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IN DEPTH

Balancing Home and Work, PHIUS, and an Historic District: The Balance Project

Balance Project
By: Mojarrab Stanford Architects
Name: Balance Project
Type: Mixed-Use Condo
Size: 3,450 square feet combined
Location: Historic Railyard District, Santa Fe, New Mexico
Completed: Spring 2011

Economically responsible. Passive House Institute US (PHIUS) certified. Super efficient. Mixed-use development. The Balance Project, conceived by Mojarrab Stanford Architects (MoSA), put combining these values together to the test. ***Energy Design Update*** spoke with Vahid Mojarrab and Jonah Stanford to get an in-depth look at how they drew these concepts and values together.

Stanford and Mojarrab, partners at MoSA, in Santa Fe, New Mexico (*http://mo-s-a.com/*), are dedicated to the Passive House ethos. Stanford provides architectural design and energy conservation consulting services to public and private clients who actively prioritize environmental efficiency, and is a graduate of the first Passive House Consultant training in North America and a past Board President of Passive House Institute US. Mojarrab has over 20 years of planning and architectural design experience in both the residential and commercial sectors.

Most recently, MoSA projects won awards from the US Green Building Council® recognizing the Balance Project for "Best Indoor-Air-Quality" and Volkshouse for "Best Energy Efficiency." (see Figure 1)

Figure 1. The south side of the residential unit. View to the living room and kitchen areas. Cement board siding and stucco. Image courtesy Mojarrab Stanford Architects (MoSA).

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Figure 2. Site rendering for the Balance Project. Image courtesy Mojarrab Stanford Architects (MoSA).

How did this project come to be?

JS: Let's talk about the location first, because that is important in itself. The Balance Project is located in the Historic Railyard District of Santa Fe (see Figure 2). The location represents a unique exercise in planning that the city took on 10 years ago. What is now the District was two fairly large parcels of land close to the interior urban core of Santa Fe that belonged to the railroad. It was completely abandoned and un-maintained. The city decided to purchase the property from the railroad, and created a non-profit that would oversee management, planning, leasing, and long-term guidance over the newly created Santa Fe Railyard District. This was an innovative planning initiative on the part of the city. Master planning was done, incorporating parks design. The upper and lower Railyard sections were directly connected by open space and bike paths, and irrigation ditches that are 400 years old running through the space were preserved. At the same time, we got our commuter train from Albuquerque to Santa Fe, the Rail Runner, to that location. The non-profit then made land available for development, with all parcels under long-term leases of 90 years. This was much more in line with commercial development.

VM: The Historic Railyard District area was also unique in that they promote innovative design and offer flexible zoning. This was a perfect fit for our project.

JS: In 2008, both Vahid and I were working for an affordable housing non-profit in Santa Fe. We were both exposed to the Passive House approach, and attended the first generation PHIUS training. The reason Passive House triggered a lot of interest for us is that we had been struggling hard to try and increase efficiency and sustainability in our affordable housing developments. Toward that goal, we both felt like we hit a hard spot we couldn't move past. Like most North American architects, we were thinking about the efficiency of the building linked directly to the efficiency of its mechanicals. In our affordable housing, we were using a typical 85% efficiency heater; to move to a 95% efficiency model would more than double the cost of that component. We were seeing a curve in construction cost, and simply could not afford to increase the efficiency of the building. We didn't know how to get beyond that. When we were exposed to the Passive House approach, a light switch went on. The whole approach really reverses the investment in efficiency. It says that it is far more cost efficient to save energy than to generate it efficiently. Of course, even in Passive House, there's diminishing returns at a certain point, but that occurs far beyond the performance point we need to obtain.

VM: Passive House also gives us a systems perspective. The first training gave us an understanding of integrated design, and how components impact each other; where performance and return is. We turned towards a really better understanding of system design than component design.

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Figure 3. Project at rough framing. The Larsen Trusses are in place forming a 9" cavity for cellulose insulation forming the primary thermal envelope. The plywood air barrier can be seen behind the trusses fully taped. Image courtesy Mojarrab Stanford Architects (MoSA).

JS: Vahid and I felt the Railyard was a great opportunity to bring a lot of our vision together. That was the ultimate impetus for the Balance Project. One unit is my personal residence, the other one is our office. If you don't have a Passive House client, you have to make your own, and that's what we did. Because of the Balance Project, we have the ability to talk about things with clients today as a physical experience, not just head knowledge, but demonstrated by tactile experience. We are living and working in certified Passive Houses.

Walk us through the building's assembly, components, and performance.

JS: When we started designing the Balance Project, only two certified Passive Houses existed in North America. At the time, we felt like we were standing on the edge of a diving board.

Our typical wall assembly at Balance is 17″ thick, and has an insulation value of approximately R-60. We used 100% cellulose insulation for its R-value. In the wall assembly, we tried very much to follow standard North American practices, yet still achieve Passive House R-values and thermal bridge-free construction. Because Vahid and I try so hard to have these buildings built economically efficient as well, we really wanted to align construction to standard practices, and use available materials. So far, every Passive House we've done has used 2x6 framing 24″ on center, and sheathed like any other building out there (refer to Figure 3). This allows a very typical framing crew to build the structure of our buildings. All of our electricals and mechanicals run within the interior cavity on that structural core, allowing subcontractors to easily perform their work, too.

What Vahid and I have found is it was most economical to isolate primary performance characteristics that were needed: structural, airtightness, and thermal envelope. We did not try to find one material that did all of those well; we found there were too many exceptions to the rule, and that approach gets really complicated. So, we isolated the structure to the interior of our building, a very traditional approach, and allowed trades to work within it as they typically would.

Sheathing is our airtightness layer, as well as for sheer support. Our primary thermal envelope is on the exterior of that structural core. For the Balance Project, we used Larsen trusses, a fairly common technique in North America now for Passive House construction. The Larsen truss is basically a non-structural truss that hangs off of the building, and is simply there to create the cavity for additional insulation (refer back to Figure 3, and see Figure 4).

In the walls, we used a German window product, Optiwin™ (*http://www.optiwin-usa.com/builders.html*). The unit has aluminum cladding on the exterior and wood on the interior. We selected triple-pane glazing, and all units have an overall U-value of .09. We alternated the solar heat gain coefficient (SHGC) on the glazing based on orientation; all southern glazing is 0.63, everything else is 0.53.

For the Balance Project ceiling and roof, we used pre-manufactured, prefabricated, open web trusses, which were pre-sloped. Our airtightness layer is to the interior of the trusses, basically on the ceiling of the structure. We achieved just over an R-100 insulating value with 36″ of loose cellulose.

Knowing now what we do, we over-insulated the slab a bit, it's between 6″ to 7″ of 2 lb density DPS. It is a shallow, frost-free slab, so no footing or stem wall exists

