BUILDING PASSIVELY

17 tips from our experts on the best way to carry out passive house design and construction for your next multifamily project.

By Robert Cassidy, Executive Editor

The concept of "passive house" originated in North America in response to the OPEC oil embargo of 1973 and the subsequent energy crisis. At that time, the U.S. Department of Energy and its counterpart in Canada started promoting cost-effective, "passive" energy-conservation measures—insulating buildings better, halting air leakage in the envelope, installing energy-efficient glazing. Once the oil embargo was lifted, in March 1974, America's homebuilders quickly fell back to erecting energy hogs.

In 1991 Swedish academic Bo Anderson and German physicist Wolfgang Feist designed the world's first *passivhaus* (the German term)—a four-unit row house

The 28-unit Distillery North Apartments, South Boston, Mass. Project team: Fred Gordon/Second Street Associates, ICON Architects, Petersen Engineering, Mechanical Air of New England, Adam Cohen and Mark Anstey, and Commodore Builders.

LEARNING OBJECTIVES

After you have read and studied the text, you should be able to:

DISCUSS briefly the history of passive house design in the U.S. and Europe.

DESCRIBE the key elements of passive house design to qualify for passive house certification.

LIST types of insulation and wall assemblies that can be used in passive house multifamily projects.

QUANTIFY the recommended heat energy savings, cooling energy savings, and total energy savings for passive house design.

PHOTO: CAMILLE MAREN, PRIMARY DESIGN

TECH

'HIGH-PERFORMANCE WINDOWS AND DOORS ARE EXTREMELY IMPORTANT.'

—KATRIN KLINGENBERG, CPHC, PASSIVE HOUSE INSTITUTE US (PHIUS)

Perch Harlem, at 542 West 153rd Street, New York, designed by Chris Benedict, RA, for Synops Capital Partners. Its 34 market-rate units are clad in an EIFS façade with DensGlass sheathing and eight inches of foam insulation. The large fixed windows measure 7½x7½ feet; the smaller windows are operable.

in Darmstadt, Germany. Five years later Feist established the Passivhaus Institute (PHI), which developed the Passivhaus Standard for certifying buildings. Since 1996, PHI has certified about a thousand projects in Europe.

In 2003, architect Katrin Klingenberg built the first such structure in North America: Smith House, in Urbana, Ill. This was followed by architect Stephan Tanner's BioHaus school building, in Bemidji, Minn. A year later, Klingenberg and Tanner hosted the first passive house conference in North America. In 2007, Klingenberg and builder Mike Kernagis founded Passive House Institute US (PHIUS) and developed the Certified Passive House Consultant certification. There are now more than 1,500 CPHCs in the U.S. and Canada.

PHI and PHIUS split in 2011 in a dispute over standards. PHI insisted that its standard could be applied to buildings in any climate. PHIUS held that, to be meaningful, a passive home standard had to take into account North America's vastly different climatic regions. Three years ago, PHIUS, in cooperation with the DOE, the Residential Energy Network, and Building Science Corporation, issued its own standard, PHIUS+. Since 2015, Chicago-based PHIUS has certified or precertified more than 700 projects, including more than 70 multifamily ventures.

Our experts offer the following practical tips to help you get started on your passive house project.

1. Assemble a team committed to passive house principles. The architect, builder, mechanical engineer, energy modeling consultant, and other technical specialists must really buy in to the passive house concept for the project achieve passive house certification. "We've learned from experience that all the parties must buy in to the passive house commitment to ensure success," said Dylan Martello, CPHD, Senior Building Systems Consultant, Steven Winter Associates.

"It's especially important to have a builder who understands the correct way to install the air barrier, how to eliminate thermal bridging, and the right way to size mechanical systems in a passive house project," said Josephine Zurica, PE, CPHC, LEED AP, Dagher Engineering.

"Bring the general contractor in early, to help you with the schedule, the choice of façade system, the details of the window installation, and the logistics of the site," said Aleksandr Yelizarov, Monadnock Construction's Project Manager on Cornell Tech's 26-story passive

PHOTO: PHEBE HORSCHEL

The Orchards at ORENCO (Phase I), by REACH Community Development, Ankrom Moisan Architects, William Wilson, Stonewood Structural Engineers, Humber Design Group, RDH, Green Hammer, PAE Consulting Engineers, American Heating, Merit Electric, PMC, Walker Macy, and Walsh Construction.

house residential tower in New York. "You have to keep costs in check, and if your attitude is that you're just not going to redo the drawings, your passive house project is not going to work."

2. Put a Certified Passive House Consultant on the team, especially for your first few passive house multifamily projects. There are more than 1,500 CPHCs in the U.S. and Canada. They can be especially helpful with your energy model, which has to be fully completed before you can continue toward PHIUS certification. Passive House Institute US also offers a training program for builders to learn to "speak" passive house and earn PHIUS Certified Builder accreditation.

