Metal Architecture

FEATURES (HTTPS://WWW.METALARCHITECTURE.COM/ARTICLES/FEATURES)

Designing for Passive House

A cost-effective approach to energy efficiency, comfort is key to passive design strategies

By Marcy Marro
Editor

Posted October 01, 2020

The Modern Lakefront Residence, designed by Passive Design Solutions. Photo: Elemental Photography

When it comes to sustainable building, there are a variety of different certifications and programs a building can be certified through to show how health-conscious it is. While most people are familiar with LEED, the Living Building Challenge and the WELL Building Standard, Passive House is still making headway in the North American market.

Design Principles and Certification

According to the Passive House Institute US Inc. (https://www.phius.org/home-page) (PHIUS), passive building comprises a set of design principles used to attain a quantifiable and rigorous level of energy efficiency within a specific quantifiable comfort level. There are five building science principles that are the basis for passive house design:

- Employs continuous insulation throughout its entire envelope without any thermal bridging.
- The building envelope is extremely airtight, preventing infiltration of outside air and loss of conditioned air.
- Employs high-performance windows (double- or triple-paned windows depending on climate and building type) and doors—solar gain is managed to exploit the sun's energy for heating purposes in the heating season and to minimize overheating during the cooling season.
- Uses some form of balanced heat- and moisture-recovery ventilation.
- Uses a minimal space conditioning system.

Maintained by PHIUS, the PHIUS+ Certification program (https://www.phius.org/phius-certification-for-buildings-products) is North America's leading passive building certification program. It combines a thorough passive house design verification

protocol with a stringent quality assurance/quality control (QA/ QC) program that is performed on-site by highly skilled and specialized PHIUS+ Raters and Verifiers.

Benefits include: PHIUS+ climate-specific and cost-optimized performance metrics; comprehensive design and energy model review; rigorous quality assurance; earn U.S. DOE Zero Energy Ready Home Status; earn U.S. EPA Indoor airPLUS label; RESNET HERS Index Score; and listing on the PHIUS+ certified projects database.

To learn more about Passive House, visit:

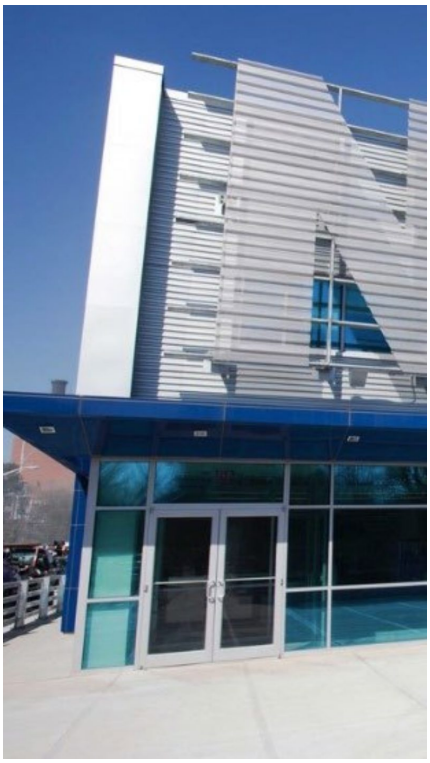
Passive House Institute US Inc. (PHIUS): phius.org/home-page (https://www.phius.org/home-page)

International Passive House Association (iPHA): passivehouse-international.org (https://passivehouse-international.org/)

Passive House Institute (PHI): passivehouse.com (https://passivehouse.com/)

North American Passive House Network (NAPHN): naphnetwork.org (https://naphnetwork.org/)

Buildings that meet PHIUS+ use 40 to 60% less energy for space conditioning than conventional buildings. PHIUS+ buildings have superior indoor air quality, resilience during power outages, and an extremely quiet, comfortable indoor environment. To date, PHIUS has certified or pre-certified 4.2 million square feet of projects, including 100 multifamily projects totaling more than 2.7 million square feet. Projects have been pre-certified or certified in 37 states and provinces in North America. Additionally, passive design building principles and the PHIUS+ standard has been used to achieve net zero buildings.



Designed by Spacesmith, the LEED Gold-certified NYPD Brooklyn North Tow Operations sets a precedence for operations facilities.

The use of passive design strategies is not limited to residential properties, and can include multifamily buildings, office buildings, schools, retail, even skyscrapers. By making efficient use of the sun and heat recovery, buildings keep comfortable temperatures year-round, without the use of conventional heating systems. Passive cooling techniques, such as strategic shading and high-quality insulation, are key to promoting occupant comfort.