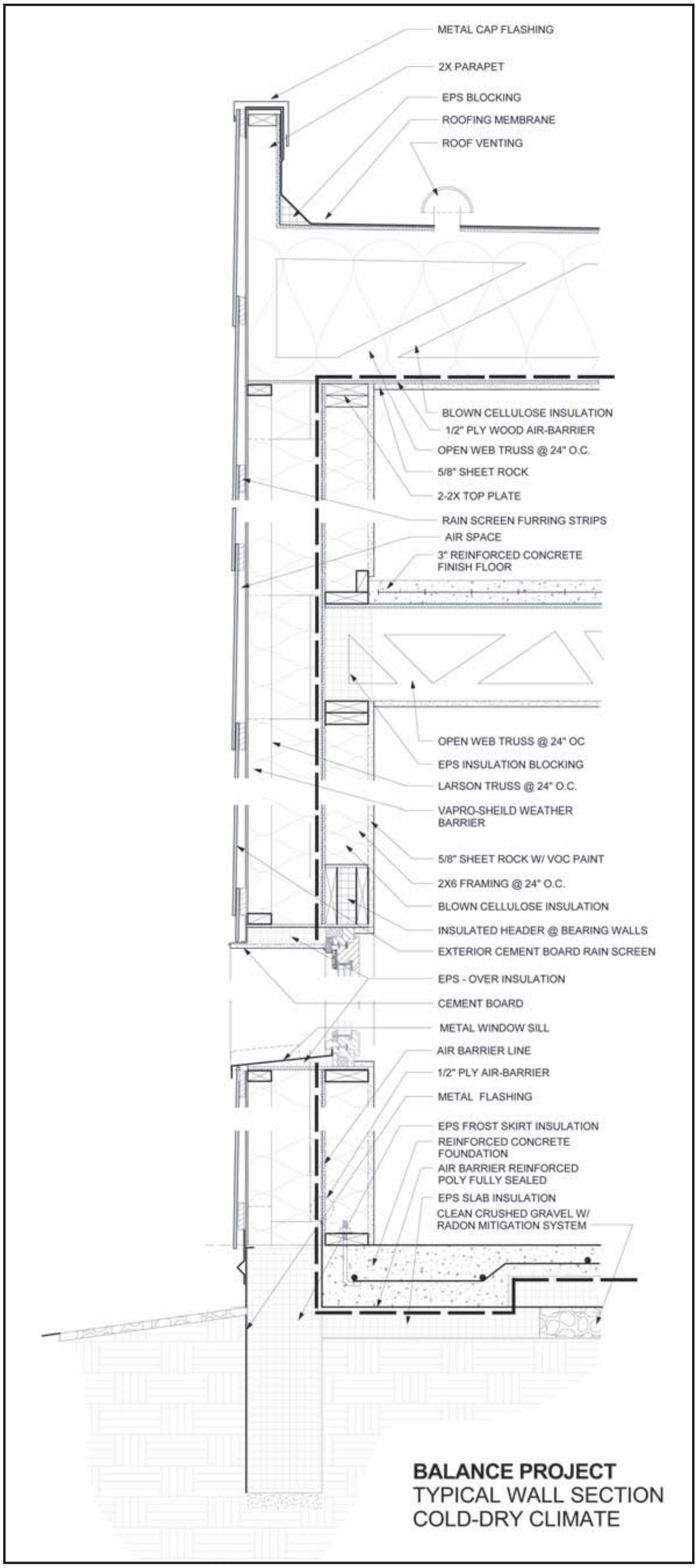

Figure 4. Typical wall detail. Image courtesy Mojarrab Stanford Architects (MoSA).

Figure 5. Insulation at slab. Image courtesy Mojarrab Stanford Architects (MoSA).

per se. We chose a monolithic raft slab; the foundation at grade is protected by a 9″x26″ frost skirt. The slab on grade is 5″. To the interior, we just exposed the concrete as our finished floor surface (see Figure 5).

One thing we did that was fairly innovative with this project, yet extremely simple, is that, on the second floor, instead of using lightweight concrete that then requires a separate flooring surface applied over it, we went ahead and used 3″ of typical 3,000-psi concrete. That gave us quite a bit of additional mass in the building, as well as allowed us to use concrete as our finish surface upstairs. The structure for the mid-level was also open web trusses.

VM: Another notable is that we selected ⅝″ type x gypsum board on the interior of the house. This material selection gives a little more mass than a standard ½″ gyp board would. That was helpful. Again, we didn't want to introduce something that is unfamiliar with local trades because we didn't want to inflate costs with foreign processes or materials.

JS: Anything we can do to increase massing in our climate is a good thing. This can be a challenge – to introduce mass into light frame construction.

One of the other things we've done at the Balance Project that we are really happy with is the integration of mechanical systems for heating and domestic hot water (DHW). We used a very simple unpressurized, open, drain-back system. The project has eight flat-plate solar collectors on its roof, which all year round charge a 700-gallon hot water storage tank. That tank is located on the exterior of the building because we would be overheating the house, due to standby losses, if we had placed it within the home's interior. The tank is insulated to R-40, and has a maximum temperature of 160 degrees. The same water that flows through the panels and tank is also the same water traveling through the radiant floor tubing to heat the slab, when there's a call for heat. It has worked very smoothly. There is a common understanding that, in a Passive House, heating distribution is not as critical due to the little heat loss that occurs; that heat can be distributed through the building through radiation and conduction, rather than convection. For the Balance Project, we did a typical radiant floor zoning layout, with seven different zones. We found that, in the main unit (2,500 sq ft), we can maintain exceptional comfort with only one zone on (refer to Figure 6 for the building's floor plan). This result really did reinforce and prove that heating distribution in a Passive House is not so much of a concern. It is important to note that cooling is not the same because cooling is a lack of energy, and requires more active distribution. It is very rare that we need to heat the home or office; we only had radiant heating on for approximately four weeks this winter. The heating system itself is a minor aspect.

For our DHW supply, the main water supply comes in and goes through a 120-foot copper coil heat exchanger, through the solar hot water storage tank, so that, when the water exits the tank, it's at the temperature of the tank, which is around 160 degrees. From there it goes to a mixing valve, where it is cooled to 120 degrees, and runs through an on-demand electric hot water unit that just checks the temperature to verify how hot the water is. The electric unit is there as a backup in case of a storage tank temperature drop. That system has also been amazingly simple and successful. We have about a 98% solar fraction on heating and DHW. Our system component costs were $10,000; the installation was $5,000. For the 3,400 sq ft space, our system only cost $15,000.

Some of our greatest innovations are also our most simple.