3. Devote the time up front for careful planning, modeling, and design—and thinking. "Figure out the right strategies first, and talk out the pros and cons," said architect/builder Tim McDonald, Onion Flats. Resist the pressure to move too fast. The time spent on early planning will pay off in schedule savings—and fewer mistakes.

As you work through your modeling, you'll have to make decisions about a number of crucial factors:

• *Airtight construction*—namely your choice of air barrier ("often the starting point for passive house design," said PHIUS's Klingenberg).

• *Continuous insulation* ("ci") at "super" R-value.

• *Centralized or decentralized ventilation system*, using energy recovery ventilation (ERV) or heat recovery ventilation (HRV).

PHIUS+ certification calls for 0.05 CFM per gross square foot of building envelope area (at 50 pascals test pressure), and 0.08 CFM/gsf of envelope area (at 50 Pa) for buildings over five stories.

• High-performance windows and doors ("extremely important," according to Klingenberg)

• Eliminating thermal bridging

• Optimizing internal solar gains

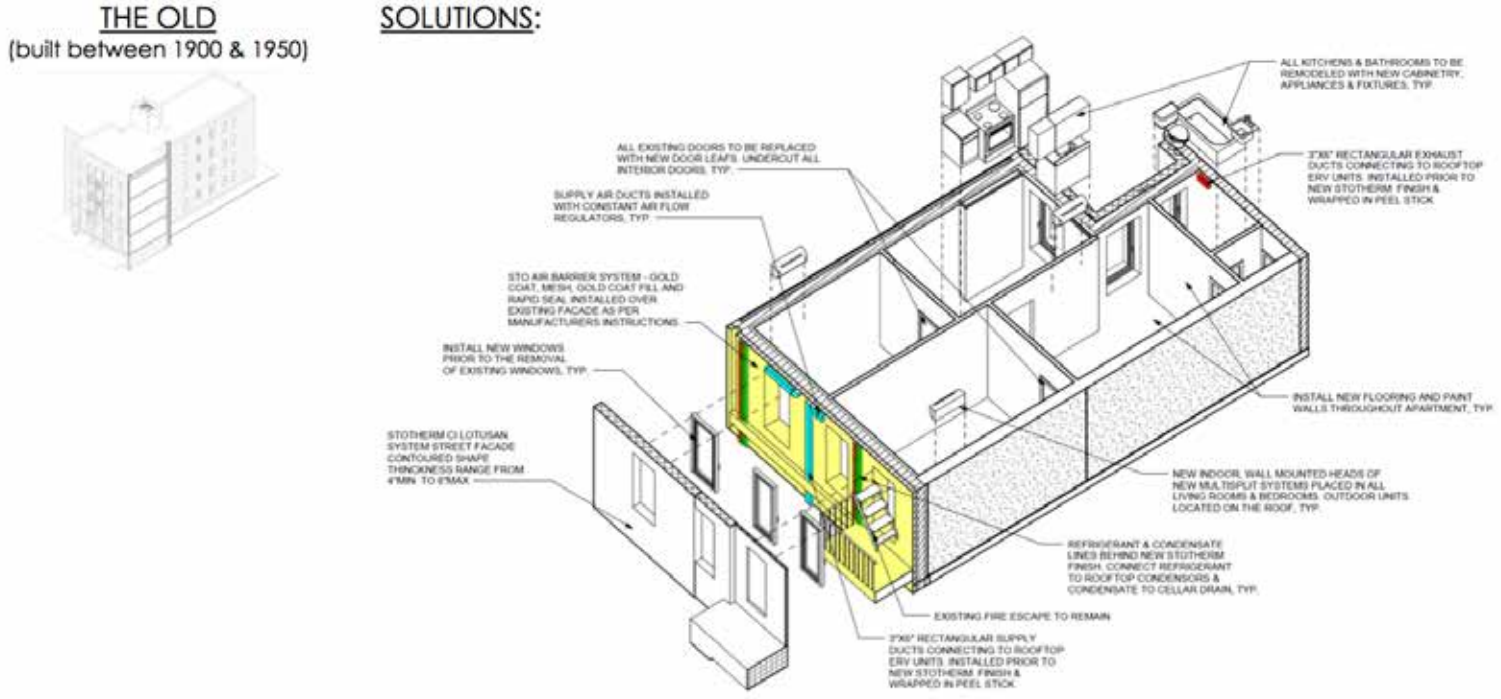
On this last point, designers can use daylighting to optimize solar gain and provide warmth, and exterior shades to help cool interiors—techniques you're already familiar with.

