A Policy Roadmap
TO CLEAN CARBON CONSTRUCTION
For Nonprofits, Governments and Other Public Policy Professionals
Passive House Institute US
AS CLIMATE CHANGE LOOMS ON THE HORIZON, more and more public policy professionals are looking for ways to slash the carbon footprint of their jurisdictions. Buildings and construction represent a significant slice of the carbon pie, and also a considerable opportunity for improvement.

Fortunately, the construction sector has been cleaning up its act since the 1970s oil embargo. Today there is a possible path to net-zero energy and carbon-neutral construction built on 50 years of science and data. The most significant opportunity is in commercial construction, but single-family homes can add up too—especially the retrofit market.

Toward this effort, the Passive House Institute US (PHIUS) teamed with Building Science Corporation (BSC) and the National Renewable Energy Lab (NREL) under a grant from the U.S. Department of Energy (DOE) to write the first (and only) Climate Based Passive Building Standard, PHIUS+. The first version of the standard appeared in 2015 and was updated with PHIUS+ 2018. One result of this collaboration—and of building a standard based on a foundation of science—is that all PHIUS+ Certified buildings are automatically eligible for the DOE’s Zero Energy Ready Home designation. This built-in eligibility exists because the PHIUS+ Standard was developed to tailor zero-energy construction strategies to the local climate to find the most affordable route to extreme energy efficiency. This cost-optimization approach puts PHIUS+ into the sweet spot between energy-efficient construction and local conditions—including climate, materials, and labor costs.

A happy accident that we discovered over the last 20 years is that passive building and net-zero energy construction is easier to achieve in larger buildings than smaller ones because the surface-to-volume ratio is more favorable. Consequently, multifamily is a huge opportunity, especially in this economy. You’ll see some examples of commercial and multifamily later in the Passive Building Examples section.

The marketplace reflects this reality. Since releasing the PHIUS+ 2015 Standard, PHIUS has certified more than a million square feet across more than 1,200 multifamily housing units. Designers, developers, and builders sometimes find that their first projects can cost a bit more. Still, as the team’s experience grows, it is possible to tunnel through the cost barrier, making PHIUS+ certified buildings no more expensive than standard code buildings.

Many cities, states, and counties are implementing carbon-conscious construction guidelines, so your jurisdiction will not be starting at square one. Toward the end of this guide, we cover some ways to make implementation a little more palatable to your stakeholders and list many resources you can contact for advice/commiseration.

Thank you for working to combat climate change through positive construction improvements.
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Passive Building is Taking Off in the Multifamily Sector

The release of the climate-specific, cost-optimized PHIUS+ Passive Building Standard ignited tremendous growth in passive building from coast to coast, with the most significant gains occurring in multifamily housing. PHIUS+ Certified projects now total more than 1 million square feet across 1,200 units nationwide.

Developers pursuing certification under the PHIUS+ Standard report a cost premium for passive building methods at approximately 0 percent to 3 percent over a standard Energy Star construction baseline. Some developers even report a negative cost premium for passive building since the high-performance enclosure calls for much smaller mechanical equipment, reducing both first costs and operational expenses for the life of the building.

The PHIUS+ Passive Building Standard is the only passive building standard in the world based on climate-specific comfort and performance criteria.

PHIUS+ is an affordable way to assure a durable, resilient, and energy-efficient building wherever it is. PHIUS standards can be applied to buildings of all types so that they use 86 percent less energy for heating and 46 percent less energy for cooling when compared to a code-compliant building (2009 International Energy Conservation Code).

The PHIUS+ Standard doesn’t just exceed the requirements of Energy Star and other U.S. standards and programs; it builds on them. As a result, the DOE is now promoting PHIUS+ project certification as the highest attainable level of energy efficiency.

Certification of the completed building is contingent upon verified performance and existing building energy metrics. Certification, however, is not a crapshoot. The intensive design process identifies weaknesses and opportunities in the building models, which allows designers to dial-in cost and energy savings. Buildings are pre-certified before construction begins, so if the building is constructed as it is designed, buildings are almost certain of PHIUS+ certification.
Developers who are building to the 2009 IECC, are ready to step up to Energy Star 3 and IAQ Plus. If you’re building to Energy Star 3 and IAQ Plus, you’re halfway to Zero Energy Ready Home. If you’re doing ZER Home, you’re close to PHIUS+: a building that is not just comfortable, healthy, durable, and super energy efficient, but also remarkably resilient in the face of natural disasters and climate change. PHIUS+ is a cost-effective path to healthy, comfortable, zero-energy, zero-carbon, buildings because it focuses on local climate patterns and data.

The PHIUS+ certification program requires all projects to be zero energy ready per the guidelines of the DOE Zero Energy Ready Home program (ZERHome). That means a project can go off the grid with a modest onsite renewable energy system. Onsite renewable energy systems can either be incorporated during initial construction or added on at a later date.