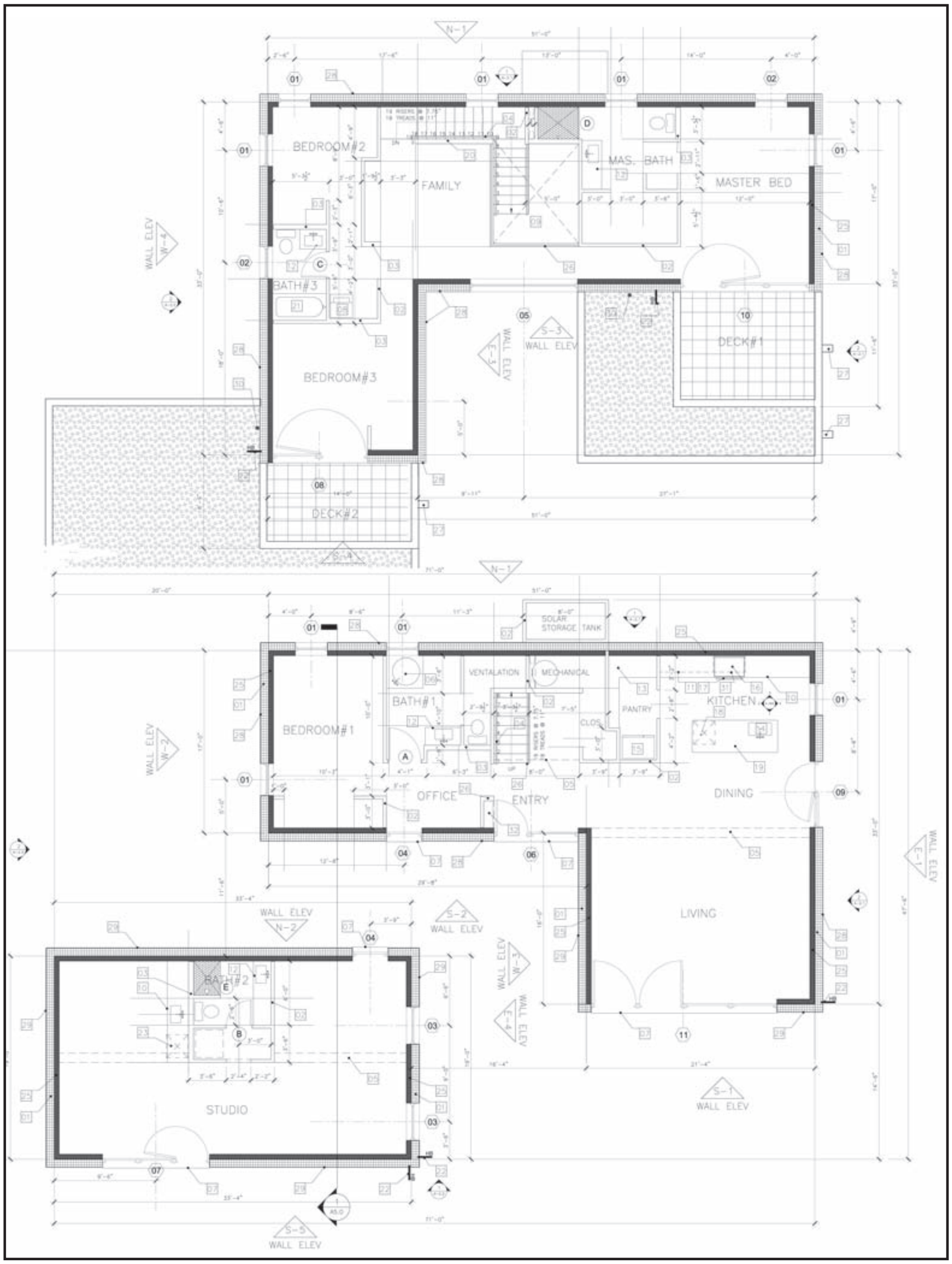

Figure 6. Balance Project floor plan. Image courtesy Mojarrab Stanford Architects (MoSA).

What kind of quantifiable performance data are you seeing from the project?

JS: The entire Balance Project is 100% electric. We have no natural gas on site. Our typical electric utility bill year round is between $48 to $65 a month. That's 100% of the energy usage for both buildings. The energy intensity of Balance is shockingly low.

When you analyze the utility bill, and take into account the $12 service fee, and estimate a $50 average total, the average rate is 9 cents per kWh, roughly in a month, at 555 kWh per month. That accounts for 100% of all energy use. Our office electrical loads probably are 35% to 40% of that total load.

Total energy use annually is 6,259.7 kWh/a, based on actual energy use data from the power company. With a total square footage of the project at 3,450, this means that we use 1.8 kWh per sq ft annually. In Passive House talk, we quantify our energy use based on TFA (Treated Floor Area), which is the open interior floor area. Based on the TFA of the project, we use 2.49 kWh/a sq ft. This is less than ¼ of the allowed limit for a Passive House. So, we could use four times more energy and still meet the Passive House standard!

Almost all of our energy loads are from cooking or plug loads. Both units have 100% light-emitting diode (LED) lighting. With 100% of interior and exterior lights on in the compound, we are only using 180 watts. This is very efficient from a lighting perspective. Vahid and I also have a bunch of computers, printers, and routers running full-time in the office. The energy recovery ventilators (ERVs) also represent a good portion of the base load, as they are running constantly.

VM: The office is very high in energy demand, as many plug loads are on. It's amazing the effect that the consumption of appliances and computers can have on overall usage, as homes become truly high performance.

JS: The LED lighting has been a huge aspect of our performance. Electrical usage can be a tricky thing to plan for. In our experience, PHPP always had a lot of assumptions. We felt it was better to use PHPP to understand the thermal envelope, and not try to go into it to plan for electrical usage. You can end up jumping through hoops just to try and make the software work for the building, or worse make the building work for the software. As with anything, there are distinct limitations to it. It is important to stay grounded and focused on the intent, and avoid the "when all you've got is a hammer everything looks like a nail" scenario. We try to consistently bring common sense to the design process. PHPP is really good for figuring out the performance of a building when it comes to cooling, heating, or spec heating; however, determining the overall solar fraction for DHW can be tricky, as, in the software, a system is designed to be more of a standalone system. Our systems in Balance are totally integrated, so we just put in the minimum performance for solar DHW for certification on PHPP. When all was said and done, our modeled energy usage estimate was way higher than our actual usage.

VM: It's a very broad assumption, or broad brushstrokes, that this PHPP software takes in some categories. Most programs are like it. I'm not criticizing PHPP; rather, by experience, we can understand how buildings perform, and know how to better use software.

What other unique elements of Balance need to be highlighted?

JS: The Balance Project has so many more aspects of sustainability that went beyond energy efficiency. No paint was used anywhere, just zero volatile organic compound (VOC) plaster, which simply is a commercially available sheetrock compound. The elimination of a commute, access to public spaces, local restaurants and trails, and parks are huge aspects to the overall sustainability of the project. No house is going to reduce your environmental footprint like getting rid of a car. Passive House certification was a very important part for this project in a lot of ways, but just as important was the integration of grading, site drainage, and materials usage. The Balance Project has been extremely efficient and successful in those ways, as well.

VM: We used a lot of recycled material in construction. We found a concrete manufacturer in Albuquerque and integrated rejected product into the design. We also picked up recycled fixtures that went into the house.

JS: The home and office interiors are extremely simple, not a whole lot of detail in it. I find that a planned simple interior means that the materials you do use are very effective. All of the tile in the shower, bathroom, and kitchen are remnants. We got an old farm sink and a Japanese soaking tub from friends getting rid of them. Inside the space are simple exposed concrete and sheetrock surfaces. What looks like exposed beams are glue laminates, so we can efficiently use wood scraps and pieces, instead of cutting down one big beam. Around 300 square feet of pavers in the breezeway are from recycled stair treads.

You try to have fun when interior buildings spatially work in simple ways, and don't rely on material finishes to create architectural attractiveness. That's also what impacts the financial feasibility of this type of construction. Nothing is more efficient than good design. It really has to start there. If your spaces are laid out well, are humanistic, and tend to be comfortable spaces, it doesn't require a whole lot of finishes to make it so.

Energy Design Update thanks Jonah and Vahid for sharing the Balance Project with us. To visit Mojarrab Stanford Architects online, go to *http://mo-s-a.com/*. For direct contact, visit MoSA at 928 Shoofly Street, Santa Fe New Mexico, or call 505-577-4295 or 505-412-1242.

IN DEVELOPMENT

An Exercise in Efficiency, Community, and Planning: EcoVillage TREE Neighborhood

In August 1997, the hammers were set down for the final time in the FROG EcoVillage neighborhood, in Ithaca, New York, the first co-housing project in New York state. FROG was recognized by the National Association of Homebuilders in 1996 with an "Excellence in Innovative Housing" award, and all its homes featured passive solar design, triple-pane fiberglass windows, and dense-pack cellulose insulation composed of recycled newspapers. In 2004, all homes in EcoVillage's second neighborhood, SONG, were completed. This second generation of homes featured passive solar design, photovoltaics (PV), solar hot water, high-efficiency condensing gas boilers, Eco-Block foundations, Durisol foundations, Structural Insulated Panels, super-insulated roofs, several types of high-performance windows, straw bale insulation, rainwater collection, composting toilets, drain heat recovery, and salvaged materials.

In 2008, the development of a third residential neighborhood was announced: TREE (*http://ecovillageithaca.org/treenew/*). In June 2012, the community broke ground on the project. The neighborhood will consist of 40 homes, 15 apartments, and 25 single-family residences, with units ranging from 450 to 1,440 square feet, and costing between $80,000 and up to $235,000 for a 3–4 bedroom single-family home (see Figure 7).

Figure 7. View from TREE construction site. Image courtesy Lois Arena.