McDonald listed several other choices you must make: exterior insulation or cavity insulation; prefabricated or site-built building envelope; and centralized or decentralized hot water and laundry facilities. He said he always "pushes" for an all-electric building, rather than using natural gas (a nonrenewable fuel source) because the electrical system can be tied in with solar PVs to generate electricity for the building.

Furthermore, "gas-fired equipment is inherently problematic to operate within the passive house envelope," said Cristoph Stump, AIA, LEED AP, Trinity Financial, who is developing a 27-story passive house tower in the Bronx, N.Y. "Gas requires lots of makeup air, and its exhaust air can't reasonably be used for energy or heat recover."

4. Design your passive house multifamily complex to the local microclimate. The IECC climate zone map delineates eight very geographically broad zones. PHIUS uses data from more than 1,000 EPA

PHOTO: CASEY BRAUNGER / ANKROM MOISAN ARCHITECTS



Schematic by Chris Benedict, RA, shows planned passive house reconstruction for "Casa Passiva," one of 12 existing buildings (266 total units) in Brooklyn's Bushwick neighborhood, for RiseBoro Community Partnership. The work, which will be done with tenants in place, will run about $70,000 per unit.

and NOAA weather stations to hone in on local microclimates. This allows you to set your space-conditioning targets much more precisely.

5. Use a three-step approach to your planning process. Passive House design comes down to three basic steps, according to PHIUS's Katrin Klingenberg:

• *Reduce energy consumption* for heating by as much as 90% and by 50% for cooling (for an overall average around 50-70%) via passive measures—continuous "super"-insulation, an airtight barrier, high-performance windows and doors, eliminating thermal bridges, employing "controlled and balanced ventilation" (energy-recovery or heat-recovery ventilation), and optimizing solar heat gain via external shades and daylighting.

• *Balance these costs* against the project budget.

• *Look for additional energy efficiencies*—LED lighting, Energy Star appliances, downsized mechanical systems.

Note: In the case of multifamily high-rise structures, it is difficult to impossible to reach net-zero energy using solar arrays. The available roof space is usually not sufficient to mount enough PVs to achieve net zero.

6. Don't wed your design to any single factor or course of action. Resist the temptation to insist on a specific product or system that you love—a certain window, insulation type, air barrier, or wall assembly ("It's got to be ICF!") Look at the whole project, run everything through your energy model, match the costs up to the budget, and see if that "perfect" window really works for the job. It might not.

Similarly for rules of thumb. Don't assume you have to meet a specific window-to-wall ratio or R-value for the walls. Design to the specifics of the project—the climate, the building orientation, the building's occupant density—not to some preconceived notion of a "favorite" from past work. Klingenberg has noted, for example, that there are options on insulation, including blown-in fiberglass, cellulose, and polystyrene, any of which have been proven to work in passive house projects. Consider the performance aspects of such products for each project, not a prescriptive approach. As Kristin Nelson, AIA, Senior Associate, Dattner Architects, put it, "There are many ways to get to the end goal."

7. Find the "sweet spot" between energy savings and cost. In modeling your design, you need to balance energy savings and cost effectiveness. At some "tipping point" in your model, the damage to your budget of saving a little more energy may become so exorbitant that it's not worth the effort to go further. At this point, you should be approaching 90% savings on heating energy and 50% on cooling energy, said PHIUS's James Ortega, CPHC. PHIUS+ certification targets for space-conditioning performance were developed using this sweet spot.

8. Consider all your options for the wall assembly. Klingenberg said many different wall assemblies have been used successfully in passive house projects— conventional stick-frame construction with rigid insulation (the most common wall type used in PHIUS+ certified

DIAGRAM: CHRIS BENEDICT, RA, FOR RISEBORO COMMUNITY PARTNERSHIP

'ALL THE PARTIES MUST BUY INTO THE PASSIVE HOUSE COMMITMENT TO ENSURE SUCCESS.'

— DYLAN MARTELLO, CPHD, STEVEN WINTER ASSOCIATES

Passive house modules being fabricated at the Onion Flats facility in Pennsylvania. "Figure out the right strategies first, and talk out the pros and cons," advises architect-builder-developer Tim McDonald. The time spent on early planning will pay off in schedule savings—and fewer mistakes.

projects), masonry, steel or concrete frame with continuous exterior insulation, insulated concrete forms (ICF), and structural insulated panels (SIPs). The wall assembly is a crucial component for providing thermal mass, and you have several proven choices to work with.

9. For high-rise multifamily structures, the building's density becomes as influential as the height. The sheer volume of a high-rise apartment building in relation to its exterior surface area makes it a little easier to achieve passive house goals than it would be for a single-family home or a smaller multifamily complex.

