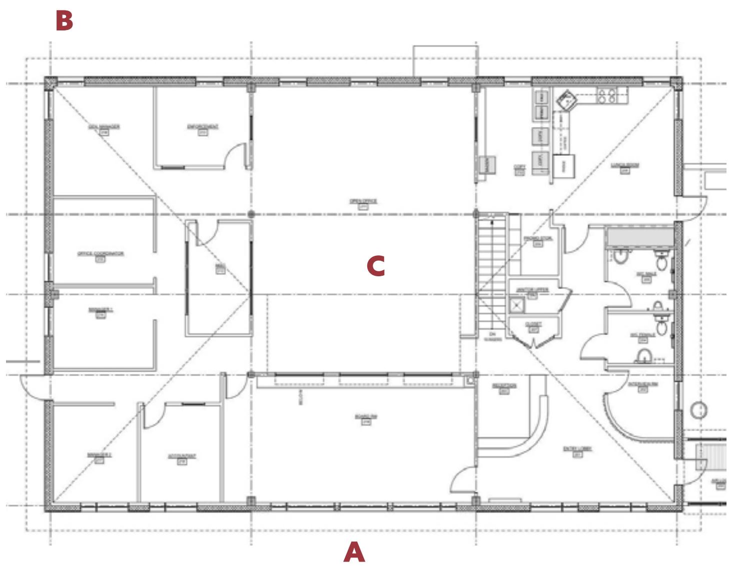
**Basements are the cheapest living space available.** Daylight basements already have three walls of natural insulation, so they are thermally stable. Because this basement faces north, windows were kept to a minimum. Photo taken at B on floor plan.

**Occupant health and well-being was a goal of the new office building.** Abundant daylighting, thermal and acoustic comfort, and high indoor-air quality are at the top of the design list. Another goal for the company was leadership in resource management. One example can be seen in the recycled-glass-aggregate polished-concrete floor, the first of its kind in Nova Scotia. Photo taken at C on floor plan.

valuable input that others are often not aware of. This extensive integrated design process identified three priorities for the new office building: indoor health, responsible waste and resource management, and energy-efficiency leadership.

## PHIUS is a great fit for occupant health and well-being

"Buildings should do more than just not make the occupants sick," says Jennifer Corson, one of the architects on the project. "The building should promote health, comfort, and prosperity." Because the indoors are thermally isolated from the outdoors, the building is significantly more comfortable than a regular building would be. But buildings can also help people to be more prosperous in the course of their business day. Corson describes the concept of indoor environmental quality, or IEQ, which goes a couple of steps beyond indoor-air quality (IAQ). IEQ includes daylighting, ventilation, humidity, and thermal and acoustical comfort. Beyond the stringent IAQ strategies already incorporated in the PHIUS+ requirements, the team created abundant




**Mundane can be magnanimous.** The floor plan reflects pretty standard office needs: public work space, private offices, a conference room, a kitchen, a couple of bathrooms, various storage centers, and a janitor's closet. The surprising part is how comfortable it is to sit next to a window in Nova Scotia during winter—or summer, for that matter.

## LESSONS LEARNED

***Keep it simple.***
Use passive measures before active, THEN use simple systems. Even though we had a simple mechanical system. It took significant effort to get the building controls to work properly.

***Mock-it up, review it, build it, review it***
Working mock-ups into the contract ensures the contractors know what to do on critical assemblies, like windows and air barriers. Pre-drywall blower door test is the best opportunity to find air barrier issues.

***Make it easy for the occupants.***
Some people don't like to tinker and prefer to "set it and forget it" Designing for natural ventilation and night-time cooling requires users to be aware of the energy-saving opportunities. Educating and encouraging the building users to engage with their building's operation helps them take advantage of those opportunities.

*—Keith Robertson, Solterre Design*

daylight and views through the work space using operable windows with climate control and fresh-air ventilation.

### It takes 80 percent less energy to deliver a superior building

VWRMA's goal was not just to keep their energy costs low, but to illustrate leadership in not being wasteful 'in the name of inertia.' VWRMA believes that despite the way they earn a living, the best waste-management strategy is to not produce waste in the first place. This led them to look for an energy-efficiency standard that aligned with their mission. They stopped looking when they found PHIUS+. The new office building is the first certified commercial passive building in Canada, and it also achieved LEED Gold.

The superinsulated, airtight building envelope and high-efficiency mechanical system use around 80 percent less energy than a similar structure built conventionally. By designing a building that uses so little energy, VWRMA has slashed their current operating costs and protected against future high energy costs. They also added a platform for a wind turbine, which could make the building carbon negative within a reasonable payback period.