The occupants of this neighborhood are seeking Passive House (PH) certification for 12 of the 25 homes, as well as the community living center, along with US Green Building Council® Leadership in Energy and Environmental Design (LEED) Gold and ENERGY STAR® certifications. Steven Winter Associates, Inc. (SWA) was brought into the project to support the implementation of the PH design, and to provide third-party verification for these programs.

For a building to be certified as PH, the final design must result in a predicted annual space heating demand no higher than 4.75 kBtu/ft^2 (site energy use), and a total annual source energy use less than or equal to 38 kBtu/ft^2. These thresholds generally result in a 60–70% reduction in overall energy use compared to a home built to current code levels. To ensure compliance and optimal performance, PH design typically includes extensive energy and hygrothermal modeling using the Passive House software (PHPP), THERM, and WUFI to evaluate energy performance, thermal bridging issues, and hygrothermal performance of the building shell. Throughout the construction process (especially for the first few buildings), several inspections will be conducted, along with preliminary blower door testing and onsite training to help the team meet the rigorous airtightness requirements of the PH standard, which is set to 0.6 air changes per hour (ACH) at 50 pascals, approximately 6½ times lower than ENERGY STAR v3.0 requirements for this climate zone.

Because of this community's commitment to sustainability and the extremely high level of efficiency of these homes, the TREE neighborhood has been identified as a Building America research project for 2013. Building America is a residential research program under the

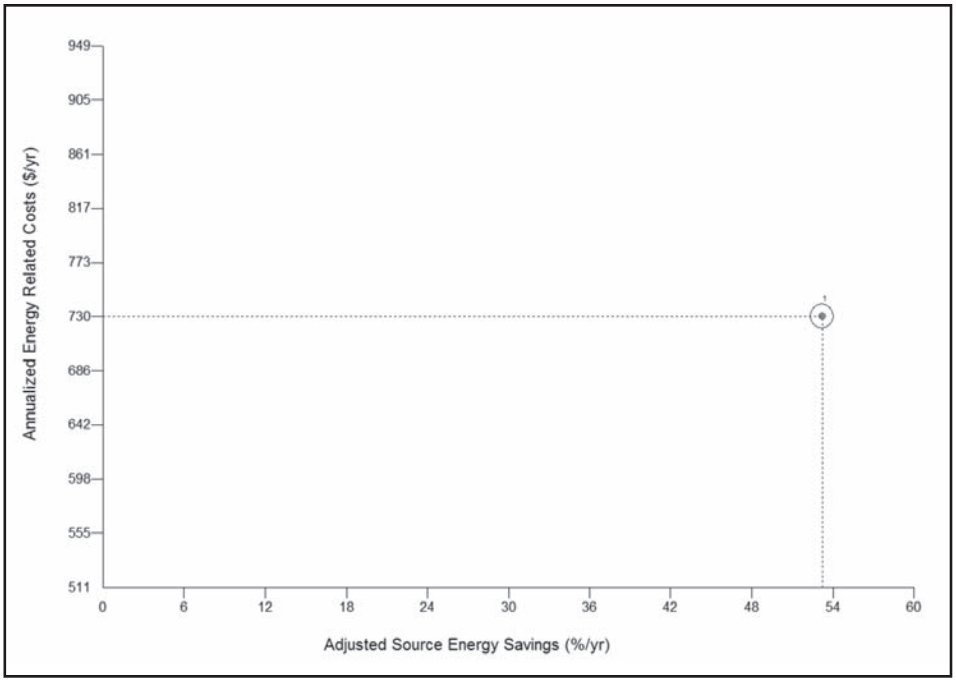

Figure 8. Preliminary modeling results from BEopt™ showing 53% savings over the Building America Benchmark. Figure courtesy Lois Arena.

US Department of Energy, which has a goal of demonstrating how cost-effective strategies can reduce home energy use by up to 50% over current codes. For new construction, this represents a typical home built according to 2009 International Energy Conservation Code (IECC). Preliminary modeling using BEopt™ indicates that EcoVillage's specifications for TREE will result in source energy savings in excess of 50% over the Building America benchmark (see Figure 8).

In addition to analyzing the community's energy use, SWA also intends to gather data to analyze current mechanical system sizing methods for super insulated, low-load homes in cold climates. Actual heating energy use will be monitored and compared to results from currently accepted sizing calculations. The team is hopeful that this research will result in better guidelines for sizing mechanical equipment in highly efficient homes.

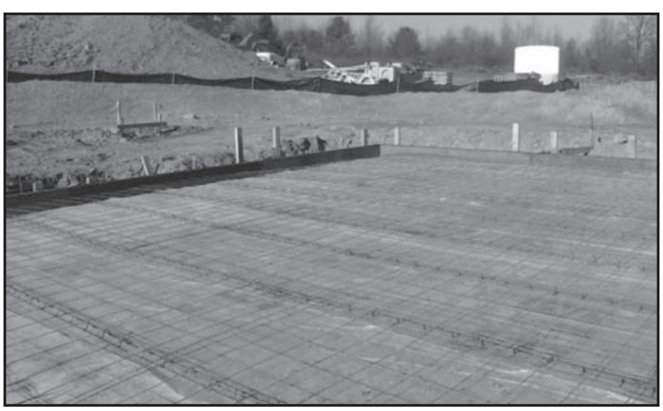

Figure 9. First slab poured 11/2012. There is 5 ½" of polyisocyanurate insulation under the plastic. Image courtesy Lois Arena. Figure courtesy Kendall Carpenter.

SWA will verify system performance with onsite testing that will include short-term blower door and mechanical ventilation system testing and long-term system performance monitoring. Long-term monitoring will focus on heating and cooling season performance at design conditions.

After construction is complete, the following parameters will be monitored and/or measured to determine the actual loads:

- Inside temperature [°F],
- Outside temperature [°F],
- Energy consumption of electric resistance baseboard heaters [Btu],
- Overall heat transfer coefficient of the building envelope assembly [Btu /(h °F ft^2)], and
- Building envelope areas [ft^2].

The actual heating load will be compared to modeling results from currently accepted mechanical equipment sizing software. The monitoring time period will be early spring through winter of 2013.

Beyond the long-term data collection, SWA's participation with TREE also offers valuable insights into high-performance design on a community scale, both for planning, modeling, and certification purposes. ***Energy Design Update*** spoke with Lois Arena, of Steven Winter Associates, Inc., for a more in-depth discussion of these lessons.

How are you resolving the demands from competing certification requirements?

Key among the conflicting issues are the ventilation requirements for the kitchen and bathrooms for both ENERGY STAR and LEED, which require levels as dictated by ASHRAE Standard 62.2. PH prerequisite ventilation levels for these spaces are much lower. PH design

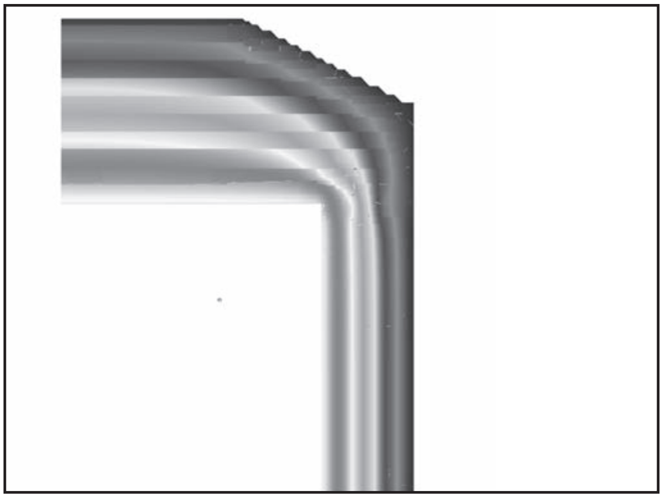

Figure 10. Image from THERM of the Wall/Roof Intersection. Figure courtesy Lois Arena.

puts a much higher emphasis on balanced continuous ventilation systems, not intermittent high levels of exhaust. To solve this conflict, we had to install a system with the capability to boost to the higher levels on demand in those areas. This, of course, changes the energy balances, which you must consider in initial modeling.