Through the proper orientation of a building on a site, and optimizing the amount, type and location of openings, Tim Keil, RA, principal at Phoenix-based Studio Ma (https://studioma.com/), explains, "The goal is to create a building that is comfortable and energy efficient just sitting there, and to connect the occupant to the natural climate outside. The architect should design the building to take advantage of diurnal temperature changes and convective currents to combine energy efficiency with the occupants' comfort and enjoyment of the naturally occurring climate."

TAT designed Moran Square in Fitchburg, Mass., which combines three individual sites—a firehouse, empty lot and furniture store—into one building consisting of 44 affordable residential units, 25 structured parking space, and approximately 8,000 square feet of commercial office space. Photo courtesy of The Architectural Team.

Increased Interest

An increase of interest in environmental issues such as climate change is leading to an increase in interest for passive design strategies. Natalie Leonard is an engineer and a Certified Passive House Consultant and Certified Passive House Builder. President of Passive Design Solutions, (https://www.passivedesign.ca/) Halifax, Nova Scotia, Canada, she notes that with the current state of the industry in the midst of the COVID-19 pandemic, where people are stuck in their homes for longer periods of time, there is interest in making homes

better. People have extra time on their hands to research and plan, and Leonard notes that the home renovation and building industry is expected to be busy for the next few years in general. Passive design makes for more comfortable and enjoyable spaces, so the current conditions are generating more interest in energy-efficient residential design.

"People are realizing that their home is one area where they can make a significant contribution to the fight against climate change," she says. "There is also a large cohort of baby boomers looking to retire and downsize, who are realizing that volatile energy prices can be an uncertain part of financial planning in retirement, and so getting a house that has tiny energy bills makes for more predictable monthly costs."

Similar to driverless technology or electric vehicles, Victor Body-Lawson, AIA, principal, Body Lawson Associates Architects & Planners (http://www.blarch.com/), New York City, notes that passive design has become a mainstream approach for architecture, including metal architecture today. "Climate change is the big driver," he says, "as are recent changes to building codes where the authorities having jurisdiction are asking for net zero energy—or near net zero—building operations by 2030."

In Phoenix, where Keil is located, people tend to expect air conditioning with the extreme heat. "What we try to communicate to clients is that the extreme temperatures make it all the more important to employ passive design, in order to reduce equipment sizes and minimize energy costs."

When it comes to affordable housing projects, Nate Thomas, project manager, The Architectural Team Inc. (https://www.architecturalteam.com/) (TAT), Chelsea, Mass., says several states have added incentives in their [Qualified Allocation Plan (QAP)] that push for passive house. "Secondly," he adds, "with certain municipalities and states pushing to meet their 2030 emissions goal, there is pressure and interest in pushing passive design strategies to help meet this goal."

Long-Term Benefits

According to PHIUS, passive design strategy carefully models and balances a comprehensive set of factors including heat emissions from appliances and occupants to keep the building at comfortable and consistent indoor temperatures throughout the heating and cooling seasons. As a result, passive buildings offer tremendous long-term benefits in addition to energy efficiency, including superinsulation and airtight construction that provide unmatched comfort even in extreme weather conditions; continuous mechanical ventilation of fresh filtered air for superb indoor air quality; a comprehensive systems approach to modeling, design and construction, which produces extremely resilient buildings; and by minimizing the load that renewables are required to provide, a path to net zero and net positive buildings.

Designed by Studio Ma, the George is made up of eight single-family attached units arranged in four groups of two units each. Located in Phoenix, the project incorporates passive design principles. Photo by Michael Weschler; Courtesy of Studio Ma.

Elisabeth Post-Marner, AIA, LEED AP, principal at Spacesmith (https://www.spacesmith.com/), New York City, notes that the benefits of passive house design fall into three categories: health, sustainability and operating costs. When it comes to the heating and cooling system for passive house design, energy recovery ventilation blows fresh air into the house 24 hours a day, seven days a week, with all

exhaust air thrown outside. "This is very different than traditional house and building heating and cooling, which recirculates exhaust air to various degrees depending on the system used," she says. "The benefits of fresh air cannot be overrated: cognitive function and respiratory health are two big ones."

Passive houses are also carbon free, with no gas cooktops, oil heaters or fireplaces allowed due to the carbon released into the atmosphere, which when combined with oxygen makes carbon dioxide (CO_2), the biggest cause of global warming. And, because passive houses are highly insulated, they can be heated and cooled using minimal energy. "A 2,000-square-foot house may use as little energy as that equivalent to two light bulbs to heat and cool each month," explains Post-Marner.