**Point-source savings.** If you can meet your needs without plugging into the grid, why plug in? All of the exterior lighting is self-sufficient, solar powered with no wires leading to the building.

Chapter 5

# BREAKING DOWN THE NUMBERS


**Ribbon-cutting day for 36 families.** Weinberg Commons, developed by Housing Up, provides housing for low-income and formerly homeless families in the Washington, DC, area. This housing retrofit uses 75 percent less energy than comparable buildings—a boon to the tenants.

## How much extra does PHIUS+ certification cost?

This question is hard to answer for the same reason that it is hard to say how much a bag of groceries costs. It depends on what's in the bag.

Almost everything in the process of passive building, design, construction, and development involves trade-offs. It's hard to quantify the cost of an enclosure system without considering what other things are being done—or not being done—that affect the total cost.

It depends on what's in the bag.

### The grocery bag that developers use is a pro-forma document

All of the cash that flows through a project finds its way into a pro forma. Everyone's pro forma looks different, but it generally contains costs, financial resources, and revenue. Costs break down into hard costs (sticks and bricks), soft costs (architecture, permits, consultants, finance fees, etc.), and construction costs. Financial resources include equity investors (who expect a return over time) and debt from financial institutions, like banks, which expect a fixed-return rate on their loans.

Revenue comes in the form of rent, but also in the form of vacancy rate. Lower vacancy means higher revenue. Expected revenue may be 10 percent of the total cost in a year—that is a reasonable target. This revenue is then allocated to property taxes, utilities, maintenance, and management. What is left over is called net operating income, or NOI.

## Net operating income drives value

NOI of for-profit development is typically used to value the property at some sort of rate. If we expect a 5 percent return on equity, the value of the property is 20 times the NOI. Most developers aim for positive NOI, but some—such as affordable-housing projects—do not. Some properties are planned to be tax shelters, so the NOI is planned to be zero. For the most part, though, developers are looking for a positive NOI on their projects.

## What happens when PHIUS+ is added to a market-rate grocery bag?

There is typically a premium for adding PHIUS+ to the plans. Experienced developers can do it for no premium, but first-time PHIUS+ developers report premiums around 5 percent. Adding it into the total land and soft costs, the premium is closer to 3 percent, but 5 percent makes the math easier. To fund it, you need more debt or more investors.

It's difficult to get the extra 5 percent from banks because the appraiser has to recognize the added value. Appraisers do not generally recognize added value for comfort, durability, and healthful indoor environments—yet. At least until the market recognizes the value, you need to find the extra 5 percent through investors. There are other ways beyond investors to defray the passive-house premium. Utility incentives, state energy department incentives, municipal incentives, and grants can all bring in extra cash to offset the premium.

On the revenue side, it's safe to expect higher revenue for a passive building in the form of higher rents, lower vacancies, or both. The allocation is more favorable, too: Utilities will certainly be extremely low. Maintenance will likely be lower, too, but management, taxes, and debt will remain the same. Higher revenue and lower allocation expenses mean a higher NOI, which translates into value when the building is sold or financed or re-financed.

## Developers are calculating risk takers

Developers like proven things that have worked in the past. They want to see a track record, and they look at data. In the end, though, they are risk takers. Breaking ground on a new project is inherently a leap of faith. Bankers and underwriters are not risk takers.

"We depend on a lot of outside capital," said Sloan Ritchie of Cascade Built in Seattle, "because we do not have $50 million laying around, so we have to validate our model with investors, appraisers, lenders, underwriters, executive loan committees—if any one of them does not like the project, we are finished."

This is a major part of Ritchie's process: validating the model to outside people. All of these people are risk averse, whereas a developer's job is to take risks.


**Affordable and profitable.** The 35-unit Pax Futura in Seattle has small individual units (350-sq.-ft. studios), which rent for $1,000 a month each. The rent at Pax Futura is considered affordable because typical rent is twice that in Seattle. An extra $50 per unit per month could translate to $400,000 when it is time to sell the building. It is easier to get the extra $50 if you offer superior IAQ, comfort, and extremely low energy bills.

**A mixed-use experiment that cost less than 5 percent extra.** Seattle's 13th and Pike is a six-story apartment building with 48 units, retail, commercial, and a parking garage. Total hard cost is estimated to be around $12 million, and PHIUS premium of $500,000 is about 4%.