Another area of conflict between the programs is mechanical system sizing. While ENERGY STAR requires Manual J calculations, in the "Do's and Don't's" section of Manual J, the author states that these methodologies don't apply to passive solar homes. PH has its own method of calculating mechanical system sizes, which is based on dynamic modeling. Because there is so much mass in a Passive House, and such a low rate of heat loss, the 1% design temperatures dictated by Manual J result in severe oversizing of the mechanical equipment. Therefore, the PH software uses design temperatures considerably higher than those required by Manual J.

The last area of direct conflict we are seeing relates to setback thermostats. ENERGY STAR requires that setback thermostats be installed for compliance; however, in many low-load homes with very small heating systems, we are starting to recommend that setbacks are kept small, or not used at all. Because the systems are sized to the loads, there isn't enough capacity to come back from a very deep setback. It can take hours for a properly sized system to bring a home back up to temperature. On the other side, the rate of heat loss is so low that, even if they want their rooms cooler at night, the temperatures may not drop to the desired levels. What we are starting to see in super insulated homes is that people are keeping their bedrooms cooler, while keeping the living spaces warmer. I believe that even homes meeting 2012 building codes will be so efficient that we'll see similar behavior changes.

Based on the requirement to balance all of the desired certifications against each other, what specifications were selected? What products or methods did you use to meet the specifications?

For the ceilings in the homes, we are installing approximately 25" of blown-in cellulose to achieve an R-90. The insulation value for the wall cavity will be R-52. The community has decided to use a combination of closed-cell foam and cellulose. Triple-pane, UPVC windows were selected with a center of glass U-value of 0.106 Btu/hr °F ft^2) and a solar heat gain coefficient (SHGC) of 0.62. The slab foundations will be insulated with polyisocyanurate rigid boards – R-19 edge/R-35 under (see Figure 9).

For the mechanicals, the group decided on electric resistance heat, no cooling, and solar thermal with electric backup for the domestic hot water (DHW). As a community, they did not want to bring in any fossil fuels to this site. The only options left are electricity and solar thermal. Heat pumps would have been a more efficient heat source, but are also much more costly, and even the smallest heat pumps can be oversized for a Passive House. And, since they felt cooling is unnecessary for their location, the homeowners opted to go with electric resistance heat to save on cost. We were also looking at heat pump water heaters (HPWH), as opposed to the solar thermal systems, but these homes don't have basements, which would mean the HPWH would be close to the living space. Several occupants were concerned that they would be too noisy. More importantly, they wanted to promote more renewable technology. The goals for sustainability are very strong in the community.

This community is unique because the project will test the real affordability of going high performance on a production scale. These are not low-income homes where substantial donations and government subsidies often offset the costs of construction, but neither are they custom homes for very wealthy customers. These homes represent standard homes for the average consumer.

As noted above, you used several software packages: Passive House Planning Package (PHPP), THERM for thermal bridging, and WUFI. How did this analysis interact? Did it drive any changes?

Design of a Passive House can be a very iterative process, and may require several passes with each of these software packages. The PHPP is used to determine compliance with the PH requirements. In order to properly determine compliance, a thermal bridging analysis must be performed for every critical connection in the building – i.e., slab/wall connection, corners, wall/ceiling connection. This is where THERM comes in. These details are modeled in THERM, and the overall heat transfer coefficient of the connection is entered into the PHPP. Depending on whether there is a positive or negative impact on compliance, redesign of that component may be needed or desired (see Figure 10).

A hygrothermal analysis of the building shell, while not required, is encouraged. This is where WUFI comes into play. If the intended design is not predicted to perform well, redesign may be needed. In that case, all applicable THERM models may need to be updated, and that information re-entered into the PHPP.

For this project, the cladding design, spray foam levels, and overall R-values of each component were all influenced by the modeling. One of the biggest benefits of all of this modeling is that it can be used as an educational tool to demonstrate to the construction team how a super-insulated shell has to be built to handle moisture and thermal bridging issues. Passive House is so different from conventional construction that the first one for any member of the team involves a huge learning curve.

What lessons have you learned from working on this community-scale project?

We have been working with EcoVillage on the TREE neighborhood (*http://ecovillageithaca.org/treenew/*) since January 2011. The big difference between this community-scale project and others I have worked on is the decision-making process. Most co-housing communities encourage a participatory process where future residents participate in the design of the community so that it meets their needs. EcoVillage actually takes this a step further and requires consensus from the group before a decision is finalized. Because of the need for consensus, the process can be quite lengthy, and redesign and the evaluation of several iterations may be necessary.

Committees are often formed to help distill the information down so everyone understands the various choices they are being asked to make. If committees are involved, it is imperative that the PH consultant be kept in the decision-making loop.

Also inherent to co-housing projects is a strong focus on community and the features that will foster this, such as porches, front doors, and windows facing the common space. While there are wonderful features to incorporate into any design, they may compromise the energy performance of the homes, and solutions should be considered at the beginning of the process.

Normally, in a production-scale development, all decisions concerning materials, equipment, efficiency levels, etc., are made far in advance of construction starting. Because co-housing encourages owner input, changes are still being considered and made, even as the builder is breaking ground. This can result in a significant amount of additional modeling and architectural work.

The major benefit of working with this co-housing community is that the group is very solutions oriented. They are all very committed to creating a sustainable, efficient community. They want to use the community as an education center for others to learn more about co-housing and sustainable design and construction. This makes it a very nice fit for Building America, as part of that research includes post-occupancy utility bill analysis, interviewing the builder and tradesmen about what worked and what didn't, and producing guidelines for others to benefit from going forward.

Has building to such a high performance level on a community-scale presented any other issues?

Selection of the final wall design was highly influenced by the fact that an entire community of homes needs to be built, as opposed to just one. Issues concerning the framing process included speed, reproducibility from one home to the next, and cost. Initial designs incorporating Larsen-style trusses hung on the exterior of a conventional structural 2x4 wall called for spray foam to be applied from the exterior, which would potentially require tenting of the homes to prevent overspray on neighboring buildings and equipment. Seasonal considerations included concerns about drying in the homes quickly and the ability to heat them so the trades could continue working in inclement weather. Decisions about the final design were highly dependent on the number of homes to be constructed, the speed at which that needs to happen, and the overall cost.

Any information about expected results?

We hope that this research effort will result in the successful implementation of a cost-effective systems package that achieves, at a minimum, performance in excess of 50% over the Building America Benchmark.

We also anticipate that heating loads will be lower than predicted, while energy used for lights, appliances, and miscellaneous electric loads will be higher. Several other PH consultants who have performed on-going monitoring of these types of homes are finding this trend.

Energy Design Update thanks Lois for pulling back the curtain on the TREE project, and sharing her early findings with us. Watch for a follow-up report as data are gathered and analyzed.

Lois Arena is a Certified Passive House Designer. She serves at Steven Winter Associates, Inc., where she also works on the Department of Energy's Building America program, and conducts advanced systems research. She received her MS in engineering from the University of Colorado's Building Science Program, and possesses over 17 years of experience in the building science field. Arena may be reached at Steven Winter Associates, Inc., 61 Washington Street, Norwalk, CT 06854, via phone at 203-857-0200, ext. 214, or via e-mail at *larena@swinter.com*.

IN BRIEF

Fifth Public Comment Period for LEED v4 Open

On October 2, 2012, the US Green Building Council® (USGBC) announced the opening of the fifth public comment period for the proposed update to its Leadership in Energy and Environmental Design (LEED) green building program, LEED v4. This comment period will close on December 10, 2012.

