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Buttoned Up for a New Century

Preservation meets performance when a Brooklyn architect applies Passive House principles to four iconic urban town houses

BY JEREMY R.M. SHANNON

When my wife and I struck out on our own in 2005 to create our two companies, Prospect Architecture and Prospect Development & Construction, we wanted to lead the way in sustainable design and construction in New York City. Like many new firms, we rode the leading trends: LEED accreditation, recycled products, water conservation, energy efficiency, and local sourcing of products and services whenever possible. Carla and I approached our clients with the idea that building sustainably was not a choice—it was simply the way we worked.

Despite all this effort, the idea of game-changing sustainable construction still seemed out of reach. Then in 2008, I read an article about Passive House construction that talked about reducing heating costs by 90% over typical construction. By the end of the article, I was hooked on the idea.

The timing coincided with a project we were just starting: a renovation of a 120-year-old brownstone in the Park Slope neighborhood of Brooklyn. With approval from our client, we hired David White of Right Environments—one of only three people then certified as Passive House consultants in New York—to help guide us through the process.

In looking for a precedent to help us along the way, David and I discovered that nowhere in the world was there a published interior renovation of a historic building to Passive House standards.

While the idea of Passive House is simple to understand, designing a Passive House takes know-how and effort, and constructing one takes attention to detail and constant quality checks. The challenges we faced during the renovation of this house were many: historic-preservation regulations, codes that lagged behind technologies, consultants struggling with design parameters, and contractors unable to implement Passive House techniques cost-effectively and on time.

Passive in progress. *Brooklyn architect Jeremy Shannon has renovated three vintage Park Slope town houses (photos left, facing page) to Passive House standards. He expects to certify his fourth retrofit, now under way (photo right, facing page).*

Passive House Academy rules in New York

The Passive House concept was invented by Wolfgang Feist, whose Passivhaus Institut (PHI) in Germany has trained just under 30 organizations to certify Passive Houses worldwide. To date, only two organizations other than PHI have certified projects in the United States: the Passive House Institute US (PHIUS) and the Passive House Academy.

While PHIUS was the first to certify Passive House projects in the country, it lost its ability to certify new projects in 2011 after a series of disagreements with the founding Passivhaus Institut. Passive House Academy, which was launched in Ireland by landscape architect and environmental designer Tomas O'Leary, gained a presence in the United States and particularly in New York in 2010. Because the Passive House Academy remains a legitimate certifying organization in the international Passive House community, as well as a strong supporter of New York Passive House (nypassivehouse.org), we are working with it for certification of our fourth project and subsequent projects. New York Passive House is also working with the Passive House Academy to promote and set up certification training in 2013 for designers and builders in each of the state's major cities.

Now, almost four years later, we've completed three historic retrofits to the Passive House standard. We expect to finish a fourth in early 2013 and have it certified by the Passivhaus Institut through the certifier Passive House Academy (sidebar p. 57). Our design-build process has been a key factor in learning quickly what works and what doesn't; with no space between the drawing board and the job site, we've been able to adjust our methods as we go along to avoid repeating the same design mistakes.

Tightening the envelope

A key element of Passive House design is airtightness. Without airtight construction, the best insulation available is wasted. To understand this, think of water leaking out of a cup. Regardless of how thick and strong the cup is, if you have a hole at the bottom, the water will leak out.

The air-leakage rate for Passive Houses is limited to 0.6 air changes per hour at 50 pascals of pressure (ACH50). The current ANSI standard for new construction in the United States is 5.5 ACH50—almost 10 times as high a rate.

Initial blower-door tests of these homes revealed air-leakage rates of 10 to 18 ACH50, making even the newer Passive House EntreFit standard for existing structures, 1.0 ACH50, a stretch. The heating-and-cooling requirement of no more than 4750 Btu per sq. ft. per year is the same as it is for new construction. Perhaps more important, a tight house is a check on the construction process. If airflow cannot be controlled, the building is vulnerable to other problems.

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TWO-FAMILY TOWN HOUSE

Four stories plus cellar; pre-1890

Antiques aren't airtight. *The leakiness of the original doors on the author's first retrofit contributed to the home's inability to meet Passive House benchmarks. In the living room, original and replicated moldings help modern, high-performance casements to appear as double-hungs that have always been there (photo facing page).*

Decouple insulation and air barrier

Initially, our plan was to use 3½ in. of closed-cell spray foam (R-6.9 per in.) throughout the house as both insulation and air barrier. In factory conditions, spray foam is airtight. In the field, however, we found that techniques used by spray-foam companies left leakage points even after we adjusted the framing to leave a 1½-in. gap between the exterior masonry and the studs. We have used more than a handful of spray-foam contractors over the past seven years and have seen application deficiencies with all of them.