The physics of volume-to-surface area has its advantages in large multifamily settings, notably high-rises. In some cases, said development consultant Hank Keating, you may not need triple glazing: Double glazing will do the trick. Similarly for insulation: Due to the density and lesser envelope area per square foot of floor area of the larger building, you may be able to reduce the insulation from, say, R-32 to R24. "It's not automatic that you'll need a crazy amount of insulation" in a passive house multifamily high-rise, said Keating.

10. In large-scale passive house projects, a certain amount of thermal bridging can be tolerated. This is almost a corollary of the previous point. You should reduce thermal bridging as much as possible, said PHIUS's Lisa White, CPHC, but larger buildings, including major multifamily passive house complexes, can tolerate some structural thermal bridging (again, due to the surface area-to-volume-to- factor) and still meet PHIUS certification standards. Stump cautions that care needs to be taken to avoid condensation around thermal bridges.

11. In modeling large-scale or high-rise affordable housing, be aware of occupant load factors. Households in affordable apartment developments may include adult parents, several children, grandparents, and pets—the presence of which can complicate the energy model.

In housing occupied by large families, heavy use of the apartment—more people using it, and for longer hours, especially on weekends—may raise concerns about buildup of interior moisture. Heavy "occupancy load" may also lead to greater demand for cooling than usual, said Dylan Martello. These factors are not easy to predict or model.

Condensation is a factor that bears serious consideration and is a big bugaboo with builders, but properly designed and constructed passive house structures actually have a lower risk of moisture problems than conventional buildings, due primarily to their continuous air flow.

12. Casement windows and awning windows work well in passive house buildings, including apartment projects. Passive House design experts agree that these windows provide excellent air tightness, and can also be opened for ventilation as needed. "Awning

PHOTO: ONION FLATS

windows with limit stops are particularly good for child safety and if open when it's raining," said Keating. As for double-hung windows, "It's hard to get them as tight as they need to be" for passive house certification, said Ortega.

13. Hold off on renewables such as photovoltaics until you've deployed every energy-conservation measure you can afford. You want to get to 80-90% heating energy conservation and 50% for cooling (for an average 50-75% total energy conservation, depending on location), before you start thinking about solar panels, unless you have the budget to shoot for net zero or net plus. In some cases, you may want to consider a small PV array as a "resiliency" backup for crucial mechanical systems or emergency lighting in the event of a power outage.

14. Downsize your mechanical systems to take advantage of passive house design. Passive house buildings are designed with lower space-conditioning loads than conventional buildings, so you're probably going to need much smaller mechanical systems than would be called for in conventional construction. These savings should be factored into your cost analysis.

According to passive house experts, the currently available heating/cooling systems (variable refrigerant flow, or VRF, systems and ductless minisplits) are not available in small enough capacities that would be needed in most passive house multifamily projects, so some of the anticipated cost saving from downsizing the mechanicals is lost.

15. Make energy-efficient lighting choices. You're already doing this (or should be) in your "non-PH" projects: Keep doing so in your passive house endeavor. Consider the best lighting power density for wayfinding purposes for your project. Install occupancy sensors in hallways, common rooms, laundry rooms, and amenity spaces. As Ortega put it, "The most energy-efficient light is the one that's off."

PASSIVE HOUSE TECHNICAL ADVISORS

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Exterior of 803 Knickerbocker, Brooklyn, N.Y., has sculpted EIFS for visual and shading effect. The 24-unit passive house, designed by Chris Benedict, RA, has a ground-floor community facility. It was built by Galaxy Construction for RiseBoro Community Partnership at a cost of $180/sf.

16. Test the building for air leaks during construction. For passive house certification, your multifamily building must pass a "blower door" test to check for air leaks. Don't wait till the end of the job to do this. Do the test while the air barrier is still exposed, advised Klingenberg, so you can patch any air leaks that the test has revealed.

17. Get your trades on board early with passive house training. "Your mechanical engineering trades are critical to success in multifamily passive house," said Steve Bluestone. If possible, said Keating, give key trades, especially construction workers, the opportunity to go through passive house training before the work begins. Such training can, for example, reinforce the need to keep the building airtight by not unnecessarily punching holes in a wall.

"Design like nobody is watching," says architect/builder Tim McDonald. "I want my process of design to be informed by the passive house [process], but the model doesn't have to dictate the design. I always design the building I want, then test it in the model. It's important that architects not be turned away from passive house design because they think that a passive house building needs to look a certain way. I have never worked that way." And, we hope, never shall. |**M**|

EDITOR'S NOTE

This completes the reading for this course. To earn **1.0** AIA CES HSW learning units, study the article carefully and take the exam posted at **BDCNETWORK.COM/PASSIVE2018**

PHOTO: CHRIS BENEDICT, RA