Calibrated to move buildings to Net Zero—affordably
The PHIUS+ 2015 Passive Building Standard merges aggressive carbon and energy reduction with cost-effectiveness. It’s all about the bottom line.

In cooperation with Building Science Corporation under a DOE Grant, the PHIUS Technical Committee developed passive building standards that account for the broad range of climate conditions, market conditions, and other variables in North America’s varied climatic and economic zones.

The committee’s three-year study yielded a formula that generates cost-optimized performance targets for more than 1,000 locations in North America and beyond. The resulting Passive Building Standards provide cost-effective paths to net-zero and net-positive buildings. Consequently, PHIUS+ certified projects also earn U.S. DOE Zero Energy Ready status.

The highest level of energy efficiency
The research has since been refined based on U.S. DOE peer review and public comment. The PHIUS Technical Committee will update the formula in three-to-five-year cycles to reflect changing economic, climatic, and other variables. The first update was in 2018. The DOE now promotes PHIUS+ certification as the highest attainable level of energy efficiency within its suite of programs.

The overachievers’ club
Builders can earn additional recognition if their PHIUS+ design achieves either of the following performance goals:
Supply-air heating and cooling sufficient—The plan is supply-air heating and cooling sufficient per WUFI Passive, with an average design ventilation rate of no more than 0.4 ACH. Low peak-loads are the key to this recognition.

Source net zero badge—To meet the Source net zero badge, the building must generate as much energy as it uses on an annual, source-energy basis. Source-energy includes the energy loss at the plant and through the transmission lines. PV panels on the roof are much more efficient than a coal plant 300 miles away.

Buildings in the overachiever’s club are not only an asset to the building’s occupants and owners, they are assets to the planet and their communities because they pump much less carbon into the atmosphere and they illustrate proven construction strategies that other building owners and developers can learn from.

PHIUS+ Certification requirements overview
The PHIUS+ 2015 standard is a performance-based standard with some prescriptive requirements that appear mostly in the design-review phase. It’s essential to take care of these requirements ahead of time because the bulk of the PHIUS+ standard is a performance-based standard.

There are four pass/fail criteria
Each project’s location determines the specific energy targets.

Heating and cooling demand—The project must not require more heating/cooling than specified in the standard for your climate zone.

Heating and cooling peak loads—This varies by climate. The project must be able to meet peak loads without oversizing equipment.

Primary energy demand—This accounts for where the energy originates and therefore depends on the energy source, as well as how efficiently the energy flows to the building. For commercial buildings, energy demand is measured per square foot.

Airtightness—The airtightness target depends on the envelope area, not the volume of the building.
A DIRECT MAP TO CARBON FREEDOM

The Best Path to Zero Energy Is an Aggressive One

The PHIUS+ Standard is a logical outcome of steering construction and design professionals to design and build more energy-efficient and healthful buildings. Early steps in the process raised construction costs because they represented additional items that needed to be “bolted-on” to an existing system of construction. Verification required extra steps, and sourcing materials often took extra time and effort. Energy efficiency, indoor health, durability, and carbon footprint were not baked into the design and construction process. They were afterthoughts to an established process, which, almost by definition, added cost to the project. Sometimes, the add-on efforts caused problems with health or durability. Exterior insulating systems (EIFS) got a bad rap in the Southeast as did structural insulated panels (SIPs) in the northwest. Add misguided and unintended vapor barriers throughout the humid south and mold outbreaks flourished. Many insurance companies vanished, and builders, code officials, and policymakers got jumpy.

Fortunately, those painful lessons learned have crystallized into best practice guidelines and certification systems. Decades of field data offer steps along the path of continual improvement, beginning with aggressive energy code compliance. Add inexpensive solar panels to the steps listed on the next page, and buildings that produce as much energy as they use are affordably achievable almost anywhere.

The key for builders and designers is to begin with the end in mind, rather than to begin with the beginning in mind. The construction process typically sees many change orders, so builders, contractors, designers, and code officials are accustomed to breaking ground with a certain amount of unknown variables on the spec sheets. “Get the building out of the ground as quickly as possible” is often the battle-cry.

As designers and builders move through these steps of continual improvement, though, they’ll notice economies of planning that can improve performance and cut costs from the process. These economies may not have been obvious or available looking at the plan through yesterday’s glasses, but looking through a carbon/health/durability/cost lens, they are as clear as day. As architects, builders, code officials, developers, and engineers become familiar and comfortable with these steps, it is easier for them to swap out yesterday’s glasses for today’s.
STEPS OF CONTINUAL IMPROVEMENT: A Logical Blueprint for Implementing Policy

1 The International Energy Conservation Code (IECC)

The code is an excellent place to begin because, well, it is the law. Even if your jurisdiction hasn’t adopted the 2018 code yet, it is wise to get up to speed with what is coming down the pike—blower doors, energy scores, and continuous exterior insulation.

