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INDUSTRY NEWS

A (Near) Zero-Energy Rehab

Of the twelve building projects selected to take part in the Canada Housing and Mortgage Corporation (CMHC) EQUilibrium Initiative (see "News Briefs," *EDU*, July 2006 and "Net-Zero in Canada," September 2008), all but one involved new construction. The lone exception is the recently completed Now House project in the working-class East York section of Toronto (see Figure 1).

The Now House project was conceived by the Toronto organization Work Worth Doing, a collaborative group of sustainable building experts and homeowners led by Toronto design consultant Lorraine Gauthier. Its goal, according to Gauthier, was to apply sustainable building practices to mid- and lower-income housing. "When people see these kinds of ideas in a house they're familiar with they can visualize them in their own homes," she says. "In an expensive new model home they just seem completely out of reach."



Figure 1. As seen from the street, near-zero-energy Now House is all but indistinguishable from other modest 60-year-old houses in its Toronto neighborhood.

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The House

Between 1941 and 1946, the Canadian-government-owned Wartime Housing Limited – the direct ancestor of today's CMHC – built at least 30,000 small, simple story-and-a-half bungalows for munitions workers and returning veterans. After the war, the plans were made available to builders at low cost, and hundreds of thousands of additional houses were built, some as recently as the 1970s. It is estimated that one million of them are still in use today.

Like its contemporaries, the house at 12 Topham Road was lightly framed and insulated. Thanks to its small size, however – just 1,300 square feet of living space, including a basement exercise area – it was less an energy hog than an energy piglet: before renovation, the homeowner burned about 90,000 cf of natural gas for heat annually, and used a bit more than 5,000 kW of electricity. The structure was also somewhat tighter than the Now House team had expected, registering a respectable 4.61 on the initial ACH50 blower-door test.

Insulate It and They Will Come

Architect David Fujiwara argued strenuously for insulating the full basement foundation from the outside,

even though the required excavation work would take a big bite out of a tight budget.

"Interior basement insulation doesn't work well and it's almost impossible to avoid mold growth," he says. "You might as well do it right, because once you make a basement warm enough to live in people are going to live there whether it's a healthy space or not." After excavating to the level of the footings, workers replaced the original sediment-filled clay drain tile with plastic pipe, and covered the exposed foundation walls with asphalt dampproofing, dimpled drainage mat, and two 2 1/2-inch layers of Owens-Corning Celfort polystyrene. The above-grade portion of the polystyrene was protected with a layer of half-inch cement board that was later parged to resemble the original concrete.

The seven-inch-thick floor slab in a 200 square-foot area used by the homeowner as a yoga studio was jackhammered up and the soil beneath excavated to an additional depth of nine inches. Five inches of polystyrene and PEX tubing for radiant subslab heating was applied, and a new, thinner slab poured for a net gain of six inches of headroom.

Larsen Trusses and Polyurethane Foam

In insulating the remainder of the building shell, the team used a version of the "chainsaw retrofit" developed by the Saskatchewan Research Council's Dr. Rob Dumont during the 1980s. After stripping the aluminum siding and metal roofing to expose the horizontal 7/8-inch board sheathing, the team fabricated six-inch-deep Larsen trusses from parallel lengths of 2 x 2 joined with 3/8" plywood webs and screwed them through the sheathing and into the exterior wall studs (see Figure 2). Window openings were extended with 3/4-inch plywood frames screwed to the faces of the original rough openings, and the prepared walls were sprayed with about 5 inches of BASF Walltite Eco medium-density polyurethane foam.



Figure 2. Dimension lumber and plywood trusses screwed to the sheathing on sixteen-inch centers provide adequate insulation space and a nailing base for finish siding.

David Fujiwara notes that, although the trusses seemed insubstantial when first screwed in place, they became absolutely immobile once embedded in foam. The foam layer, added to the layer of R-8 mineral wool in the stud cavities, provided a wall assembly of about R-38. Low-e pultruded fiberglass windows with nailing fins were installed in the extended rough openings and Hardiplank fiber-cement siding was nailed directly to the exposed edges of the trusses.

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Two Ways to Insulate a Roof

Because the south-facing half of the pitched roof had to be beefed up structurally to take the weight of two large evacuated-tube solar thermal panels and a 2-kW PV array, the roof sheathing was removed to permit sistering the original 2 x 4 rafters with 2 x 10s. The original mineral-wool batts were removed and a seven-inch layer of foam was sprayed directly against the inner face of the drywall in the empty rafter bays. The resulting R-40 roof was sheathed with new plywood.

On the north side, the original roof sheathing was left intact, and workers removed the sloping layer of upstairs gypsum board to provide access to the stud cavities. Fujiwara didn't want to spray foam insulation directly against the sheathing, however, for fear that an eventual roof leak would trap liquid water against the sheathing and lead to rot. Instead, half-inch spacer strips were screwed to the sheathing at the rafter edges and $\frac{3}{8}$ luan plywood was fastened over them to create a shallow but continuous ventilation channel running the length and width of the rafter cavities.

To bring the insulation layer to the required thickness and add a thermal break beneath the new drywall, lengths of 2 x 2 were hung beneath the rafters with plywood gussets – “essentially one-sided Larsen trusses,” according to Fujiwara – and the resulting bays were filled with more foam and covered with new drywall. Finally, the short section of attic floor beneath the peak of the roof was foamed from inside the cramped attic space itself.

The metal panel roof was fastened to 2 x 4 purlins that were extended beyond the gable ends to overhang and tie into the wall trusses.

A Single-Tank Hybrid Heating System

With the post-renovation estimated heat loss for the house dramatically reduced, the oversized existing gas-fired hot air furnace was replaced with a hybrid solar-thermal heating system that makes use of the existing ductwork for heat distribution.