Ritchie presented a business case for PHIUS+ development at the 2017 North American Passive House Conference using a couple of recent projects as examples. Cascade Built is a general contractor and developer that builds for itself and other owners. The examples Ritchie highlighted included an affordable housing complex (previous page) and a mixed-use six-story apartment featuring retail and commercial space (above).

### Lending, debt, and equity investors

Investors may not know much about passive building, but because you may have a lot of face time with them, you can usually get them on board with the program. You'll still need to show track record, data, and projections, because many investors are cautious, but you have more time to educate them and bring them around. Bankers are less easy to convince.

Ritchie's rule for communicating with bankers is "never to say 'passive house,' 'passive building,' or anything like that. They do not know what it is, so—by and large—it is a red flag." Rather, talk about comfort, air-conditioning, exterior shades, quiet, low energy, and futureproof. These things make sense and translate to bankers. You are unlikely to get the question "Have you built a comfortable building before?" Most likely, they're just going to think you're a good marketer with a good project. Investors may think passive house or PHIUS+ is really cool, but the bankers are writing you off as the words come out of your mouth.

### The two markets in commercial development: tenants and buyers

It's hard to estimate and prove how much extra a tenant will pay to rent space in a PHIUS+ building. If they are willing to pay more, will they be better tenants? Will there be less wear and tear? Probably, but you cannot really prove that to a banker. Even for the "affordable" $1,000 apartments, most people are willing to pay $20 extra. Maybe it breaks down to 10 bucks for thermal comfort, 5 bucks for indoor-air quality, four bucks for quiet. Add another buck for a lower carbon footprint.

The buyer really only looks at the NOI—all the income minus the expenses. So if passive house has an economic value, it has to end up in NOI somewhere. You either need more rent or less expenses. Otherwise, there's no economic value to it—in this model. Twenty bucks per month times 35 units times

## LESSONS LEARNED

***Never say 'passive building' to a banker***

"We had a project, and it went to the lender, and everyone said, 'It looks good, we agree with the numbers and the project and the market, so we want to get an appraiser.' The appraisal comes back over the projected value, so it moved to the underwriters, who got tons of data, approved the project, and completed the underwriting. It moved to the last step: the rubber stamp from the executive loan committee.

Someone on the executive committee asked, 'Isn't passive house where there's a rock pit underground for heating and cooling?' My vice president of banking was attending, and he didn't know the answer to that question. All of a sudden, the executive committee thinks there is going to be a rock pit underground to heat the building. They didn't know what passive house was, but that's what they thought it was, so guess what happened to that loan? It did not get rubber-stamped.

That's when we stopped ever saying 'passive house' to bankers."

*—Sloan Ritchie, Cascade Built, Seattle, WA*

**If the banker thinks you're building an earth ship, you are sunk.** Sloan Ritchie, a developer in Seattle, never says the words "passive building" to bankers anymore. Bankers don't know what it is, so it raises questions. Instead he talks about comfort, durability, and energy efficiency.

12 months is $8,400 per year. Dividing by the capital rate (20 times the NOI) gives a value of $170,000 for adding PHIUS+ to the grocery bag.

### Will people stay longer in a PHIUS+ building?

Five percent vacancy is a common rate to use for underwriting. Will tenants stay longer in your passive building? It is reasonable to bet that tenants will stay longer because PHIUS buildings provide a superior environment. Because we don't have data, though, it ends up being a bet. Maybe you can change the vacancy rate to 4 percent. This extra income every year translates to a value. As you move from 5 percent to 3 percent on the 35-model unit pictured earlier; you create $183,000 of value. That $183,000 is pretty similar to the extra $200,000 you paid for passive house upgrades. So maybe the vacancy pays for the whole thing. But you don't know for certain. You cannot prove it to bankers.

Those apartments cost about $1,000 a month. How much more will tenants pay to live in a space with superior IAQ, comfort, and energy consumption? If people in affordable housing, like Pax Futura, will pay an extra $20 per month, tenants in larger and more luxurious accommodations will probably pay an extra $50 per month, so that's an additional $20,000 income per year, which translates to $400,000 in value. So when the building gets sold, someone's going to pay an extra $400k for your $50 bump in rent. Not only does that pay for the PHIUS+ certification, it also pays a nice return to the investor.

Chapter 6

# SIX STEPS TO PHIUS+ CERTIFICATION


## Start early and sweat the details; construction will be smooth

The Department of Energy is now promoting PHIUS+ certification as the highest attainable level of energy efficiency as part of its program suites. PHIUS+ certification has risen exponentially over the past five years, with the affordable multifamily passive-building sector in particular multiplying. As of 2017, PHIUS has certified and precertified more than a million square feet of North American projects.