For this reason, and to avoid the use of harmful HCFCs in the blowing agent, we limited the use of closed-cell spray foam in our last three projects to below-grade applications where its relative impermeability to moisture was an asset. In the rest of the house, we got better results by decoupling the insulation and air barrier, using Sto-Guard Gold Coat elastomeric coating (stocorp.com) as an air barrier on the inside of all exterior walls, paired with various insulation types to achieve our needed R-value. By separating the air barrier and the insulation layer, we are able to test the air barrier earlier in the process, and with more attention to detail. Our tests include a visual inspection of the coating as well as a blower-door test, which we can do before the framing is done, meaning fewer obstructions to work around.

One type of insulation can't do it all

We now use cellulose insulation for as much of the above-grade insulation as possible. In ceilings, we use either loose-fill or dense-pack cellulose, depending on the depth of fill required. We also dense-pack all of our exterior walls with cellulose, making sure to keep the framing members from touching the brick so that we can get several inches of continuous insulation around the perimeter. Where the exterior walls meet the shared party walls, we wrap the insulation back about 2 ft. from the corner to eliminate the thermal bridge at the masonry intersection of the town houses.

Rigid polyisocyanurate boards are used for thermal-bridge details around the structural beams and in other space-restricted areas; we use a variety of thicknesses, depending on the application.

Around windows, which we set in the masonry walls in a manner typical of these town houses, there is a gap of about 3 in. between the windows and the brick. We fill this gap with open-cell spray foam to achieve a higher R-value than we'd get with cellulose. We reduce the environmental impact

Air-sealing

Exterior walls: Closed-cell spray foam

Party walls: StoGuard elastomeric coating

Window sealing: Closed-cell spray foam and butyl tape

Insulation

Below-grade walls: 3 in. closed-cell spray foam (R-21)

Above-grade walls: 3½ in. closed-cell spray foam (R-24)

Around windows and doors: 2½ in. closed-cell spray foam (R-17)

Below roof: 14 in. to 24 in. loose-fill cellulose (based on flat roof wedge; R-50 to R-86)

Windows

Triple-glazed Optiwin aluminum-clad wood tilt-turn casements (Ucog 0.09; frame 0.13; SHGC 0.053)

Exterior doors

Front: Existing historic with added double gasket; new triple-pane glazing

Additional: Passive House-certified Optiwin aluminum-clad wood

HVAC

Heating and cooling: Daikin 3-ton condenser; one 1.5-ton and two 0.6-ton air handlers

Ventilation: Two Zehnder ComfoAir 350 HRVs (converted to ERVs); shop ductwork; ventilation combined with conditioned air prior to Daikin condenser

of using open-cell foam by using bio-based insulation with a water-based blowing agent.

Tapes trump foam for air-sealing

For our goal to limit spray-foam use, we've also backed away from our dependence on spray foam as an air-barrier connection around window frames. Our first three projects used this method, and we still see problem areas in the air barrier where the foam weakened over time or pulled away during curing. For our fourth town house, we're coating the brick with StoGuard and bridging the gap with Pro Clima's Contega FC tape (foursevenfive.com). The adhesive strip on one side of this felt tape attaches to the window frame, and the nonadhesive side attaches to the StoGuard-coated masonry with a caulk supplied by Pro Clima. This method lets the wood window move with the seasons without stressing the air barrier.

We use the same tape to curb air leaks around joist penetrations in shared party walls. Underestimating the air-leakage potential, we used StoGuard and canned foam around the joist penetrations, but this failed to meet airtightness requirements. We added caulk on the next two projects, but it didn't help. We now use the tape, affixing its adhesive side to the joists and embedding the other side into the masonry wall with a ⅜-in. bed of plaster of paris and joint compound with ¼ in. troweled on top. This gets into the felt fibers and not only creates an airtight connection between the joists and the masonry wall, but also leaves enough flex in the tape to make the joint durable for decades.

In cellars, foam requires a backup

In our first two projects, we depended on closed-cell spray foam as a watertight layer for the cellars, but minor leaks developed in places where the foam had been applied imperfectly. As insurance, we are now using a Delta MS waterproofing mat (cosella-dorken.com) with a 6-in. horizontal overlap on the front and back walls and a 3-ft. overlap on the party walls. We follow up by spraying closed-cell foam directly onto the waterproofing mat and running the foam underneath the slab, which is further drained by a bed of gravel fill and a percolating drainage system.

