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Home Energy Magazine Online March/April 1996

Off-Grid in a Cold City: The Alberta Sustainable Home

by Ted Rieger and Jeanne Byrne

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A new alternative home in Canada showcases energy and environmental features in every aspect of its construction and operation.

The Alberta Sustainable Home is a new suburban three-bedroom house and office that will soon be independent of the sewer, electric, and water systems. Located in the cold, dry, sunny climate of Calgary, AB, the home is now demonstrating the feasibility of environmentally sustainable, cost-saving devices-from Eco-studs in the framework to graywater heat recovery devices.

Although it was built for about the same price as a comparable conventional home, the Alberta Sustainable Home has received a preferential mortgage rate, is expected to have an unusually high resale value, and will cost about $1,500 per year (Canadian) less for utilities.

The Alberta Sustainable Home was built privately by Autonomous and Sustainable Housing Incorporated (ASH), in partnership with some 215 companies worldwide. Construction began in September 1993, and the designers and builders have lived and worked in the building since April 1994. About 13,000 visitors have toured the home to date.

Striving for Health and Independence

The Alberta Sustainable Home is intended to be environmentally responsible, healthy for occupants, energy-efficient, and affordable. Although it is located in a cold climate with 9,621 heating degree-days (at 65F base), the home has no gas line, boiler, or forced-air furnace.

Design strategies and technologies to reduce energy needs include high R-value insulation, heat exchangers, high-performance windows, energy-efficient appliances, airtightness, water conservation technologies, and passive and active solar systems. The designers are also testing other renewable-energy technologies, and have tried to minimize indoor air pollution. They used renewable resources, salvaged items, and materials with low embodied energy wherever possible.

Solar power is the house's primary energy source. Active and passive solar designs take advantage of the fact that Calgary has the highest number of bright sunshine hours of any major Canadian city. The home's acrylic stucco exterior helps absorb and store passive solar heat. For instance on a cold day the temperature of the stucco may be -13C (9F) in the shade and 21C (72F) in the sun. The lowered temperature difference across the wall decreases conductive heat loss. Dark interior floor tiles and heavy brick in the fireplace provide thermal mass. A modest array of grid-connected photovoltaic (PV) solar modules is expected to produce about 2,000 kilowatt-hours (kWh) per year. Passive solar devices provide hot water and space heating, and residents use solar box cookers.

A Showcase of Technologies

The Alberta Sustainable Home demonstrates hundreds of energy-saving strategies, including more than 20 new technologies, some in the prototype stage. The occupant-designers hold regular open houses for visitors to view the home's unique elements. However, they expressly state that the project is not an "advanced house." Its purpose, rather, is to replace high technology with appropriate technology. In fact, many of the items, such as the multipurpose masonry heater (for space heating, water heating, and baking) are old ideas executed with forethought and skill.

Space and Water Heating

The main backup heater is a Tempcast masonry unit-a wood-fired, multipurpose fireplace located in the living space. The brick structure absorbs daytime solar heat in the winter and releases it into the home at night. It has two combustion chambers with an external combustion air supply. The combustion efficiency is 94% and thermal efficiency (heat transferred to the living space) is 65%. This one unit provides space heating, heats water (with heat exchanger coils in the primary combustion chamber), and cooks food (the secondary combustion chamber is used as a baking oven after the fire is out).

The domestic water heater consists of a horizontal 80-gallon tank containing three heat exchanger coils. The first brings heat from the fireplace; the second brings heat from a solar panel on the roof; and the third provides hot water for a radiant floor heating system.

A ground source heat pump is also being installed that is expected to have a Coefficient of Performance (COP) of 5.5. The piping was buried under the water storage cistern 10 ft below grade, where the yearly average temperature is 5C (41F).

