The New O’Neill Passive House Retrofit

**Overview:** Located just blocks off the plaza in historic downtown Sonoma, PassivWorks has built the first Certified Passive House™ in California and the first Certified Passive House™ retrofit in the country. Homeowner Catherine O’Neill wanted a comfortable and environmentally-friendly home. Upon learning the advantages of the Passive House Standard, she decided to create a model home and help set a new benchmark for energy efficiency in America.

**Design Challenges:** Constructed in 1960, the ranch house was originally two structures linked by a covered breezeway. Site conditions and zoning required that the existing footprint and foundation remain. The two existing uninsulated slabs were of different heights and needed different insulation solutions. Solar orientation was poor and limited due to shading by adjacent buildings and trees. Single story, North-facing, ‘U’-shape configuration not optimal from a performance standpoint.

**Location:** Sonoma, CA

**Climate Zone:** Two; Mixed Dry (CEC)

**Size:**
- Existing 1,933 s.f.
- Expanded to 2,357 s.f.

**Levels:** 1 Ranch

**Construction:** Residential

**Walls:** R-31: 2x6’s added to 2x4s, dense pack fiberglass, ext EPS hdbd.siding-rainscreen

**Roof:** R-74: metal roof over EPS; 15” BIBS dense fibergl, drop ceiling

**Floors:** R-12-20: 4” EPS over exist. slab, VB, sprung floor w/hardwd. or tile

**Mechanicals:**
- UltimateAir RecoupAerator ERV with solar thermal coupled water-to-air heat exchanger for supplemental heating,
- Mitsubishi Mr. Slim heat pump for backup space heating and cooling,
- Heliodyne drainback solar thermal system with Rinnai tankless gas water heater for DHW backup.
- EcoSmart bioethanol fireplace insert.

**Windows:** Optiwon 3 wood, triple pane R-9; SHGC 0.52 “overinsulated” with 1.5” EPS

**Cost/Benefit Analysis:** 15% Passive House premium over regular construction, 9 year estimated recoup rate.
Design Solutions: Site
The existing house was a run down, 1,933 sf eyesore without a street-front entry and in an odd configuration consisting of two separate structures connected by an outdoor breezeway. Cathy had purchased the home based on its location and its “good bones.” Zoning requirements and expansive soil on the site required that the footprint of the building be unchanged and that the existing uninsulated concrete slab floors remain. The solar orientation of the house was not ideal and there was a 30-foot Chinese Pistache tree that would have to be moved in order to make room for the new covered porch on the west side. Architect Jarrod Denton devised a beautiful solution to the odd structure by connecting the two existing parts with a long, angled corridor that would house the new kitchen and frame the courtyard, making the house into a U-shape and adding an additional 400 sf to the house.

Design Solutions-Envelope:
Builder Rick Milburn decided on the Pressure-Equalized Rain Screen Insulated Structure Technique (PERSIST) system to create an airtight envelope. This method was developed in the colder climate of Canada and although he knew it might be overkill, he decided to err on the side of caution as a Certified Passive House retrofit had never before been successfully executed in the US. The building’s shell is comprised of:

Renewables: 2.15 kW grid-tied PV system, Heliodyne solar collectors and storage, drainback system.
Resource conservation: OVE framing, FSC siding and hardwood flooring, engineered framing lumber, low cement, high flyash concrete, locally fabricated casework, salvageable and recycled materials, low flow plumbing fixtures, EnergyStar appliances, LED and CFL lighting throughout, drought resistant landscaping, permeable hardscaping, rainwater capture
• Grace Ice & Water Shield® over 1/2" FSC plywood sheathing
• InsulFoam® R-Tech IV expanded polystyrene (EPS)
• InsulFoam® IX EPS
• Aerogel Spaceloft
• Optima® blow-in blanket system (BIBS) fiberglass insulation
• Stego® Wrap vapor barrier
• Protecto Wrap® Super Stick Building Tape™

The walls have a total of 3 3/4” of EPS while the roof has 2 1/2”. Milburn chose InsulFoam for multiple reasons including the proximity of the plant (less than 50 miles), its use of post-consumer and industrial waste, and the ability to return any waste material back to the plant for re-entry into the manufacturing stream.