In our second project, we needed to devise a stepped-footing detail to increase the lower floor's ceiling height (photo p. 60). In this case, we wrapped the closed-cell spray foam from the wall around the footing and continued it below the slab.

Separate systems work best

On our first project, we combined the ventilation system with a Daikin heating-and-

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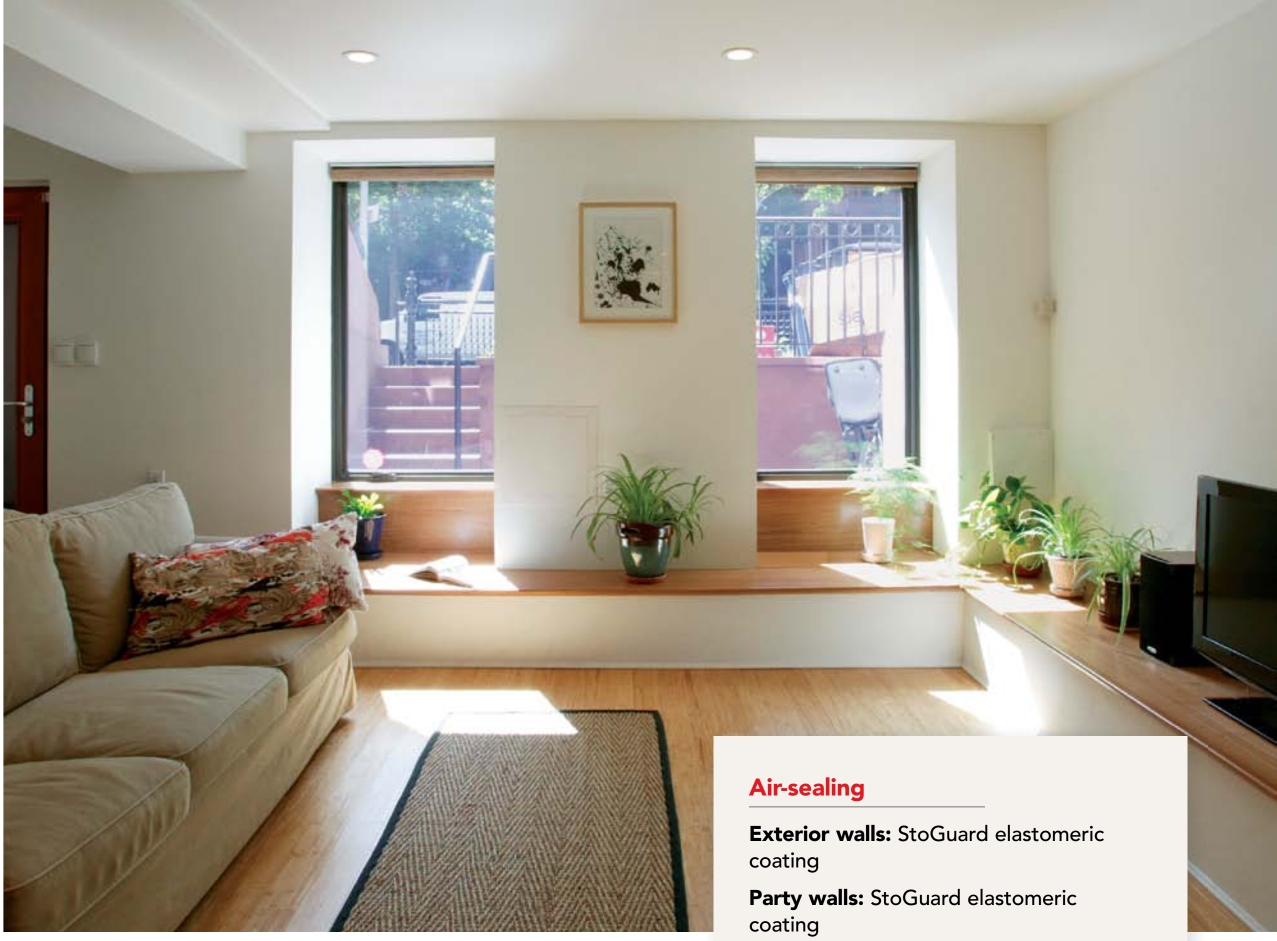
TWO-FAMILY TOWN HOUSE