The ICC added flexibility to the code in the 2015 version with a performance path, making it easier to hit the aggressive targets set in the 2012 version. If a builder can get the required energy score, they pass. The 2018 version raises the performance bar somewhat.

2 DOE’s Zero Energy Ready (ZER) Home program

The Zero Energy Ready Home program is field tested—and not just by boutique builders on the coasts. Since 2008, more than 14,000 ZER Homes have been built by production builders like Mandalay Homes of Prescott, Arizona, Thrive Home Builders of Denver, Colorado, and Palo Duro Homes of Farmington, New Mexico. Zero Energy Ready Homes exceed Energy Star and IECC requirements, while hitting additional health and efficiency targets:

- EPA’s Indoor airPLUS certification assures clean, breathable air
- All major appliances must be Energy Star
- Efficient duct and hot water distribution design reduces energy losses as air and water are moved from point A to point B.

3 Energy Star 3 and 3.1

Energy Star is a significant next step for builders and designers because it drives home the importance of airtightness, thermal bridges, and HVAC design to a building’s overall energy use. If net-zero is the goal, then it is critical to understand how these variables work together. Even before cheap solar, this is the low-hanging fruit.

Energy Star certification is based on climate zones because each place faces different challenges and opportunities. Energy Star 3 is based on the 2009 IECC, and Energy Star 3.1 can help building professionals make choices to deliver value and savings in light of the steeper 2012 IECC.

4 PHIUS+ Certification

The steps on this list could represent additional costly items and processes bolted on to the construction process, but when aiming for excellence it makes sense, to begin with excellence in mind. PHIUS+ Certification uses 3D energy and moisture modeling software to tailor each building to its climate zone and site conditions. That’s how PHIUS+ delivers buildings that perform as promised, as affordably as possible.

For precisely this reason, the best way to get to zero energy is through PHIUS+ Certification. PHIUS+ comes from the same building science that guided the IECC, Energy Star, and the ZER Homes program be-
The value scales up nicely

Single-family home builders can find economies of scale as the team gains experience. In multifamily, the savings can compound even faster. A 58-bed long-term health facility in eastern Washington cost about $120,000 less to build than a comparable built-to-code building because the design team was experienced.

“Return on investment’ presumes an initial investment,” said Sam Rodell, the architect on the project. “Because there was no additional investment beyond what was in the budget, the ROI is either spectacular or irrelevant—depending on how you think about it.”

When passive building principles are applied to buildings—houses, apartments, offices, and skyscrapers—you get predictable performance, unmatched comfort, superb air quality, and resiliency in the face of climate change and power outages. And all of it is a simple slight improvement on what we did yesterday.

Modeling on a computer is better than designing on a hunch.

WUFI Passive is the most potent energy and moisture modeling tool available. Developed by Fraunhofer Institute for Building Physics in collaboration with PHIUS and Owens Corning, WUFI Passive is a user-friendly software uniquely suited to North America’s varying climate zones.
The Cost of Passive Building Depends on the Team

One of the first questions we get after, “What is passive building?” is “Does it cost more?” the short answer is, “Of course, it does. Quality always costs more.”

The longer answer is more nuanced. For commercial and multifamily construction, expect to pay about 5 percent more if your design and construction teams are 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. Sunshine Health Facility, the 58-bed facility in Spokane, Washington, that was mentioned earlier, built for less than standard code construction by practically eliminating the heating system. With extra-thick insulation and 70 people generating heat every day, not much supplemental heat was needed. Because the insulation was cheaper than mechanical equipment, the team was able to come in under the cost of a standard-code building.

As more large-scale window and door manufacturers bring high-performance products to market, economies of scale will further drive down costs. But windows and doors are not the only items in the passive-building grocery bag, so to speak.

The cost question is nuanced 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 extra insulation 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.

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 premi-
ums around 5 percent. To fund it, a developer needs to borrow more or find more investors. It’s challenging to get the extra 5 percent from banks because the appraiser has to recognize the added value. Appraisers do not generally recognize the added value for comfort, durability, and healthful indoor environments—yet. Builders can help things along by encouraging the bank to select the right appraiser. Still, until the market recognizes the value, developers need to find the extra 5 percent through investors, utility incentives, state energy department incentives, municipal incentives, and/or grants. The cost premium for superior construction is an area where policy professionals can shoulder some burden. The extra 5 percent is a pain-point that can be soothed with incentives or policy. We don’t need to finance 100 percent of a project to promote net-zero. Perhaps just financing the premium is all that’s necessary to tip the scales.

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 undoubtedly be extremely low. Maintenance costs will be lower, too, but management, taxes, and debt will remain the same. Higher revenue and lower allocation expenses mean a higher net operating income (NOI), which translates into value when selling the building. The chief financial challenge is the upfront premium for adding PHIUS+ Certification, which can vary between 0 percent and up to 5 percent.