The PHIUS+ 2015 Passive Building Standards represent a sweet spot where aggressive carbon and energy reduction overlaps with cost-effectiveness. It's all about the bottom line.

There are six main steps in the process, with numbers one and six being the easiest.

### 1 Set the goal, and build your team

If you're not sure right out of the gate that you want to pursue PHIUS+ certification, a feasibility study can show you how close your current design is and what it will take to get to PHIUS+. After deciding on the goal, set up your team.

You'll need a CPHC professional and a Verifier, both certified by PHIUS. It is wise to hire a PHIUS-trained builder, too, but some untrained builders can do it. It's important to get the PHIUS certification staff involved as early as possible. They have seen many of these projects unfold; they know what can go wrong in the field. They can help you sidestep landmines that others may not notice.

Request a PHIUS+ certification fee and project contracts. Depending on the project size, you either need to get a custom fee, or you can use one of the base fees listed on phius.org. Also, each project needs a project contract with the project name and owner.

## 2 Register for certification and create the project in our database

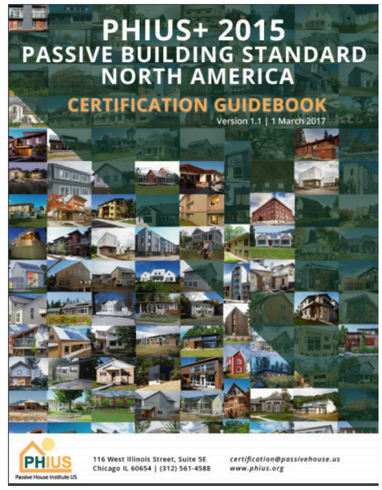
The contract and payment are submitted by the consultant or the project owner. After registration, we send the CPHC professional a login to our database so they can create the project and begin uploading information and documents. Upon precertification, the project will be visible in our project database, so upload a lot of great photos and as many details, notes, comments, and lessons learned as you can. After the project is created in the database, we create a project Dropbox folder for your team to submit documents. This folder is used throughout the certification process: design review, precertification, and on-site quality-assurance/quality-control checklists and documentation.

### LESSONS LEARNED

Collective experience matters because individual experience is limited. The reality is that on a standard build, everyone has done 20 or 30 projects. On a PHIUS project, the experience is not nearly as deep. Everyone may have done one or two projects. Check your ego at the door because you're probably going to be wrong about most things that you would normally do on a project. Hopefully at the end, you'll get something that really works.

Team is a huge part of how to get it done.

*—Sloan Ritchie*




**PHIUS Certification Guidebook.** The comprehensive guide has a section up front to help tailor your certification packet to the particular requirements of the building type, such as commercial, multifamily, or industrial.

## 3 Submit your package

After registering for PHIUS+ certification, you should prepare your PHIUS+ submission package. Submit a set of plans (including elevations, sections, and details) along with a preliminary energy model (built by your CPHC professional). Before creating the model, though, study up on the prescriptive requirements. The design team should pay particular attention to the moisture design guidelines for building assemblies in your specific climate zone.

Look through the quality-assurance/quality-control checklist, too. Although these checklist items are for the rater or verifier at the end of the project, the design team should be aware of them at the beginning. In addition to plans and an energy model, we like to see performance data for windows, a shading study, and performance data for mechanical systems and appliances. The PHIUS+ certification packet lists all the documentation you need to submit.

The CPHC professional will then create the initial energy model using the modeling protocol in the PHIUS+ certification guide. The guide follows the order of the energy-modeling software, so while it is technical, it is also intuitive. This first energy model is like an advanced feasibility study. The team learns where the building stands as designed and what you need to do to get to PHIUS+.

# 4 Earn precertification

With plans and a model ready, the CPHC professional will prepare all other documentation for the first round submission. There are almost always three rounds of design review, with the first round taking the longest.