Five stories plus cellar; pre-1890



Detail becomes design. *In the second house, a step footing was needed to lower the bottom floor for a comfortable ceiling height. The detail was incorporated into the room as a wraparound bench. Closed-cell spray-foam insulation from the wall was wrapped around the footing and then down below the slab, which eliminated any chance of thermal weakness.*

cooling minisplit system by putting the fresh-air supply in front of the internal air handler. Ventilation-air flow rates, however, were too restricted when the air handler was turned off. Our options, then, were putting the ventilation air into the ductwork directly after the air handler or separating the systems. While adding fresh air after the air handler can work, the large ducts—whose size is based on heating and cooling needs—dump too much ventilation air in rooms closest to the air handler, making it hard to balance ventilation for all the rooms. By separating the conditioning and ventilation systems, we found that we could microadjust each system with separate damper controls.

The Zehnder ERV (zehnderamerica.com) that we use is a well-designed plug-and-play system with 3-in. flex tubes and air-sealed supply and junction boxes that make it easy to install and balance. Separating the two also allows the air-conditioning system to use fewer, simpler ducts so that installing and balancing that system is also easier.

With separate ducting for the ERV and the heating-and-cooling system, as well as the new city code requirement for sprinklers in almost every building, we need a significant amount of mechanical space in these already space-challenged homes. To avoid unsightly soffits running around rooms at the ceilings, we take some space along the party wall on the side of the house opposite the staircases, and drop many of the bathroom and hallway ceilings by about 6 in. Because ceiling heights in these town houses run around 9 ft., the lowered ceilings don't bother clients.

Don't overinsulate

There's a particular danger when you're upgrading historic or existing buildings whose facades need to remain intact. Once you insulate the interior of a building, the temperature of the exterior masonry is no longer moderated by heat loss from the interior, leaving the facade exposed to damaging freeze-thaw cycles. Water in the masonry freezes, deposits its salts, thaws, and then absorbs more salts from the masonry and freezes again, each time exerting more pressure on the structure.

While temperature extremes are rare in New York's climate zone, we don't want to take that chance. To eliminate the risk, we don't overdo the insulation on the interior, and we use modeling software such as Therm and WUFI to make sure that we are not creating a saturated wall. We also rely on our structural engineer's assessment of the

Air-sealing

Exterior walls: StoGuard elastomeric coating

Party walls: StoGuard elastomeric coating

Window sealing: Closed-cell spray foam and butyl tape

Insulation

Below-grade walls: 3 in. closed-cell spray foam (R-21)

Above-grade walls: 5½ in. dense-pack cellulose (R-21)

Around windows and doors: 2½ in. open-cell spray foam (R-14)

Below roof: 14 in. to 24 in. loose-fill cellulose (based on flat roof wedge; R-50 to R-86)

Windows

Triple-glazed Serious fiberglass casements (Ucog 0.11; frame 0.28; SHGC 0.47)

Exterior doors

Front: Existing historic with added double gasket; new triple-pane glazing

Additional: Passive House-certified Bieber aluminum-clad wood

HVAC

Heating and cooling: Daikin 3-ton condenser; one 1.5-ton and two 0.6-ton air handlers

Ventilation: Two Zehnder ERVs (ComfoAir 550 and 350); shop ductwork for main branches; Zehnder 3-in. tubes for each room; ventilation separated from conditioned air

Compression-fit sliders. *In the rear of the house, Passive House-certified tilt-open sliders from Bieber connect the interior to the small backyard without compromising the envelope or the historic facade.*

Getting preservationists on board

Preservation and sustainability haven't always gone hand in hand. Although reusing an older building is assumed to be inherently more sustainable than tearing it down, this is true only if the building undergoes a major energy retrofit. Studies by the Passivhaus Institut and others have shown that energy consumption through the useful life of an unimproved building can be 10 times the amount of energy that it would take to rebuild the same building.

Our first and fourth Passive House projects were within a historic district where all the exterior changes are regulated by New York City's Landmarks Preservation Commission (LPC). We experienced our first real collision between preservation and sustainability in 2009, when we proposed to install tilt-turn Passive House-certified windows instead of double-hungs. There currently are no double-hung windows in production that are airtight enough for Passive House standards.

The LPC staff rejected our proposal for tilt-turn windows with a fake center divide to simulate double-hung windows, pointing out that the commission's charter stipulates that the operation of new windows must match that of the windows being replaced. To use the windows that we wanted, we would have to appeal the staff's decision before the Landmarks Preservation Commission board.