Airtight Construction

Air sealing is provided by airtight drywall, closed-cell soft polyvinyl chloride (PVC) gaskets, water-based vapor barrier paint, and a Poly Air Dam on all bottom plates. Both front and rear doors have airlocks-a two-door mud room design-to prevent direct heat loss. However, airtightness has not sacrificed indoor air quality, which was taken seriously in the design of the home.

Conventional heat recovery ventilators (HRVs) are supplemented by heat exchangers on the dryer exhaust and the graywater outlet. The ventilation air is also preheated by the dark stucco of the south elevation and a solar hood collector that collects the warmest outside air off the south wall. Within the house, heat is destratified with a fan that blows warm air from the second floor through tubes into the concrete slab for storage.

A seven-filter Nutech scrubber air cleaner was also installed for dust, smoke, and pollen control between the HRV and the fresh-air diffusers to the house.

Insulation Potpourri

A variety of insulation materials are being tested and demonstrated in the building's north wall cavities. These materials include straw, sheep's wool, blown-in fiberglass, Roxul's Flexibatt (a springy mineral wool that conforms to deformities in the wall cavity for a snug fit), Icynene spray-in foam, and non-CFC isocyanurate from Firestone. All have insulating values from R-3.5 to R-4 per inch, except the isocyanurate, which has

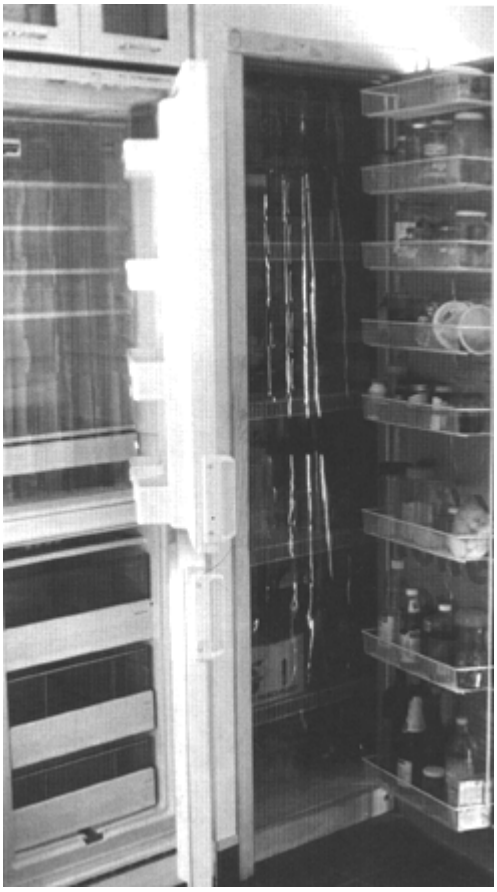
The Alberta Sustainable Home's shallow foundation saved substantially on building costs. Instead of a typical concrete foundation and footing, the house has a 2-ft deep trench around its perimeter, which is filled with gravel. The foundation is insulated under the slab with rigid foam (Terra Foam); the insulation also extends four feet horizontally from the edge to intercept the heat from the slab and stop frost penetration.

an R-value of about 8 per inch. The rest of the mammoth 13-inch exterior wall cavities (R-5(inch roof cavities (R-74) are filled with cellul(insulation. Terra Foam-manufactured by Beav without CFCs or HCFCs-is used under and at the concrete slab.

Window Shopping

Several of the home's many advanced window provide a net heat gain (that is, the solar energ greater than the heat lost on a daily basis), by incorporating argon and krypton fills and low- A window prototype from Willmar rated R-17 center of the glass has five glazings-two of gla three of Heat Mirror film-and has krypton gas Southwall's Warm Edge insulating spacers.

Appro Refrig(



Using both technology and tradition to keep food cool, the house's ultraefficient

An ultr Danish refrige with R- refrige only 0. kWh/d kWh/y meets s Europe standar recycla house a contain level c(store fr vegetal closet l motoriz damper connec thermo remove warmth cool ai cold cl(enable(designers to put in a smaller refrigerator, which they use only six months per year. (In the winter th closet is cold enough to use for refrigeration.)