In a press release from USGBC, Scot Horst, Senior Vice President, LEED, USGBC stated that "LEED v4 will have the greatest impact of any rating system we've developed by focusing on building performance and rewarding innovative product manufacturers who offer best in class products. LEED v4 will help change the way project teams think, integrate, plan, execute, and operate their buildings."

As technology and advances in building science and building techniques lead to better performing buildings, USGBC felt the need to advance their own performance measurement system. Proposed changes to LEED v4 aim to push the envelope on energy efficiency. Notably, LEED v4 will allocate nearly 20% of all points to optimizing energy performance over ASHRAE 90.1-2010.

Major changes noted in the LEED v4 draft include impact categories and increased technical rigor. New impact categories reward positive impacts, and include credits for green vehicles, protecting or restoring habitat, demand response, environmental product declarations, disclosure of raw materials extraction and material ingredient reporting, construction and demolition waste management, and daylight. These categories will serve as the driver for determining the technical requirements of the rating system, and to assign points to each credit. According to USGBC, projects have "incentives to pursue higher-point-valued credits and higher certification levels and achieve better environmental, economic, and social outcomes."

In addition, USGBC listed the following updates included in the proposed LEED v4:

- Places a renewed importance on integrative process and the benefits of early design analyses and project team collaboration.
- Includes a Location and Transportation category that rewards projects for using existing development infrastructure, embracing the principles of walkability, connectivity, density, and quality alternative transportation.
- Defines high performance site design by increasing requirements for rainwater management, heat island reduction, and light pollution reduction, while significantly reducing the LEED documentation associated with each credit.
- Expands the scope of water efficiency to total building water use.
- Requires building level water and energy metering to understand and manage performance.
- Increases emphasis on energy and the associated impacts by allocating 20% of all points to building energy efficiency.
- Encourages enhanced building commissioning for greater energy and operational performance.
- Brings the benefits of smart grid thinking to the forefront with a credit that rewards projects for participating in demand response programs.
- Supports a lifecycle approach to product and material specification through a revised and strengthened Materials and Resources credit category.
- Drives leadership in the manufacturing sector by promoting innovative reporting tools and programs.
- Encourages support of products extracted and manufactured from domestic and local sources.
- Takes a more performance-based approach to indoor environmental quality to ensure improved occupant comfort.

Beginning in November, USGBC ran a LEED v4 beta test that includes user review and testing of LEED v4 forms, reference guide materials, submittal requirements, and the certification process. The beta testers will also rate USGBC's new system of reporting, which is aimed at simplifying the certification review and documentation process. To access LEEDv4 and make comments, go to *https://new.usgbc.org/leed/v4/#*.

Cleantech Open Announces 2012 Winners

During its 2012 Global Forum, held November 8–9, 2012, Cleantech Open (*http://www.cleantechopen.com/app.cgi/content/home/index*) selected winners from across the country competing for the National

Grand Prize, and recognition as the up-and-coming cleantech startup.

HEVT, of Chicago, Illinois (*http://www.hevt.com*), took home the 2012 National Grand Prize for their development of an alternative to induction and permanent magnet motors. The HEVT patented switched reluctance motors (SRMs) could provide a high-performance alternative to induction and permanent magnet motor/generators. Currently, HEVT technology is used to provide electrical assist to bicycles (eBikes), but the company touts that SRMs disrupt current motor technology from approximately 150 watts scalable to one megawatt or more, and could serve in the future to power air conditioners and other major mechanicals. The product also boasts reduced cost volatility due to the use of zero rare earth minerals.

GR Green, of Burnaby, British Columbia, Canada, took home the 2012 category award for Green Building. GR Green developed and patented a new process to produce roofs from recycled plastic and limestone, harnessing waste plastic product to make an affordable roof rated at 50 years. The product uses a proprietary process, which makes the recycled plastic pliable and flexible, and can be installed with nails. Full-scale product production is planned for fall of 2013 on two separate roof lines, "GR GREEN Cedar™," which mimics cedar shakes, and "GR Green Slate™," which mimics slate. All products meet Built Green™, US Green Building Council's® Leadership in Energy and Environmental Design (LEED), and "Cradle to Cradle" standards. Products have been tested, passing: Weathering Test, ASTM G-155 for 2,000 hours; Wind Uplift Resistance Test, CCMC Section 6.4.6 – passed the required interval wind load to 170 km/hr; Dynamic Water Infiltration Test, CCMC Section 6.4.6; Heat Aging Test, CCMC Section 6.4.12; Freeze Thaw Test, CCMC Section 6.4.13; Dimensional Stability Test, CCMC Section 6.4.1; Water Absorption Test, CCMC Section 6.4.2; Flexural Strength Test, ASTM D790-07; Traffic Load Test, ASTM E661; and, Nail Pull Through Test, ASTM D1037. Visit GR Green at *http://www.grgreen.com*, or contact GR Green Building Products, Inc., #117 – 3191 Thunderbird Crescent, Burnaby, BC V5A 3G1, via phone at 1-778-855-2549, or via e-mail at *info@grgreen.com*.

Rentricity of New York won the 2012 category award for Renewable Energy for building a smart and sustainable water grid. SiNode of Illinois was recognized in the category of Energy Efficiency for developing a silicon-based anode for lithium-ion batteries, which significantly increases energy capacity and reduces charge time. Red Ox Systems was awarded 2012 Category Winner for Air-Water-Waste, and Sustainable Systems International won the National Sustainability Award for its off-grid, solar-powered milk chiller. For a full list of all finalists, and links to category winners, go to *http://cleantechopenglobalforum.com/meet-the-finalists/*.

Founded in 2006, the mission of the Cleantech Open is to find, fund, and foster entrepreneurs who have big ideas that address today's most urgent energy, environmental, and economic challenges.

Environmental Leader and BASF Release EL Insights: Green Building Materials Report

On November 1, 2012, Environmental Leader released its EL Pro on Green Building Materials, sponsored by BASF – The Chemical Company. While green construction growth has slowed, the report predicts a return to former growth levels by 2016. Overall, EL Pro stated that emerging green building products are not only helping improve environmental impacts, energy efficiency, waste reduction, and resource impacts in new construction, but also in deep energy retrofits. The report cites resource conservation, energy efficiency, recycled content, recyclability, durability, low emissivity, low toxicity, and moisture protection ability as key criteria for builders to evaluate when selecting appropriate building materials. The Green Building Materials report listed the following as resources when selecting products:

- ENERGY STAR®: This US Environmental Protection Agency and Department of Energy program designates energy efficient products (*http://www.energystar.gov/*). Federal guidelines require the use of ENERGY STAR insulation, doors, windows, and skylights in government buildings.
- National Fenestration Rating Council: Covers windows, doors, skylights, and curtain walls (*http://www.nfrc.org/*).
- Cool Roof Rating Council Labeling Program: Lists roof surface products with their radiative values (*http://www.coolroofs.org/aboutthecrrc.html*).
- Blue Angel: Covers products including insulation, PV panels, paints, wallpapers, and floor coverings (*http://www.blauer-engel.de/en/blauer_engel/index.php*).
- M1 Emissions Classification of Building Materials: Covers products used in work spaces, including gypsum boards, chipboards, plywood, steel plates, and blocks.
- SCS® Recycled Material Content Standard V5-0: Covers products including ceramic tiles, composite wood goods, carpets, and textiles (*http://www.scscertified.com/docs/SCS_STN_RecycledContent_V5-0_100311.pdf*).
- Indoor Advantage™ and Indoor Advantage Gold™: Covers products including ceiling tiles, wall panels, wall/floor coverings, sealant, and adhesives (*http://www.scscertified.com/gbc/indooradvantage.php*).