"Most passive designs are also simple in shape," Leonard says, "a side effect of the way the energy model measures heat loss, but this limitation can turn into an advantage in cost-effective designs that are elegant in their functional simplicity. Some of the early North American passive designs left a lot to be desired—uninspiring boxes with tiny windows and poor light inside. Since then, lots of really amazing designs have shown that exceptional energy performance and comfort can look and feel amazing, too."

"Not only are there lower operational costs due to smaller more efficient systems a building employing passive design strategies is more resilient, generally has higher indoor air quality, greater user comfort and most importantly greatly reducing the carbon emissions produced by a building helping to mitigate the impacts of the climate change," says Thomas.

Additionally, Body-Lawson notes there is also better building performance overall, with healthier living and more effective long-term benefits. "Passive design means the facilities have smarter building systems, more environmentally attuned and sustainable building materials, as well as better-controlled ventilation systems. These lead to improved health outcomes overall, and also benefit the occupants, community and planet."

Affordable housing developments, such as the new Home Street Residences for low-income seniors in Bronx, N.Y., are also getting into the passive design trend. Photo: Erik Rank; Courtesy of Body-Lawson Associates.

Environmental Impact

Many of the passive design strategies are straightforward and achievable, and as Thomas notes, are the most effective path toward lowering carbon emissions, and ultimately achieving net zero emissions, which is critical to mitigate climate change. "For this reason," he says, "implementing [these strategies] throughout all building types and locations is extremely important."

"Passive design represents an evolution of not just construction, but also an evolution of the people that we are," says Body-Lawson. "It's an approach that shows we recognize our challenges with energy sources and what impact our buildings have on the planet. Passive design also responds to climate change problems that we have created and experience today. It's a building approach that recognizes we are responsible for taking care of our environment."

"As fossil fuels become depleted and global temperatures rise, increasing the impacts of climate change on our world, it would be foolish to fail to recognize that buildings contribute 60-75% of all energy consumption, heat generation and carbon output," explains

Joshua Zinder, AIA, LEED AP, managing partner at Joshua Zinder Architecture + Design LLC (https://joshuazinder.com/) (JZA+D), Princeton, N.J., and president-elect of AIA New Jersey. "Passive design, with or without certification under Passive House, offers a path to reduce impacts on the environment while improving the performance of new buildings being constructed."

When it comes to housing, Leonard says the decisions made now will be impacting the families that live in those homes, and our society at large, into the end of this century. "Unlike some other big energy consumers—individual transportation for example—the built environment is (literally) a concrete part of our longterm infrastructure. People who invest in passive design now are investing in the future in a tangible way."

"Passive design is the most direct way to connect ourselves through built space back to the environment," adds Keil. "To enjoy natural daylight, we simply create openings to let it inside. This must be balanced with other factors and concerns, though, such as solar heat gain, which will be more or less desirable depending on the climate and the season. Striking the right balance presents the challenge for the architect."

Energy Modeling

Energy modeling is key to PHIUS+ certification, since the building has to meet criteria in energy used for heating, energy used for cooling, energy used for appliances and lamps, airtightness and thermal comfort. "Energy modelling studies during the design process will ensure that these criteria are met," Post-Marner says. "Post-occupancy measuring confirms the energy modelling assumptions."

The 2,200-square-foot "Modern Lakefront" residence, designed by Passive Design Solutions, is a certified Passive House. Photo: Elemental Photography.

Adds Keil, energy modeling and simulation software can help architects understand occupant behavior, revealing paths to engagement that can optimize and reduce power consumption. "Energy modeling software allows the project teams to optimize the buildings systems and envelope for the climate/orientation in which the project is situated," notes Thomas. "This allows for the team to determine the exact amount of insulation needed at the envelope. Where thermal bridges are and evaluate the buildings performance and efficiency."

"Modeling is a critical step in the process," Zinder says, "allowing the architect to test a hypothesis prior to construction while taking into account not just the various building systems but also orientation, landscape and prevailing winds."

Passive design is more than just R-values or balancing out the window-to-wall ratios. Such things as shading, thermal mass, overheating mitigation, tweaks to geometry, and rotations on-site are all interconnected. According to Leonard, by using the energy model as a design tool, not just a how-did-we-do snapshot at the end of design, is what allows all the different aspects of a building to come into balance. "The approach is iterative, where what you learn from tweaking one aspect informs the next tweak, and then circle back to see if the project is better or worse. It takes a little more time in design but ultimately results in exceptional performance at a much lower total construction cost than just guessing."

And, when a building is substantially completed, Body-Lawson adds that visualization and blower-door tests can be used to check the airtightness of the assemblies and ensure the constructed building is performing to expectations. "Modeling and testing can be just as important as the passive design approaches themselves," he says.