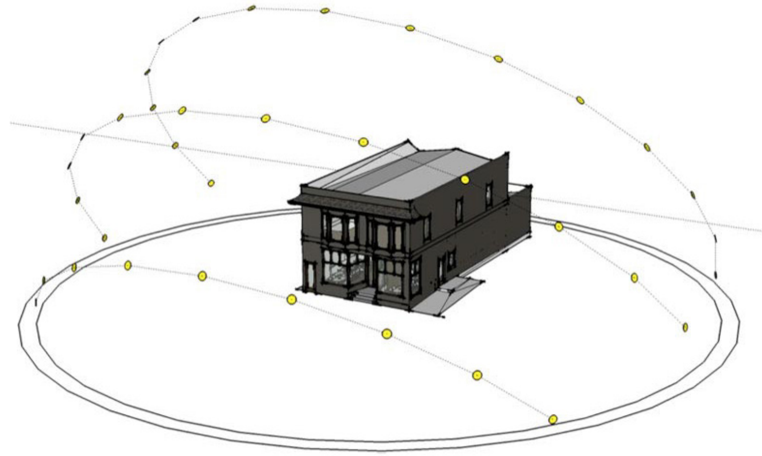
## Round one: 4 to 8 weeks

The more documentation we get, the more we can comment on, and the more accurate your round-two design will be. We will scrutinize every input of the energy model, review all the submitted drawings and specifications, and comment. We'll address areas of concern in the design and thermal-bridging analysis that may be required, and we'll ask for supporting documentation if it's missing. We recommend hiring a verifier early in design phase.

## Round two: 2 to 4 weeks

You may want to sit down before you open the first review—especially if you didn't go over the prescriptive requirements. In the first design review, you will learn what's missing and what concerns us, for example, about moisture, comfort, or other problems.

This is why we recommend that the design team look at the certification guide in detail—or email us with questions as you're modeling—so that you're not surprised by our first round of feedback. Teams that work closely with us during round-one reviews typically get feedback covering smaller-scale items; if the design team does not go through the guide, large-scale issues could push the design out of certification range.



**Sun and shading affect how a building performs.** A shading study is one piece of the package analyzed by PHIUS for precertification.

The CPHC professional works with the design team to incorporate this first round of feedback and then submits a second-round package for review—ideally with all the supporting documentation asked for in round one.

## Round 3: 2 weeks or less

The CPHC professional receives our round-two feedback and adjusts the design and the energy model if needed, and submits a package for round-three feedback, the last submission. Our round-three feedback will have minimal comments.

With everything marked up on the feedback form, the project is approved to move forward, and PHIUS will award the project as PHIUS+ Precertified. Now, we send a precertification letter to the team, and the project becomes publicly visible on phius.org; this is the official hand-off to the building team.


**Choose your windows early in the process.** Complete plan sets including window schedule and specifications are needed to accurately model the building's performance.

## 5 Build and verify: the QA/QC process

At this point, construction documents can be completed, and the baton is passed from the design team to the construction team. As the project breaks ground, you can be confident that you are on the path to meeting the PHIUS+ certification standard.

PHIUS

## 6 PHIUS+ certification

After construction and verification, PHIUS adjusts the project's final energy model to match the results confirmed by the verifier. We then review final documentation and issue a PHIUS+ Certified Passive House Certificate to the CPHC professional and design team. A PHIUS+ Certified project plaque is available for purchase to show your commitment to higher quality construction.

### LESSONS LEARNED

*"As an architect, to suddenly learn that everything I knew was wrong was surprising. You can't unlearn this stuff, and once you're aware of it, everything around you seems negligent."*

*—Sam Rodell*

Rodell does not blame negligence on people who don't know what they don't know, but he notes that it seems negligent that within the design and construction sector of this vast economy that passive-building techniques are so foreign to so many.

Chapter 7

# FREQUENTLY ASKED QUESTIONS

**High-performance construction is not for everybody.** Some builders have had contractors walk off the site when trying to figure out nontraditional insulation details. Many contractors simply don't know what they don't know; other contractors thrive on measured results through the construction process.

## Cost, certification, resilience, and ventilation are top queries

We hope this guide has answered most of your questions, but in case it hasn't, we've assembled a collection of common questions we've received over the years.

Of course, you can find more information at phius.org, at multifamily.phius.org, on the Klingenblog, and listed on the resource page at the end of this guide.

**Q Does it cost more to build to the PHIUS+ standard?**

**A Of course, it does. Quality always costs more.**

For commercial and multifamily construction, expect to pay about 5 percent or 6 percent more if your design and construction team is not experienced in passive building and/or PHIUS certified.

Experienced teams report about 2 percent to 3 percent cost premium over code construction. Depending on the project, you may be able to do it for even less. A 58-bed boarding facility in Spokane, WA, was able to do it for less than code standard by practically eliminating the heating system. With extra-thick insulation and 70 people generating heat every day, not much supplemental heat is needed. Because insulation is cheaper than mechanical equipment, the team was able to come in under the cost of a standard-code building.