**Better buildings are not just for rich people**

All of this discussion of cost has focused on up-front costs. “How much EXTRA will it cost to do it the right way?” is not the best question. It seems like asking, “Yeah, but how much is it going to cost to plant this money tree? How much will it cost to pick all of that money?” The better question to ask is, “How much will it cost to build and operate over its lifetime?”

One of the main benefits of zero-energy construction is that the building produces as much energy as it uses, often more. Looking past first-cost questions makes it clear that zero-energy and PHIUS+ Certification make a ton of sense for affordable and low-income housing, health care facilities, and other buildings that house vulnerable people. And because the cost of energy generally trends upward, dollars spent today on reducing tomorrow’s energy use will grow in value. Not only will the building have zero energy bills, but the value of the money not spent increases over time. It is like a guaranteed return on investment.

Sunshine Health, in Spokane, illustrates many essential aspects of PHIUS+ Certified construction. Outside agencies primarily establish the facility’s budget, so profit margins are incredibly narrow. The design needed to be as economical as possible—both initial construction and operating costs over time. Costs were not the only concern, however. “The company is very mission-driven,” explained Rodell. “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 PHIUS+. Rodell didn’t oversell it initially, to manage expectations. 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 of construction and daily operations, the analysis accounted for inflation, interest rates, and rate of change in the price of energy over time (in Spokane, it is about +2 percent 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 explains. The predicted savings were in the six-figure range. The project has delivered more than promised.

After getting so much building for their construction budget, and after experiencing the comfort of their new facility’s environment and paying so little in utility bills for it, when it came time to build a new administration building, there was never a question as to how they’d design it: PHIUS+.

‘Return On Investment’ implies an upfront investment, but...

Passive house construction added costs to the building envelope, in the form of thicker walls, better windows, and meticulous detailing. Still, it lowered other costs moving forward—particularly with things like fire-walls. Despite the trade-offs, the finished price of the project was lower than a comparable built-to-code building would be because once the building envelope was complete, the remainder of the project went faster than usual due to simplified interior mechanical systems, ductwork, and fire dampers among construction elements.

Architects and designers considering this kind of construction often focus on return on investment, or payback time. But ROI presumes an initial investment. As we have outlined, the ROI can be either spectacular or irrelevant. Either way, it adds up to value for the people. “This particular company is not a nonprofit, but they act like it,” Rodell said. “So, that wash of funding has allowed them to improve the services they offer their residents.”

Ribbon-cutting day for 36 families. Weinberg Commons, developed by Housing Up, provides housing for low-income and formerly homeless families in the Washington, D.C., area. This housing retrofit uses 75 percent less energy than comparable buildings—a boon to the tenants.
HOW PUBLIC POLICY PROFESSIONALS CAN MAKE NET-ZERO CONSTRUCTION COST-EFFECTIVE

It Is Cheaper to Save Energy Than to Make It

The most direct path to zero-energy buildings is a conservation path. Without substantial conservation, you’ll need to invest in off-site renewables to get to energy and carbon neutrality. The buildings detailed in this booklet were able to get to net zero with site-supplied renewable energy because they invested financially and intellectually in conservation first. Conservation is cheaper than photovoltaic panels, so it is the best place to put the first dollars.

When it comes to implementing a new energy policy, you’re likely to lose some friends. Many business models are built on the old way of doing things, so new requirements almost always spell C-O-S-T to constituents. How can you make everyone happy?

Give out free puppies. Short of that, try to find ways to incorporate carbon-cutting improvements into the existing framework of their business models. Or, give them money (next best thing to puppies).

The city of Vancouver mandated heat pumps for all new construction and included incentives in the mandate totaling $50 million. If energy- and carbon-zero buildings will save a municipality or utility company money over time, then look for a way to put that cash on the table early, so you can help pay for the improvements up front. The good news is that we can tunnel through the cost barrier if we focus on the milestones to net-zero energy buildings.

To go beyond heating system mandates to a dedicated conservation approach, tie the funding/incentives to steps along the path of continual improvement by using existing building science infrastructure like the EPA's Energy Star program, the DOE's Building America program, RESNET raters, and its associated HERS scale (called the Energy Rating Index in the IECC). When states and municipalities implement stretch codes, they use these resources because they are scientifically sound, have a substantial public policy foundation, and are familiar to many building, design, and code professionals.

“This passive house design business ... there are all these terrific explanations of what it is and how it works, but you know what it really means to these families? It means they will pay almost nothing for utilities! That is what it means to these people!”