The heart of the system is a German-made, 500-liter Latento solar storage tank containing four heat-exchange coils (see Figure 3). The first coil accepts heat from the solar thermal collectors, while a second absorbs backup heat as needed from a 150,000-BTU condensing tankless water heater. One of the remaining coils provides domestic hot water, and the fourth supplies hot water to an air handler and delivers mixed lower-temperature water to the small area of radiant floor.

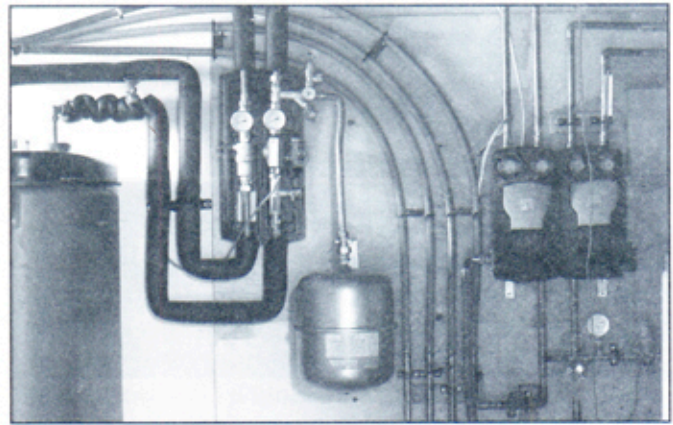


Figure 3. The 500-liter Latento solar storage tank at far left contains heat-exchange loops that enable it to provide domestic hot water while serving a solar-thermal collector, a backup demand water heater, and a combined hot air/radiant slab heating system. The PAW “plug and play” control boxes to the right of the central expansion tank house the pumps and valves that distribute hot water between the air handler and radiant slab.

A unique feature of the Latento tank is its inclusion of 20 kg of a phase-change wax to help smooth out fluctuations in solar input. As the water reaches its operating temperature of 65 degrees centigrade, the wax melts, absorbing 1.1 kW of thermal energy without increasing heat losses by further raising the temperature of the water. As the water cools after sunset, the wax solidifies and releases its heat back to the water.

Whole-house ventilation is provided by an American Standard ERV that operates independently of the heating system. A PowerPipe heat-recovery drain pipe was installed in the basement to salvage heat from outgoing wastewater.

Beyond Net Metering

According to the team's projection, the structure's 16-module, 2-kW rooftop-mounted PV system (see Figure 4, page 4) should contribute 2,410 kWh to the regional grid through a synchronous inverter. That's about equal to the home's expected annual consumption of 2,500 kWh. However, even with the improvement to the thermal envelope and the input from the solar heating system, the Now House team estimates that 19,600 cf of natural gas will be needed for heat each year, leaving the house well short of true zero-energy performance. On the Canadian EnerGuide for Houses (EGH) rating system (essentially the old HERS system, in which a zero-energy house would receive a score of 100), the Now House is expected to come in at 93.7.



Figure 4. All existing windows were replaced with low-e argon-filled units. Only one – the three-paned south facing window visible at right – was enlarged for added passive solar gain. Heat-mirror triple glazing was used in one west-facing window subject to prolonged late afternoon sun.

But, while it's expected to fall short of zero-energy performance, the Now House should achieve zero energy "cost", thanks to a very attractive rate structure available to renewable electricity producers in Ontario.

Under the Ontario Power Authority's "Standard Offer Program," the PV output from the Topham Road house will be metered separately from the power it uses. That's a departure from the net-metering system characteristic of most grid-connected systems, in which a single meter turns forward or backward in response to energy consumption and use.

The current Standard Offer purchase rate for PV power is a substantial 42 cents per kWh, while power users (including those that, like the Now House, are also producers) pay the utility between 8 and 10 cents per kWh for power consumed. The expected \$750 annual difference between those two sums should be enough to pay the anticipated gas bill several times over.

One Piece at a Time

The project's nominal \$85,000 budget doesn't count the value of a great deal of donated products, materials, and services. Without them, David Fujiwara says, the cost would have been about \$150,000. But even for a humble wartime home, he maintains, that's not an unreasonable price tag.

"There's no need to do it all at once," he says. "You could break down all the things we did into twenty separate projects. Most houses could get there in 20 to 40 years by putting some extra money into normal maintenance projects, like replacing siding, to bring it up to a higher level."

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Now House Specifications

Location

12 Topham Road, Toronto (East York section)

Completion date

September 2008

Size

1,300 square feet, two bedrooms

Passive solar features

One large south-facing window

Foundation

Full basement, poured concrete

Basement slab insulation

Two 2½-inch layers rigid polystyrene under radiant portion of slab (total R-25)

Basement wall insulation

Two layers 2½-inch rigid polystyrene (total R-25)

Wall construction

Single 2x4 walls, 16 inches on center

Ceiling insulation

7" spray polyurethane foam (total R-42)

Roofing

Prefinished steel panels

Siding

Hardiplank fiber-cement clapboards

Windows/glazing

InLine pultruded fiberglass framed windows with low-e argon-filled double glazing. One west-facing window has Heat Mirror triple glazing

Blower-door test before retrofit

4.61 ACH @ 50 PA

Blower-door test after retrofit

Not complete at press time; 1.4 ACH @ 50 PA projected

Solar thermal system

Two Apricus evacuated tube solar collectors, 51.6 s.f. absorber area with 500-liter storage tank and 150,000-BTU gas demand heater as backup

Heat distribution

Hydronic fan-coil unit and hydronic radiant slab

Mechanical ventilation

American Standard AccuExchange ERV

Domestic hot water

Active solar thermal with gas backup; drain-water heat-recovery coil

Photovoltaic system

16 Day4Energy 125-watt panels (2 kW) with synchronous inverter