Also, as more large-scale window and door manufacturers bring high-performance products to market, economies of scale drive down costs.

## Q Do tight buildings cause mold?

## A No, tight buildings do not cause mold.

Moisture, suitable temperatures, and organic material that mold can eat “cause” mold. Actually, they “allow” mold to live and reproduce. If one or more of those ingredients is not present, then mold won’t grow. Because leaky buildings could dry quickly (with air readily moving between inside and out), moisture was the limiting factor to mold growth in leaky buildings. Because buildings are made from organic material, it is very difficult to limit potential mold food, and because mold is an organism with similar physiological tolerances to humans, temperature will rarely be a limiting factor.

Because tight buildings have less air exchange with the outside, they are often blamed for causing mold. Internal moisture—in the form of humidity—can build up in tight buildings and provide the third ingredient listed above.

Passive buildings have an airtight building envelope and superinsulation, which combine to drastically reduce temperature variations and prevent condensation and mold issues. The constant, low-level ventilation also found in passive buildings further prevents moisture problems while maintaining excellent indoor-air quality.

That said, potential moisture issues must be carefully addressed at the design stage. That's whyit's important to work with a certified passive-house consultant (CPHC). CPHC professionals are trained to accurately model building performance and to identify and address potential moisture issues from the onset.

Tight buildings are good because they use very little energy and they deliver clean indoor air, comfort, and sound control.

## Q Are PHIUS+ buildings resilient?

## A Yes.

One of the best things you can do for a building in an area that's prone to power outages is to build it tight and well-insulated. When the power goes out, a building’s internal temperature should not plummet (or skyrocket) to match the outside conditions.

During the recent wave of hurricanes in Houston, Florida, and Puerto Rico, there were many cases of nursing homes with patients who were suffering—and dying—because without power, the building could not be air-conditioned.

Contrast that with a 58-bed medical facility in Spokane, WA, built to the PHIUS+ 2015 standard, which is completely buffered from power outages. When the building loses power, the temperature remains stable inside. In fact, during winter, the building is often in cooling mode because of the internal heat generation from people and computers.

When the owners of the facility add a PV array, the building will be energy independent and net zero.

## Q What's the difference between passive-house certifications?

## A Plenty.

Only one certification is tailored to the climate that the building is in. We think that's pretty important.

There are a lot of organizations with the words "passive house" in their title. Most of these are loose affiliate organizations, clubs, or groups of like-minded building professionals who want to design and build better buildings. They often want to combat climate change in their daily lives, and they recognize passive-house certification as the most stringent energy standard available. To smooth the learning curve, they form these support groups.

Despite the many "groups" and "networks" sporting the passive-house name, there are only two standard-certifying organizations: Passivhaus Institute (PHI), in Germany, and Passive House Institute US (PHIUS), in North America. Through most of their early existences, the passive-house standard was similar for both, and you could certify a building with either or both—depending on where the building was located or your personal preference.

Around 2012, that began to change, as PHIUS looked to improve the performance of buildings for North America's many climate zones. We learned that designs for Germany's climate don't exactly work in Chicago, Houston, or Las Vegas. To improve building performance in hot, humid, cold, and mixed climates, PHIUS worked with Building Science Corporation (under a grant from the U.S. Department of Energy) to write the Climate Specific Passive Building Standard. This is an actual standard, available for jurisdictions to use as a model for building codes. We also worked with the Fraunhofer Institute of Building Physics to modify their WUFI hygrothermal modeling software into a design and verification tool for passive buildings tailored to tailored to North American climate zones and weather data.

The three-year study yielded a formula that we used to generate cost-optimized performance targets (annual heating demand, annual cooling demand, peak heating load, peak cooling load) for more than 1,000 North American locations. The results are remarkable: Early test cases show that observed energy use is extremely close to the expected energy use predicted by the model.

In the early days of passive house, there were fewer differences between PHIUS and PHI becaus we both used a spreadsheet to predict the energy use. The WUFI passive three-dimensional energy and moisture modeling software has created a large-enough gap in performance that PHIUS+ 2018 will no longer support the PHPP spreadsheet that is central to PHI certification.

PHIUS+ certification is the best, most efficient cost-effective, climate-specific path to a zero-energy building.