—D.C. Mayor Vincent Gray

Another critical step in implementing a program may simply be to point out that there is a profit opportunity. It doesn't have to cost more to build better buildings, and, according to at least a couple of studies, energy-efficient houses have lower mortgage-default rates and higher occupant satisfaction. A study by the University of North Carolina at Chapel Hill’s Center for Community Capital and the Institute for Market Transformation (IMT) found that, "The odds of mortgage default on an Energy Star residence are one-third lower than those of a home in the control group." This value proposition is true across the pond, too. A recent study by the European Commission's Joint Research Centre (JRC) shows energy-efficient buildings have higher appraisal values and lower default rates.

If the tenants are more likely to stay, then the typical vacancy rate in a multifamily building may drop from 5 percent to 3 percent, which can add hundreds of thousands of dollars to the annual operating income. Anecdotally, some developers report lower vacancy rates and higher rents in PHIUS+ Certified multifam-
RESNET created the HERS Index as an easy-to-use tool for comparing the energy performance of homes. It’s akin to the EPA’s miles-per-gallon rating on automobiles. The HERS Index is also used in the IECC, where it is called the Energy Rating Index. RESNET trains and certifies Home Energy Raters, who can verify Energy Star, LEED, Zero Energy Ready Homes, and other energy performance programs. Because these raters are already working within the structure of science-based energy-efficient construction and are familiar with zero-energy practices, they are well-equipped to lighten the load of local building officials charged with verifying these new targets. RESNET raters are uniquely qualified to become PHIUS+ raters and verifiers for residential and commercial buildings, respectively.

One main reason all of these programs and philosophies come together so neatly is because they are all based on tailoring energy use and conservation strategies to North America’s many climate zones. Building codes vary based on the climate zone within which the construction takes place. Energy Star targets and methods differ depending on where the building is located, too. There is a good reason for this. The work that a building must do to overcome outdoor exposure in west Texas (hot and dry) is different from the work required in Miami (hot and humid), Maine (very cold), or California (paradise).

Energy Star’s Portfolio Manager is an online tool that allows building owners to track and benchmark the buildings in your jurisdiction. So, strategies vary for getting buildings to net-zero energy depending on where the building is located. It makes sense, then, to base policy, incentives, and design strategies on this enormous foundation of science, data, and measured performance. Lucky for you, PHIUS is here to help.
Illinois Clean Energy Community Foundation (ICECF) is a nonprofit foundation whose Net Zero Energy Building Grant Program encourages “Outcomes-Based Building Performance” by issuing condition-based funding. If a building doesn’t perform as promised, the final 40 percent of the grant is withheld. To be eligible, buildings must secure a PHIUS+ or Living Building Challenge Certification. ICECF’s Gabriella Martin notes the importance of the PHIUS+ feasibility study. “The feasibility study is valuable to the whole team, not just the design professionals,” she says. “Many of the team are not accustomed to thinking conservation-first, so considering the larger process is more eye-opening. For a reasonable fee, the team has access to the deep knowledge of the PHIUS staff in designing a zero-energy building. This is an incredibly valuable asset worth taking advantage of.”

Martin offers these three tips on setting up a community grant program:

**Keep it simple.** Align the application process with what is actually happening at different points of the project, especially during design. Usually, the more money you give out, the more documentation you require, so ICECF aligned the application process with critical design milestones: 1) predesign, 2) schematic design, and 3) design development. They tried to reduce the information needed from the design team and align that information with the process.

**Reward results.** Build the program to focus on the building’s actual performance, not just what’s modeled up-front. The goal of the foundation is to reward buildings that do what they say they’ll do. The only way to do that is to measure the building’s energy use. ICECF requires energy data after occupancy, but they are flexible in how granular the data are; some of their grantees are more sophisticated in their ability to isolate particular loads.

**Align funding to the construction schedule.** ICECF looks at the incremental costs of building net-zero and matches funding to that. Once awarded a grant, project reporting and payment requests are combined to align with construction and operating milestones: 1) start of construction, 2) occupancy, and 3) 12-month building performance monitoring. For example, up to 30 percent of the grant is awarded at the start of construction, which helps defray the cost of a PHIUS+ feasibility study and the up-front 3 percent to 5 percent premium typically associated with net-zero construction.

Because it is difficult to include the premium on a mortgage loan, funding grants like this may be the nudge that design teams need to leap to net-zero construction.

The Prairie Activity and Recreation center in Plainfield, Illinois is a beneficiary of the ICECF’s Net-Zero program. It is the first rec center in the U.S. built to the passive building standard and it is earning PHIUS+ Net-Zero status to boot.
Beach Green Dunes is a sustainable and resilient housing development with 228 affordable units in two buildings. Located a block from the Atlantic Ocean, the PHIUS+ development distinguishes itself with splashes of color, ground-floor fenestration, green spaces, and interior amenities.