Because air leakage is a big concern in high performance buildings, all penetrations through the shell were secured with boots, taped to the vapor barrier and filled with foam. In the interior walls, all electrical and plumbing pipes and cables were run through holes bored through the framing, all punctures to the exterior booted as on the outside.

The wall cavities were insulated with between 3 1/2” (existing conventional 2x4 framing) and 5 1/2” (new OVE 2x6 framing) of blown-in high density fiberglass insulation. The ceiling/conditioned attic space received 15 1/2”. For interior walls not linked to the outside, typical R-13 fiberglass batts were installed for noise reduction.

**Design Solutions – Mechanical**

The house utilizes UltimateAir’s RecoupAerator energy recovery ventilator (ERV) with Merv 12 filtration for the basis of the mechanical system with a Mitsubishi Mr. Slim mini-split for the supplemental heating. Exhaust ducts in the moist areas of the house pull moisture and odors before the ERV strips the energy from the outgoing airstream. The RecoupAerator has a 95% efficiency rating at full flow and can then preheat (or cool) the incoming fresh air stream with the recovered energy. The heat is supplied by a water-to-air heat exchanger with the water coming from the Heliodyne solar thermal system mounted on the roof. If the water in the 80-gallon storage tank drops below 110°F, the backup Rinnai tankless on-demand heater kicks in to bring it back up to 120°F.

“Passive House takes you back to the fundamental principles of shelter: orientation, seamless enclosure and insulation. Our forbearers utilized these principles instinctively. As technology advanced we began using it to replace smart thinking instead of enhancing it. Passive House does just the opposite and does it in a way that is not only unobtrusive but which promotes a simple, timeless beauty.”

Jarrod Denton
Architect
Lessons Learned:

“PHPP provides wonderful immediate feedback on cost-benefit analysis of envelope measures if it is supplemented with parametric analysis, and Excel is a great platform for this. The greatest economic value of the Passive House analysis process is likely this.”

- Graham Irwin

Passive House is quite beneficial even in the mild climate of Sonoma, CA. Energy savings are impressive, as is the comfort and indoor air quality. Solar access, orientation and building form play a large role in the insulation package required, and triple pane windows are enormously beneficial for winter performance, even in coastal Northern California. Uninsulated slabs do provide cooling benefit in summer, but this is more than offset by the heating impacts in winter. The limited slab insulation was the Achilles heel of this project, forcing higher levels of wall and roof insulation than otherwise optimal. Of the envelope upgrade measures, the most significant space conditioning savings (compared individually to code minimum) were, in order, due to slab edge insulation (R16 vs R0, 62%), air tightness (0.4 ACH<sub>50</sub> vs 6 ACH<sub>50</sub> assumed, 50%), top of slab insulation (R16 vs R0, 40%), walls (R34 vs R13, 31%), heat recovery (83% vs 0, 27%), window U-value (0.15 vs 0.4 Btu/hr.ft<sup>2</sup>.°F, 22%), and roof (R64 vs R30, 21%). As confounding as it seems, the existing pre-retrofit building could be constructed under current California building code with the exception of a requirement for double pane windows.

What really worked well?
Passive House envelope, solar thermal water heating

What wouldn't you do again?
Place the solar thermal tank within the building envelope, it causes cooling problems in summer.

Enjoying the finished project:
Since occupying the home in October of 2010, homeowner Cathy O’Neill has been thoroughly enjoying her state of the art modern farmhouse “jewel box”. Intended for her permanent residence for the rest of her life, the home’s durability and fantastic indoor air quality are distinct advantages. The home is incredibly quiet and yet, when she wants to feel the outdoor breeze, she can open her 16’ lift and slide door to the outside and enjoy the sound of her courtyard fountain (operated by a small solar pump). Her energy savings are real and tangible, averaging less than $15/month. “My favorite thing about my house is that even though it is unbelievably green, it doesn’t look like one of those geeky architectural experiments”, says Cathy.

THE TEAM

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