Rather than get frustrated, we took the initial rejection as an opportunity to create a better window. We designed a fixed top sash, made the lower sash an operable tilt-turn window, and offset it inward to simulate the profile of a double-hung window more closely. We even worked with Optiwin to expand the frame of the operable sash so that it would line up with the fixed one, enhancing the double-hung illusion (photo).

Although our redesign won over the LPC staff, we left nothing to chance. We met with community boards, city-council members, nonprofit preservation groups, and even the mayor's office staff in charge of Plan NYC, the city's green-building initiative. We explained how the Passive House approach would help to preserve the city's historic buildings. We also asked each group to reach out to the preservation community prior to our hearing and show their support for our project.

Our effort paid off. By the time we came before the board, members had heard about Passive House, and they gave us a unanimous vote of approval. Our window design, which is now described in manufacturers' literature as "the Brooklyn Double Hung," was approved for two of our projects and for projects by three other architects.

I've learned four key points in working with preservationists on Passive House projects. First, bring them in as collaborators on the project, and check your ego at the door. These people have studied the typology of local buildings more than most architects, and they have the best interest of the city's architecture in mind. Second, hold your ground on elements that matter to energy efficiency by explaining that buildings that are more cost-effective to maintain and comfortable to live in will be better maintained and appreciated by their owners. Third, remind them that Passive Houses don't require unsightly window air conditioners, so their facades remain pristine in the summer months. Last, know your building science, and be prepared to back up your insulation and air-barrier plans with testing data from Therm or WUFI models. This information can help to temper concerns that you are going to create an envelope that will cause moisture problems or damage to the structure.

3.

ONE-FAMILY TOWN HOUSE

Four stories plus cellar; 1887

Just another bump. *A 2-ft. section of thicker insulation is designed to keep heat from bleeding out at the junction of the exterior brick wall and the shared party wall. In vintage houses known for elaborate moldings and unusual interior details, this energy detail reads as just another architectural novelty.*

Air-sealing

Exterior walls: StoGuard elastomeric coating

Party walls: StoGuard elastomeric coating

Window sealing: Open-cell spray foam and Pro Clima tape

Insulation

Below-grade walls: 3 in. closed-cell spray foam (R-21)

Above-grade walls: 5½ in. dense-pack cellulose (R-21)

Around windows and doors: 2½ in. open-cell spray foam (R-14)

Below roof: 14 in. to 30 in. loose-fill cellulose (based on flat roof wedge; R-50 to R-100)

Windows

Triple-glazed Fibertec fiberglass casements (Ucog 0.16; frame 0.28; SHGC 0.61)

Exterior doors

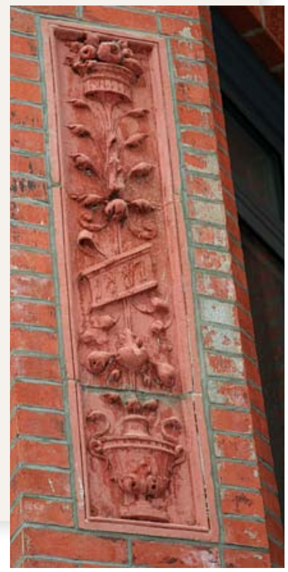
Front: Passive House-certified Bieber wood

Additional: Fibertec insulated fiberglass with triple glazing

HVAC

Heating and cooling: Mitsubishi 3-ton condenser; two 1.5-ton air handlers

Ventilation: Zehnder ComfoAir 550 ERV with Zehnder 3-in. tubes for all ports; ventilation separated from conditioned air



quality of the brick and stone on the facades of the buildings we remodel.

We also know that having vapor-open walls is extremely important in our climate because moisture drive through the walls changes direction throughout the year. When walls are vapor open, they can dry to either side.

In designing Passive House projects over the past few years, we've learned to distinguish between the moisture barrier, vapor-control layer, and air barrier. We want to keep bulk moisture out of the house and walls, we want to control vapor transmission by using products that are vapor open, and we want our air barrier to be fully continuous. Passive House air-barrier leakage rules are so strict not just because of energy losses, but because air carries lots of water within it. Keeping that water-laden air out of the interior of our walls eliminates moisture problems that lead to sick buildings.

Still, old doors will leak

The original exterior doors on these town houses are 8 ft. tall or taller, about 2½ in. thick, and have recessed wooden panels and single-pane glass panels in the upper half. Though beautifully crafted, they are impossible to seal completely. In our first two projects, we squared up each door and installed a double-gasket seal similar to what we were seeing in Passive House doors. We did the work on-site, routing spaces for the gaskets and making sure to get good compression for the seal. We installed drop bottoms to press down against the old stone sills we had left in place. We also removed the existing single-pane glass and replaced it with superinsulated triple-pane glass (bieberusa.com).