The complex provides much needed affordable housing to the area. Advanced sustainable components at Beach Green Dunes include a progressive building envelope and HVAC systems to provide unprecedented levels of comfort and air quality. The innovations of the core structure are augmented by a series of environmental design considerations such as a bioswale garden to treat and retain stormwater, solar photovoltaics on the roof, and a geothermal heating/cooling system underground.

The project incorporates many innovative features to achieve record-breaking low energy and water consumption levels:

- Insulated concrete forms provide continuous insulation and airsealing.
- Energy recovery ventilation swaps fresh air for stale air, exchanging heat in the process.
- Central air-source heat pumps provide heating and cooling.
- A large rooftop photovoltaic system produces clean electricity.
- A natural gas-fired cogeneration system produces electricity, hot water, and is a back-up emergency generator.
- Bioswales, hydric-habitat plantings, and permeable asphalt paving will retain stormwater on-site and in the surrounding area.

The buildings are designed to not only provide greater comfort, but also an enhanced level of resilience in the event that a catastrophic storm such as Hurricane Sandy hits the peninsula again.
MCKEESPORT YMCA: Single-Occupant Residency Retrofit, McKeesport, Pennsylvania

This project was the first large-scale retrofit to be designed to meet Passive House Standards in the United States. McKeesport Downtown Housing is an 84-unit single-resident occupancy facility for people at risk of homelessness. A cold-weather shelter, 60-day emergency housing, bridge housing, and Section 8 apartment rentals make up the housing programs within the shelter. Formerly a YMCA, the old brick and terracotta building was important historically for McKeesport, so the decision was made to keep the facade, and upgrade the interior.

Another decision, to design the project to Passive House criteria, went a long way toward making the pro forma work for this project. The renovation includes new lighting, air-conditioning, make-up air and ventilation systems, an elevator, and cooking facilities. Facility managers could accurately predict and budget for operations costs because they were designed to be stable, as well as low. Space was at a premium because the project was restricted to the building’s original footprint. The space within those walls, however, was relatively open, and the design team was able to reorganize that space, allowing larger resident rooms than previously existed.

Through a community process with various stakeholders, designers prioritized and added to amenities. They include a community room, a bike storage area, exterior smoking balconies, single-user restrooms, a bed bug room for non-toxic treatment of bed bugs, and communal kitchens to provide healthy options for food.

“Loving care and attention to detail are present everywhere in this very tight-budgeted solution. It is an excellent example of creating a sustainable option for those who might need it the most.”
—Jury, AIA Pittsburgh, Award of Excellence in Sustainable Design, October 2015
THE ROCKY MOUNTAIN INSTITUTE’S INNOVATION CENTER: Office Space, Bassalt, Colorado

The Rocky Mountain Institute’s Innovation Center is the most efficient building of any cold climate (so far).

The Innovation Center, which accommodates 50 staff and has room for 80 people in the convening space, is an overachiever. It goes beyond net-zero energy use to usually produce more energy than it consumes—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 credentials.

This extreme efficiency—it uses 74 percent less energy than the average office building in this climate—make RMI’s Innovation Center the most energy-efficient building in the coldest climate zone in North America. It does not get there by asking people to wear sweaters, either. The aggressive design meant that the team could eliminate mechanical cooling (which may...
not seem like a big deal in such a cold climate) and drastically reduce the mechanical heating system to a small, distributed system equivalent to that found in an average-size home—even though the building is six times larger than the average home. Eliminating the heating system in such a large building nestled in the Rocky Mountains is indeed a big deal.

Beyond the multiple PHIUS+ Certifications, the RMI Innovation Center meets the Architecture-2030 goal of a 70 percent energy reduction even without the 83 kW solar-electric system. The PV system will produce around 117,000 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, which keeps the building in the small-commercial electricity rate class.

The Innovation Center is of similar size to 90 percent of U.S. commercial offices. Over half of all commercial buildings are owner-occupied with office space being the most significant use type. In this way, the Innovation Center achieves the institute’s goal of being a “living lab” to share how the building was contracted, designed, constructed, commissioned, and operated. The proof is in the pudding, so to speak.

Lessons learned
Net-zero energy construction on a commercial scale is cost-effective and easy to achieve if you do the planning. Commissioning and monitoring comfort and IAQ systems is 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.

Secondly, although automation can take a lot of responsibility away from the people in the building, tenant engagement and education is still required to meet net-zero energy goals. If people do not understand how the building works, they can sabotage efficiency. Integrated project delivery is useful to help manage cost, contracts, and risk.
PASSIVE BUILDING EXAMPLES

ORCHARDS AT ORENCO: Affordable Housing Development, Hillsborough, Oregon

With the goal of providing a more comprehensive model of affordable living, REACH Community Development Corporation secured a 6.2-acre piece of land in Hillsboro, Oregon, and planned the construction of approximately 150 units over three phases. Phase I was constructed to PHIUS+ standards. The triple strategy included 1) securing a transit-oriented design site in the Orenco Station neighborhood; 2) building a project affordable to those earning incomes less than $30,000 per year, and 3) developing an energy-efficient building built to PHIUS+.