- Green Squared©: Covers ceramic and glass tiles and calCOMPliant: Covers composite wood panels (*http://www.scscertified.com/gbc/greensquared.php*).
- NSF® International Standard 14: Covers piping components and related materials (*http://www.nsf.org/business/plastics_piping/faq.asp*).

Environmental Leader cited BCC research predicting that the US market for green building materials will grow to nearly $31.4 billion by 2014. Structural materials are projected to make up $20.8 billion, and interior materials $5.8 billion. Meanwhile, worldwide certified green building space is set to increase from 6 billion square feet in 2010 to 53 billion square feet by 2020. By that year, about 80% of certified space will be in commercial buildings, up from 73% in 2010 – and most commercial certifications will go to existing, rather than new, buildings. Singling out windows, EL Pro predicts growth in the use of smart glass, and PVC and fiberglass as the best window frame technology for conductivity, while also noting the importance of thermal breaks, regardless of material.

NREL Announces Updates to National Solar Radiation Database

The US Department of Energy's (DOE's) National Renewable Energy Laboratory (NREL) released a 20-year updated version of the US National Solar Radiation Database, which includes 2006–2010 data for the first time. According to an NREL press release, the new version features improved cloud algorithms for modeling solar radiation data, and an improved State University of New York (SUNY) model for gridded data based on satellite observations. The update also calculates uncertainty factors for stations, to gauge suitability of data. The National Solar Radiation Web-based technical report provides critical information about solar and meteorological data for 1,454 locations in the US. Numbers from the database are also used to build NREL's Typical Meteorological Year (TMY) data sets, PVWattsTM calculator, Solar Power Prospector, and System Advisor Model (SAM). Solar system designers, building architects and engineers, and renewable energy analysts rely on solar radiation data to plan, locate, and size solar electric systems for homes.

Access the report at *http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2010/*, "National Solar Radiation Database 1991–2010 Update: User's Manual." The update is available in three forms:

- A station-based data set at the 1,454 Weather Service stations (860 of the stations have serially complete data records).
- A 10-km gridded data set (the Clean Power Research SolarAnywhere® v2.2 product based on the SUNY model) for the continental US and Hawaii from 1998–2009 (solar radiation values only).
- A solar-only enhanced research data set for the 1,454 weather observing stations.

For further information, contact Steve Wilcox, National Renewable Energy Laboratory, at *Stephen.wilcox@nrel.gov* or 1-303-384-7785.

Rocky Mountain Institute Issues Retrofit Initiative as Part of 2050 Challenge

On November 28, 2012, Rocky Mountain Institute® (RMI) featured Elaine Gallagher Adams, architect and Senior Consultant in the Built Environment Practice at RMI, discussing the Portfolio Energy RetroFit Challenge. The Challenge is part of RMI's "Reinventing Fire" vision for buildings, which aims to make US building stock 50% more efficient by 2050. Gallagher Adams promoted expanding application of the lessons learned in energy retrofits over 30 years to a much larger group of buildings. "How can we do this on a much larger scale beyond one building at a time?" asked Gallagher. Gallagher emphasized a shift in view, from looking at an individual building to a single portfolio of buildings as a valuable asset, and to move from there on how to roll out energy retrofits across all of the buildings in that portfolio. Gallagher also issued a call for case studies of entire building portfolios, instead of individual buildings. To learn more about the challenge, and to participate, go to *http://www.rmi.org/retrofitchallenge*.

According to RMI, six broad elements are critical to speeding energy efficiency gains in US buildings:

- Unleash entrepreneurial thinking;
- Make energy use more transparent;
- Provide easy-to-access, low-cost financing;
- Train and educate;
- Upgrade to next-generation building efficiency policies; and

Align incentives between utilities and customers.

"Once you build a building the wrong way it will continue to gobble resources for decades," said Amory Lovins, Chairman and Chief Scientist at RMI.

To view RMI's building homepage, visit *http://www.rmi.org/Buildings*. To view RMI's introductory video on high performance by integrated design, go to *http://www.rmi.org/built_environment_methods*.

IN PRACTICE

High Performance Window Installation – Challenges for Durability and Opportunities for Thermal Performance (Part 2)

Florian Speier

Last month, Florian Speier, of Zola Windows, discussed the overall performance implications of windows and their installation. This month, Florian discusses materials and techniques for installation.

Window Install

A high performance window install can be divided into three phases: rough opening preparation, window install, and over-insulation.

Rough Opening Preparation

As we are moving the window from the traditional outside flush installation onto the middle of the wall, the rough opening preparation becomes much more important, as the sides may now be exposed to water in regular operation. Using flashing tapes is still an option, combined with careful returns of the façade materials. However, in the last year, we have seen more and more of our customers turn to vapor permeable fluid-applied flashing systems, such as Prosoco's R-Guard. The appeal here is that a fluid-applied install is much less prone to problems in the corners of the rough opening, and also eliminates the potential for mistakes in lapping the flashing tape. At the same time, a seamlessly flashed rough opening brings the airtight layer either out to the window in an outside drying wall assembly, or in to the window in an inside drying wall assembly, which allows for an easy connection between window and airtight layer (refer to Figure 11). "As a builder, we initially approached both window installation at the center of the wall assembly and liquid applied flashing with skepticism," said Sam Hagerman, co-owner of Hammer & Hand and President of the Passive House Alliance US. "But now there's no going back. We wouldn't do it any other way. A conventional window install involves dozens of potential failure points for reverse lapping or air leaks. We've eliminated all of that in favor of a seamless, more foolproof system."

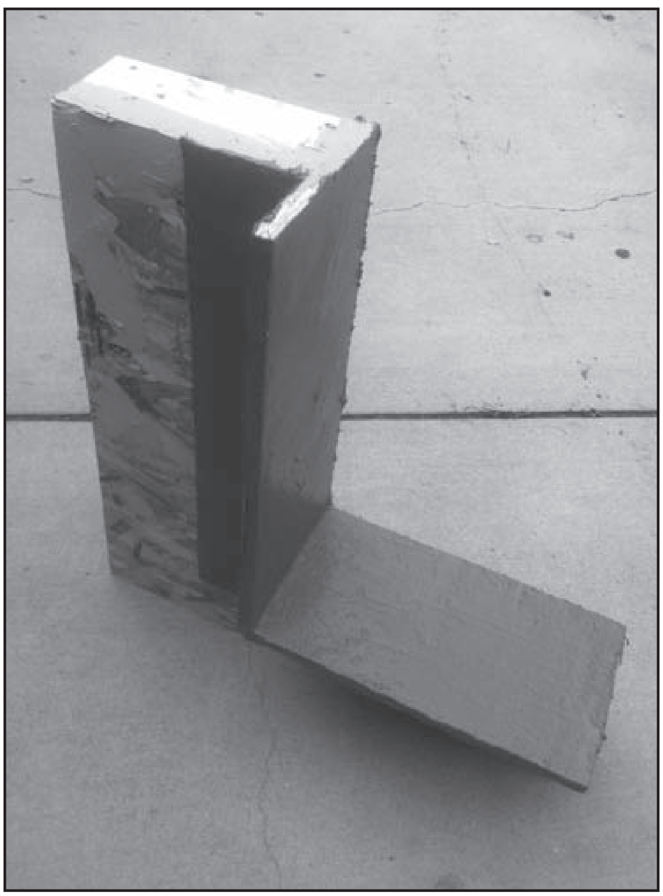

Figure 11. Corner sample with Prosoco wet flashing. Additional insulation will be added to this Passive House Wall assembly to the outside of the OSB, the window buck allows the window to be centered over the outer insulation. Image courtesy Zola Windows.

Window Install

The actual window install has four objectives: 1) physically attaching the window to the wall assembly,

Figure 12. Z bracket installation on a Zola Thermo Wood window. Image courtesy Zola Windows.