## Q Where do I find windows for my project?

## A www.phius.org.

PHIUS has certified window data available for a number of manufacturers, as well as recommendations by climate zone. Visit the PHIUS Certified Data for Windows Program resource page to learn more: www.phius.org/phius-certification-for-buildings-products/phius-verified-window-performance-data-program/find-compare-windows

## Q Can PHIUS scale to commercial?

## A Yes.

Passive house is orders of magnitude more efficient and easier to achieve than single-family residential. OK, maybe not orders of magnitude more efficient, but certainly much more.

Although plenty of single-family homes have been built to passive-house standards, the approach has been applied recently to multifamily apartment buildings and large-scale commercial buildings. The results are spectacular because meeting the energy codes gets easier as the surface-to-volume ratio goes down. Less insulation is needed in large buildings, and because more people occupy commercial and multifamily space than single-family residential, more heat is generated, which can drastically reduce the size of the heating system.

Even though there are a few things in your favor, there is still a learning hump for new designers and builders. Continuous insulation, airtightness, and balanced mechanical ventilation are less common in standard construction and may be challenging to scale up on the first project with a new team.

**Large buildings are a great fit for PHIUS.** Large buildings are easier to make energy efficient, so the cost premium for PHIUS diminishes, too. This apartment building cost about 2 percent more to build than a comparable code building on Long Island, NY.

## Q How long does certification take?

## A Longer than you think, but less if you're experienced.

The length of the certification process varies depending on the specifics of your project. The majority of time is upfront; the better you do at the beginning, the quicker the project goes.

### There are three main steps involved:

Precertification (6 to 8 months): The length of this step depends on the project type, the experience of the project team, and the stage in the process the project team decides to certify, among other factors.

The project team typically receives the first round review four to six weeks after submitting a project for PHIUS+ certification. Now, the team can reply to comments, upload requested documentation, update the energy model, and send back the completed documentation to PHIUS. Most projects require three rounds of review to achieve precertification.

On average, this process takes from six to eight months total, but can vary depending on the project schedule and turnaround time from the project team.

Project construction phase: Duration will vary by project.

Final quality-assurance protocol and on-site verification (~1 month): The PHIUS+ rater/verifier performs onsite quality assurance/quality control (QA/QC) protocols.

The typical PHIUS review turnaround time once final documentation is received is about one month.

## Q Tell me more about the HVAC system, please.

## A OK. It looks more like this: hVac.

The mechanical system is a critical component of all high-performance buildings. Design loads are drastically lower because of continuous insulation, extreme airtightness, and superefficient windows. In simple terms, the "H" and "AC" parts of HVAC are smaller, and the "V" is better, hence hVac.

Balanced ventilation that delivers fresh air and removes stale air from the living space is a primary design focus. Taller buildings have more ventilation challenges because of the stack effect, a pressure created by the buoyancy of warm air. It is also called the chimney effect because it is how chimneys work: Warm air rises and cool air rushes in to replace it. The stack effect becomes a dominant force in buildings over six stories, making heating and cooling tall buildings frustrating and complicated.

Katrin Klingenberg, the executive director of PHIUS, outlined "best" and "second best" systems for these scenarios. "Best-practice ventilation in airtight mid- and high-rise buildings is a dedicated balanced-ventilation system in each unit. This arrangement has many benefits. Best efficiency of the ventilation system (short distribution ducts, small pressure drop due to ductwork), best control of potential point loads, and best control from the user's perspective (increasing airflow when needed or shutting it off when going on vacation). It also delivers the best indoor-air quality."

Ducts are small and easy to maintain and replace if necessary over time. Each unit can be compartmentalized, so there is no stack effect, no cross-contamination of indoor pollutants, and lower fire risk from vertical-distribution penetrations.

Yes, it requires more maintenance and filter cleaning, but in most cases, projects use variable refrigerant flow (VRF) systems, and those air handlers also need filter maintenance on a regular basis.

Klingenberg's second-best practice is placing semi-decentralized balanced-ventilation units on each floor. This arrangement has many of the same benefits, (no stack effect to battle, ducts remain relatively small). They also do not require central air returns or fire dampers, and there is more zonal control than with centralized systems. This setup offers better building ventilation resiliency if one unit fails.

This solution has another benefit for densely populated buildings where cooling loads are high and indoor humidity could be an issue. Centralized dehumidification can be installed from the VRF system after the air has passed through the ventilator.

## Q What risks are associated with passive building?

## A Overdelivering.

Ok, this was kind of a trick question. But the reality is that because quality assurance and quality control are built into the PHIUS+ certification process, and because the 3D energy- and moisture-modeling is so robust, the risk of moisture damage, comfort complaints, high energy bills, or construction cost overruns is minimal. We know how the building will perform before it is built, and we monitor the construction process to make sure that it lives up to expectations and its capabilities.