Orchards at Oreno Phase I was completed in June 2015 and is the most extensive PHIUS+ Certified multifamily passive building in North America.
The development contains 57 units of housing, including 40 one- and 17 two-bedroom apartments. The building uses about 90 percent less energy for heating and about 65 percent less energy overall than a typical structure of the same type and size in the Pacific Northwest region. REACH installed an energy monitoring system designed to track and improve the tenants’ energy use habits.

Orchards at Orenco’s outstanding transit-oriented location on the MAX light-rail line provides easy access to multiple community amenities, including hospitals, airports, large area employers (Intel, Kaiser), restaurants, shopping, parks, and schools. Orenco Station is nationally recognized as a model of New Urbanism.

**Personal Experience**

REACH benefits from great press coverage of this project, and from meeting its commitment to residents to create an affordable environment in a beautifully designed building that’s in an amenity-rich neighborhood. The residents benefit from the energy savings of living in a passive house building. The savings for residents on electric bills alone is estimated at $30 to $45 per month per unit, which, for a low-income resident, is the equivalent of a 1-2 percent increase in their annual income. Also, residents have expressed that they feel better living at Orchards at Orenco and feel that their health outcomes will improve based on indoor air quality and other attributes of the building.

Mike Steffen of Walsh Construction Co. said, “It’s uncommon for market-rate apartments to have fresh air ducted to each apartment; it’s even less common in affordable housing projects. So, in addition to living in apartments with very low heating and cooling bills, Orchards residents also will have excellent air quality.”

**No lot is perfect.** The corner location and community covenants limited what could be done on Phase 1 of the project. Despite the difficulties, Orchards at Orenco hit all of its community-centered targets: affordability, access to transit, and climate responsibility.

**Wood is good.** Common spaces respond to urban design cues such as the light rail and incorporate wood from trees removed from the original orchard.
VALLEY WASTE RESOURCE MANAGEMENT FACILITY: Office Space, Kentville, Nova Scotia

This project leads the way in demonstrating super-insulation, high efficiency mechanical and lighting systems, and low water consumption, while highlighting salvaged and recycled materials. Not only is it certified LEED Silver and the most energy-efficient office building in Canada, but it is also the first PHIUS+ commercial building in Canada. The vision of the Valley Waste Resource Management Facility (VWRM) has had a profound influence on the development of the design, which will benefit the Valley community for years to come.

The result is a project that substantially raises the bar for environmentally sensitive and energy-efficient architecture in the Atlantic Region. Valley Waste Resource Management Authority, a leader in the Atlantic Provinces in promoting sustainable waste management, asked Solterre to design a building that reflected their commitment to reduction, reuse, and recycling, especially in the construction waste field. VWRM’s Offices is Solterre’s first project to combine their commercial LEED consulting experience and the green architecture practice into a truly integrated design team.

All users of the building were included in the design process, called integrated design. This particular integrated design process was extensive and identified three green building priorities:

**Occupant health and well-being**

The building should do more than “not make people sick.” The building should promote health, comfort, and prosperity. Beyond the stringent IAQ strategies, the team provided abundant daylight and views, through operable windows, with climate control and fresh air ventilation. The result is a building that offers a high-quality work environment for the VWRM team.

**Building energy efficiency**

Even though waste is VWRM’s business, the best waste management strategy is not to produce waste in the first place. The goal, therefore, was not just to keep energy costs low, but to illustrate leadership in not being wasteful.

Due to its superinsulated building envelope and high efficiency mechanical and lighting design, this building uses 70-90 percent less energy than a conventionally constructed building while increasing occupant comfort.
Progressive material and resource management
Intelligent waste management extends to the building materials, as construction debris accounts for a large percentage of the waste that VWRM manages.

The team used recycled and salvaged materials wherever possible and worked consciously to divert construction waste from the landfill.

Lessons learned
Iterative energy modeling is crucial in the early design stages.

Keep it simple. Use passive measures before active, THEN use simple systems.

Keep it simpler. Even though they had a simple mechanical system, it took significant effort to get the thermal and ventilation building controls to work correctly.

Keep it even simpler. Make it hard for the contractor to mess up the envelope. They placed the air barrier on the outside of the stud cavity, reducing the chance of electrical and plumbing penetrations during construction, as well as accidental compromise of envelope integrity due to routine uses such as hanging artwork on the walls.

Mock-ups were part of the contractual requirements for crucial envelope details. The mock-ups ensured the contractor knew what to do before installing windows and proper air barrier sealing. Mock it up, review it, build it, review it.

A pre-drywall blower door test is the best opportunity to find air barrier issues. Blower door testing was the contractor’s responsibility, as was achieving the PHIUS+ air-changes per hour threshold. The owner paid for the first test, and the contractor was responsible for re-testing if required.