We had three problems with this approach. First, the double-gasket doors proved cumbersome for clients who weren't accustomed to having to press doors together to close the latch. (New Passive House-certified doors have latching hardware that makes the initial closing easy, with additional compression applied when the latch is turned.) Second, while drop bottoms seal reasonably well if things are level and square (rare in an old house), a gap remained between the two front doors, allowing air to blow through. Third, despite all our air-sealing efforts, the old sill remained a thermal bridge under the door, drawing heat from the vestibule outside in winter. □

Jeremy R.M. Shannon is owner of Prospect Architecture in Brooklyn, N.Y. Photos by Rob Yagid, except where noted.

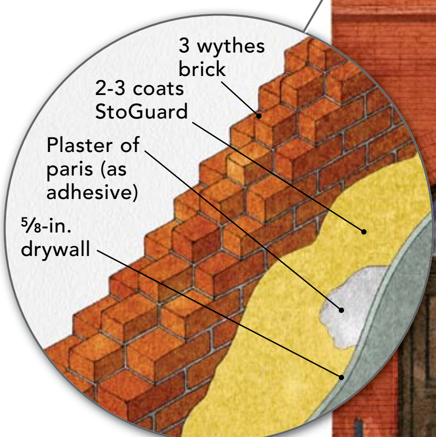
Photos this page: Debra Judge Silber. Drawings facing page: WRH-Illustration.com.

4.

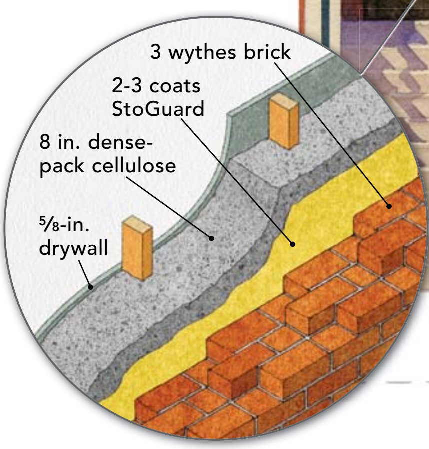
TWO-FAMILY TOWN HOUSE

Four stories plus cellar; pre-1890

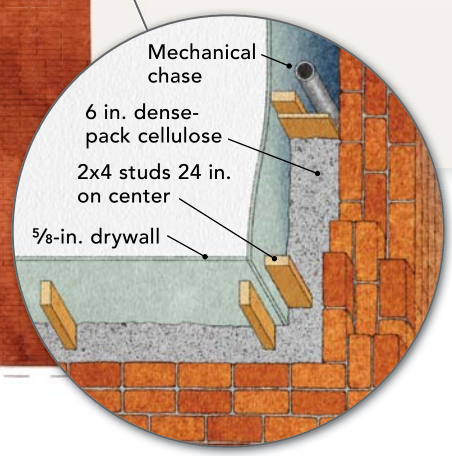
It all adds up. *Applying what he's learned, Shannon hopes to certify his fourth project. Details include air-sealing party walls, insulating and air-sealing exterior walls, and creating a thermal break at the corners. In this house, one interior sidewall is framed out for a mechanical chase; in others, the corner is bumped out (photo facing page).*



PARTY WALL



FRONT WALL



CORNER

Air-sealing

Exterior walls: StoGuard elastomeric coating

Party walls: StoGuard elastomeric coating

Window sealing: Pro Clima Contega FC tape to StoGuard coating

Insulation

Below-grade walls: 3 in. closed-cell spray foam (R-21)

Above-grade walls: 8 in. dense-pack cellulose (R-29)

Around windows and doors: 2½ in. open-cell spray foam (R-14)

Below roof: 18 in. to 36 in. loose-fill cellulose (based on flat roof wedge, R-65 to R-120)

Windows

Triple-glazed Zola tilt-turn wood casements (Ucog 0.09; frame 0.19; SHGC 0.62)

Exterior doors

Front: Passive House-certified Zola wood

Additional: Passive House-certified Zola wood

HVAC

Heating and cooling: Mitsubishi 3-ton condenser; two 1.5-ton air handlers

Ventilation: Zehnder ComfoAir 550 ERV with Zehnder 3-in. tubes for all ports; ventilation separated from conditioned air