This is precisely why we worked with Fraunhofer Institute to tailor the WUFI Passive modeling tool to North America's many climate zones and weather data. Based on our experience building a few passive houses outside Germany's climate zone, we understood that if the standard wasn't improved, then comfort complaints, high energy bills, and moisture/mold damage could become synonymous with energy-efficient building and design, and we would not be able to achieve our mission, which is "to make structures that are durable, resilient, comfortable, healthy, and super energy efficient."

So, if you build near passive-house standard or passive-house-inspired, the main risks are moisture problems and comfort complaints. Probably cost overruns and callbacks, too.

Really, the biggest risk in building is not building to PHIUS+, not modeling with WUFI Passive, and not going through the QA/QC-driven certification process. The modeling and the certification, the climate and cost optimization we all developed to make the risk question moot. The risk of passive building is not building to the PHIUS+ standard.

## Q Are there affordable-housing discounts?

## A Yes.

The discount for nonprofit developers and organizations seeking PHIUS certification for buildings is 25 percent off PHIUS's regular certification fee, not to exceed $1,000.


**Affordable housing discount.** Three foreclosed and vacant properties in Southeast DC were retrofitted into a 36-unit mixed income permanent supportive housing (PSH) community. Developed by Housing Up, it is the first multi-family passive building project of its kind in Washington, DC.

# ABOUT PHIUS

## Pushing the envelope of affordable excellence

Passive House Institute US, Inc. (PHIUS) is a non-profit 501(c)(3) organization committed to making high-performance passive building the mainstream market standard.

Our mission is to develop and promote North American passive building standards, practices, and certifications for buildings, professionals, and products to create structures that are durable, resilient, comfortable, healthy, and super energy efficient.

### The early groundwork

PHIUS was initially founded in 2003 as a non-profit community housing development organization that designed and built demonstration passive homes for the affordable housing market. The organization shifted focus in 2007, becoming the leading passive-building standard-setting, research & information provider, and certification institute in North America. PHIUS supports and inspires the growing community of passive building professionals and guides large-scale market transformation in the North American building industry.

In 2008 PHIUS established the Certified Passive House Consultant (CPHC®) credential to distinguish accomplished passive house designers in the marketplace; the certification program for builders and onsite raters was first introduced in 2012. PHIUS is the leading passive building training provider in North America, and since 2003 has trained over 2,000 architects, engineers, energy consultants, energy raters, and builders in the PHIUS+ Passive Building Standard.

### The PHIUS standard is born

PHIUS released the PHIUS+2015 Passive Building Standard in March of 2015, the only passive building standard on the market that is based on climate-specific comfort and performance criteria, and the only passive building standard that requires onsite QA/QC for certification. Developed in cooperation with Building Science Corporation under a US Department of Energy grant, the PHIUS+2015 standard targets the sweet spot between investment and payback to present an affordable solution to achieving the most comfortable and cost-effective building possible and the best path for achieving zero energy and carbon.

### Hard work pays off

Buildings designed and built to this standard perform 60-85% better (depending on climate zone and building type) on an energy consumption basis when compared to a code compliant building (International Energy Conservation Code IECC 2009).

PHIUS+ Certified and Pre-Certified projects now total more than 1 million square feet across 1,200 units nationwide. The cost-optimized PHIUS+2015 Standard is spurring new growth in passive buildings from coast to coast, with the most significant gains coming from the multifamily housing sector.

## Building up steam with respected partners

In addition to the Department of Energy, Building Science Corporation, PHIUS has established strategic relationships with key organizations including RESNET and the Home Innovation Research Labs, among others.

The organization has received funding from the Richard King Mellon Foundation and the John D. and Katherine T. MacArthur Foundation.

Through its Passive House Alliance US (PHAUS) program, a membership-based organization with over 800 members across 18 local chapters and dozens of corporate sponsors, PHIUS is building a robust national network of passive building communities across North America.

## New research initiative launched

Most recently, we've launched the PHIUS High Performance Building Industry Advisory Council, or IAC for short. The IAC is a voluntary board of leading building scientists who set (through consensus) technical standards for project and building-component certification. The council does reaearch, publishes the findings and integrates the results into the PHIUS+ Standard during regular updates.

Learn more about the Passive House Institute US at www.phius.org

# CREDITS

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