Location and Siting

A building's location will impact the types of passive design strategies that can be used. A building located in the hot and arid desert southwest will require different passive design strategies than a building located in the cold northeast. "For instance," Thomas says, "in the desert southwest, shading and the orientation of fenestration to minimize solar heat gain will likely be prioritized. Where conversely, in the cold northeast, maximizing solar heat gain for the cold months will likely be a priority. More specific to

The Staten Island Family Justice Center, designed by Spacesmith. Photo: Joe Kitchen; Courtesy of Spacesmith.

the projects' particular location, however, is a building's orientation and the immediate surroundings (i.e., large trees, adjacent buildings, etc.) that play a role in the solar heat gain potential on the project as well."

"Passive design is the first step in the design process for maximizing southern exposure in winter and minimizing it during the summer," explains Zinder. "Proper site orientation can take advantage of prevailing winds and natural convection to heat and cool buildings by leveraging the specific climate and environment. Other useful strategies include vegetative screening and shade trees, and specifying light-colored materials or vegetation with growing media for roofs, to reduce solar heat gain and filter daylight. Sometimes site constraints limit options for passive design, especially in urban environments that carry their own restrictions. But design should always begin with an approach that leverages the environment in which your building sits."

"One of the main impacts of building location is the balance between heating and cooling strategies," explains Leonard. "But even on two sites in the same climate, the amount of shading due to trees and neighboring buildings will drastically change the impact of using windows to heat and cool. The best passive designs are like the best designs in general—they start with the site and evolve accordingly."

In the northern hemisphere, Body-Lawson says it's better to have buildings oriented north and south, generally with fewer windows in those directions but with more sun mitigating devices on the southern exposure. "Building orientation is also important for photovoltaic panels, for example, which must face the southern direction."

Successful Strategies

For successful passive design, Post-Marner says there are certain techniques that are beneficial. For example, a building's orientation from north to south is mandatory, with extensive fenestration on the south side and limited fenestration on the north side. Heavy insulation helps keep a house at a comfortable temperature with little to no heat and coolant required, and an ERV system can help provide constant fresh air into the building envelope.

A lake house in upstate New York has the roofs pitched upward to capture prevailing winds, a feature that simultaneously creates a large overhang that shades the interior from the summer sun, but still captures the winter sun for warmth. Photo by Mick Hales; Courtesy of JZA+D.

"Continuous insulation with no thermal bridges, extremely airtight envelopes and high-performance windows and doors are some of the most effective passive design strategies because of the universal application they have across all building types and climates," says Thomas. "All of these work together to reduce the demand for mechanical conditioning strategies to achieve user comfort."

Regardless of everything else, airtightness is critical for every project. "Long-term airtightness impacts comfort, durability and occupant health," Leonard explains. "After airtightness, good overhang shading on the summer sun side is also a no-brainer. It's just so simple, and a textbook passive cooling strategy. Overheating is a real risk for cold climates, and summer shading is the easiest solution."

Adds Zinder, "Leveraging the natural convection of a structure to cool a building is a no-brainer. Our designs would also favor strategies that enhance aesthetics and help reduce energy consumption, such as planting shade trees—these are applicable and attainable even for existing homes in need of energy-conscious retrofits."

While different sites, climates and building geometries will all require different strategies, Leonard notes that it is important for every project to be investigated on its own terms to determine the best techniques to use. "With good design, even using code level assemblies and components, can result in a much more comfortable and energy-efficient house," she says. "Of course, it's worth using more insulation and durably airtight assemblies, but even for the most budget-strapped project there are some passive strategies that can be used to make better projects without breaking the bank."

And, as Keil notes, every project is a chance to employ passive design strategies, and to innovate and improve on previous projects' performance. "But at the core the principle is always the same: consider the location and the proposed building use, then respond to those conditions and interactions to arrive at a design that promotes occupant health and comfort using the least energy possible," he says.

"Above all, I think passive design is fundamentally a recognition that we are one with our environment," says Body-Lawson. "We should continue to ensure our impact on the environment is minimized. Ensuring a sustainable planet in the long run is critical. In this way, passive design is all about our evolution as a people—that we care about our fellow human beings, the oceans, insects, animals and everything else, so it all ties into one."

Designed by TAT, the rehabilitation of the East Haven High School in East Haven, Conn., into 70 units of mixed-income, 55+ housing is the first in the nation to combine historic rehabilitation tax credits with Passive House construction techniques to provide safe, affordable housing to East Haven residents 55+. Photo courtesy of The Architectural Team.