The site superintendent was very keen about the success of PH targets, and willing to put in extra effort—not always the case in design-bid-build projects.

Temporary heating. The contractor’s heating bill for winter construction dropped by about 90 percent after the envelope was insulated and airtight—a big bonus for them.

Some people don’t like to tinker. Users can tend to “set it and forget it.” For example: Designing for natural ventilation and night-time cooling requires users to be aware of when and how to take advantage of opportunities, and then act on them. Without clear responsibility for such tasks, energy-saving opportunities can be missed.

Thermostats set to “auto” when a seasonal change-over between heating and cooling modes would likely be beneficial.

PROJECT SPECS

LOCATION: Kentville, Nova Scotia
FLOOR AREA: 6,705 sq.ft.
ARCHITECTURE: Keith Robertson, David Gallagher, Jennifer Corson, Mark Pennel, Jordan Willett, Matt Parks | Solterre Design
BUILDER: Roscoe Construction
LEAD CPHC: Natalie Leonard
QA/QC RATER: Jordan MacDonald
LEED CONSULTANTS: Keith Robertson, Jordan Willett, Ian Anning | Solterre Design
ENERGY CONSULTANT: Natalie Leonard | Passive House E Design
MECHANICAL: Tom Watson | CBCL

Occupant-centered design. Abundant daylighting, thermal and acoustic comfort, and indoor-air quality top the list. Another goal was leadership in resource management, such as with recycled glass-aggregate polished-concrete floor.
PHIUS+ SPECIFIC INCENTIVE PROGRAMS

California Low-Income Housing Tax Credit Programs: California | New construction, adaptive reuse, or rehabilitation | Low Income Housing Tax Credits for projects that achieve NGBS at a Silver and LEED, Passive House, Living Building Challenge or the GreenPoint Rated Program. https://www.treasurer.ca.gov/ctac/tax.asp

Connecticut Housing Finance Authority: Connecticut | Affordable Housing-Multifamily | Low Income Housing Tax Credits (LIHTC): Offering tax credits for affordable housing developments built to Passive House Standards https://www.chfa.org/developers/tax-credit-program/

Deep Green Incentive Program (DGIP): Shoreline, Washington | By meeting PHIUS+ or PHUS+ Source Zero, projects can qualify for exemptions or waivers on permit fees, transportation impact fees, certain development codes and expedited permit review. http://www.shorelinewa.gov/Home>ShowDocument?id=31411


Housing Trust Fund Program: Washington | Residential-Multifamily | Applications considered for projects that implement ultra high-energy efficient elements designed to reach net-zero or PHIUS+ Standards https://www.commerce.wa.gov/news-releases/community-grants/housing-trust-fund-program-soliciting-applications-for-affordable-housing-projects/


Mass Save: Massachusetts | Multifamily-4 stories or higher | Incentives for projects pursuing PHIUS+ certification and agree to monitor and provide whole-building energy use and on-site generation. https://www.masssave.com/en/saving/residential-rebates/passive-house-incentives/


NYSERDA: New York | Mid and High-Rise Multifamily New Construction or gut rehab | Incentives and higher funding caps for buildings meeting Energy Star and PHIUS+. https://www.nysrda.ny.gov/All-Programs/Programs/Low-Rise-Residential/Mid-and-High-Rise-Multifamily-buildings


Rhode Island Residential New Construction (RNC) Program: Rhode Island | Residential-Single/Multifamily | Incentives and rebates for high-efficiency mechanical equipment and certifications such as PHIUS+, ZERH, LEED, and Living Building Challenge https://www.nationalgrids.com/media/pdfs/resi-ways-to-save/ee6174_ri_newconsprogram.pdf

Virginia Low-Income Housing Tax Credit (LIHTC) program: Virginia | Multifamily | Points awarded to developers who are certified for Passive House or Zero Energy Ready Homes (ZERH) from the U.S. Department of Energy. https://www.vhda.com/BusinessPartners/MFDevelopers/LIHTCProgram/Pages/LIHTCProgram.aspx#Xan9WC_MwI1

OTHER INCENTIVE PROGRAMS

ComEd Affordable Housing New Construction Program: Northern Illinois | Multi-Family Housing | Requires a bundle of measures that mirror PHIUS requirements. Units must be affordable to people within 80% of median income. https://www.comed.com/ForYourBusiness/Pages/FactSheets/Affordable-HousingNewConstructionOverview.aspx

Efficient New Home Construction: Minnesota | Residential | Designed to be at least 10% better than energy code (requires a HERS rater). Incentives increase up to $2000 for homes 35% more efficient than code. Additional small incentives for all electric homes. https://xcelenergy.com/programs_and_rebates/residential_programs_andrebates/home_energy_efficiency/efficient_new_home_construction


RESOURCES

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