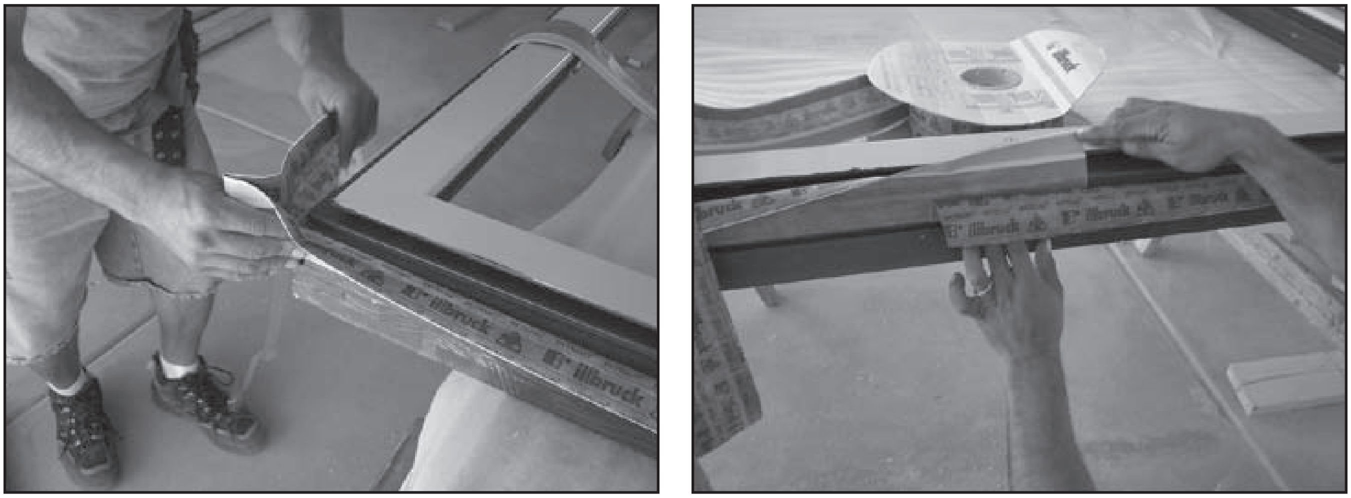

Figure 13a and 13b. Corner treatment: Illbruck Duo tape shown. Image courtesy Zola Windows.

2) creating a waterproof connection between window and prepared rough opening, 3) insulating the gap between window and rough opening, and 4) creating an airtight connection between window and wall.

The physical connection between window and rough opening is mostly done by manufacturer recommended or provided screws or clips. Here at Zola, we use German-made window install screws for all operable units, as the screw-head will be hidden between sash and frame. For fixed units, we use a Z-bracket that keys into the window frame (see Figure 12).

To achieve the three other objectives – waterproofing, gap insulation, and airtight connection, several approaches are viable and promoted by the various tape and sealant manufacturers. It is crucial to keep in mind that we must not create a vapor barrier sandwich. We need to think about the gap between window and wall like a mini wall assembly – it needs to be able to dry either to the inside or outside, as appropriate for your climate.

Specialty tape manufacturers, notably SIGA, Tremco Illbruck, and pro clima, offer tapes specifically for the outside waterproofing and the inside airtight connection. Many of these come in special varieties, depending on your façade material – they can be embedded, for example, in stucco. The actual gap is then filled with low expansion foam to increase the thermal performance of

	Air tightness	Insulation	Weather Proofing
Tape / Foam / Tape	Specialty tape to window butt or face	Spray applied foam or stuffed with mineral wool	Specialty tape to face of window
Tape / Foam / Compression tape	same	same	Compression tape at butt or face, allowing full install from inside
3 in 1	Single compression	tape on butt side	fulfills all functions
Caulk / Air / Caulk	Specialty caulk	Air space	Caulk / w drainage points

Figure 14. Typical install strategies. Image courtesy Zola Windows.

the install. If using tapes, special care must be taken at the corners, and most manufacturers provide corner folding instructions and require you to use one continuous piece of tape, with a significant overlap at the head (refer to Figures 13a and 13b).

Another approach that is very common in Europe is the use of three-in-one tapes, available in the US from Tremco Illbruck with their ExoAir Trio product. Essentially a pre-compressed foam tape, it is attached to the butt side of the window frame prior to install, and expands slowly after installation to seal the joint. Special impregnations make the tape airtight on the inside and waterproof on the outside. This can be a time saving option for experienced contractors, but requires careful and precise application. The tape will only be airtight if it is not allowed to expand farther than its specifications, which are typically ⅝". If the rough opening is planned to be ½" bigger on all four sides than the window unit, the framing must be very precise to ensure a proper seal. Special care is also needed around corners.

Fluid-applied flashing manufacturers, like Prosoco, also offer companion products for the rough opening to window connection (see Figure 14).

Prosoco's R-Guard AirDam is a high performance sealant that is specifically designed for this application. Our customers have successfully used this product on the inside for an air and watertight connection, and one the outside, while leaving drainage holes at the bottom to shed water. The gap between rough opening and window then remains hollow. While such a still airspace does not perform anywhere near as well as a foamed gap for insulation purposes, the argument made by the manufacturer is durability. The cavity can always dry out, and will always perform better than wet foam if an outside tape fails. Additionally, over-insulating the frame, described below in more detail, can lessen the impact of the uninsulated installation gap.

Over-Insulation

Over-insulation refers to the practice of adding insulating material, typically foam, to the window jamb covering up part of the frame, and thereby increasing overall thermal performance. This practice is possible depending on the design of the window, its swing direction, its hardware location, and the design of the aluminum cladding in the case of clad windows. European Tilt and Turn windows can often be over-insulated by up to three inches on the outside, covering nearly the entire window frame. In the case of clad windows, versions with recessed cladding are available from some manufacturers, so that the over-insulation can connect directly to the wood frame underneath. Some over-insulation will also be possible on the inside, if enough space is left for hinges.

American-made windows tend to be outswing in operation, thereby somewhat limiting the options for over-insulation on the exterior. Over-insulation to the interior is often possible, but care must be taken to leave enough room for the crank handle to be operated and held comfortably by the user without hitting their knuckles on the window board.

Timing of the Window Install

With the window moved to the center of the wall, in theory, we gain a lot of flexibility when to install the windows. A late window install has several advantages – the windows are less prone to get damaged during the remaining construction, and the often long lead times for high performance windows become less of an issue. Some of the above described install methods, especially if a foam tape is used, or the outside tape is replaced by a compression tape, allow for the entire façade to be finished prior to window install. In Europe, we see projects with windows being installed mere weeks prior to occupancy. This is typically not possible in the US, as most jurisdictions will require the windows be installed by the time of the framing inspection. However, we have seen several projects this year where inspectors were open to the concept of pushing the install back. As high performance window installs become more common, I hope a later window install also becomes common practice.

With proper understanding of all of the options, and sound thermal analysis of the chosen install route, high performance window installation becomes predictable, durable, and easy to carry out in the field. It does, however, take an open line of communication and good planning between the architect, contractor, and window manufacturer.

Energy Design Update extends a huge thanks to Florian, and to Hammer & Hand, for lending their experience and expertise in this article.

Swiss-trained architect Florian Speier founded Zola Windows in 2011. Unsatisfied with the selection of windows available to his architecture clients, Florian partnered with European manufacturers to design extremely energy efficient and airtight windows and doors appropriate for Passive House and Net Zero Homes. Visti Zola online at *http://www.zolawindows.com/*. To visit Hammer & Hand online, go to *http://hammerandhand.com/*, or call 1-503-232-2447 for the Portland, Oregon office, or 1-206-397-0558 to reach the Seattle, Washington office.