Vestfrost refrigerator/freezer (left) is next to a "cold closet" vented to the outside that keeps less perishable foods in the summer and allows the occupants to unplug the refrigerator in the winter.

Saving Water Inside and Out

Several water conservation technologies are also demonstrated in the home. A Phoenix composting toilet saves 5,000 to 40,000 gallons per year compared to a water-guzzling toilet (see "Composting Toilets: A Tankful of Conservation," *HE* Jan/Feb '96, p. 10). A Sealand ultra low-flush toilet that uses 0.6 liter (1 pint) per flush is also installed. Low-flow showerheads and faucet aerators also helped keep the use of city water down to 2 cubic meters (440 gallons) per month.

The home has a rainwater collection system that channels water from the roof, which was treated with an elastomeric polymer so that the water would not pick up pollutants from the asphalt shingles. Sewage treatment will eventually be handled completely on-site, with graywater applied to the landscape. Once all treatment facilities are operational in spring 1996, the residents will disconnect the home from city water and sewer lines.

Low Embodied Energy

The house's designers did not forget that it takes energy to produce all the materials that go into a home. They intercepted several items that were on their way to the landfill, such as willow branches used for stair and balcony railings, an old cast-iron bathtub, interior glass, interior doors and doorjambs, medicine cabinets, sinks, studs, a ceiling fan, rain barrels, and soffits. They also obtained materials from local suppliers whenever possible to reduce transportation costs, and used a small PV generator and wind turbine to run equipment at the construction site.

Many parts of the house were made from recycled materials. For instance, the dark floor tiles in the living room, dining room, greenhouse, and kitchen are made out of waste material from the manufacture of fluorescent light bulbs, while the lighter floor tiles in the office and the kitchen counter contain 73% recycled glass from such sources as car windshields. Rebars used in the slab-on-grade for crack control are made out of old steel from junked cars; the metal webbing and nailer plates in the roof rafters, floor joists, and Eco-Studs are 60%-70% recycled metal; the weeping tiles in the rubble trench and the radiant floor air pipes contain 40% recycled polyethylene; and the Louisiana Pacific Fiberbond exterior wall sheathing contains 23% recycled newspaper.

Retrofit Possibilities

The designers wanted the house to demonstrate not only what can be done in new construction, but also what options are available to retrofit existing houses. For instance they use window quilts on most of the north windows to reduce heat loss. These are an affordable alternative to buying new windows.

A good technology for lighting retrofits is the Sunpipe, which is less expensive than installing a skylight into an existing house. The designers installed a Sunpipe to provide sunlight for the hallway, bathroom, and north bedrooms. It channels light into the house with a minimum of glass

area for heat loss. The Sunpipe has worked well, although the occupants have noticed some condensation because it is not insulated well enough.

Pollutants Not Included

The designers left some things out of the Alberta Sustainable Home-carpeting, radioactive smoke detectors, vinyl baseboards, glue-laminated floor joists and roof trusses, premixed drywall mud, and regular floor and cabinetry particleboard. They considered these materials unhealthy for the occupants and instead selected natural, nontoxic materials and finishes, such as concrete without chemical additives, caulk and adhesives with low volatile organic compounds (VOCs) or solvents, and cabinets made of formaldehyde-free particleboard (Medite II). They used flax linoleum, cork, and pine as flooring materials. For the most part, they used natural furnishings and building materials made from renewable resources or with recycled content. Precautions were also taken with wiring and appliance selection to reduce electromagnetic field (EMF) radiation levels.

Less Power to 'Em

The house is currently connected to the electric utility grid, but it will eventually function autonomously. The designers will be testing a Stirling heat engine, a Tesla bladeless steam turbine, and solar hydrogen fuel cells for cogeneration. When up to steam, site-generated electricity could total up to 5,000 kWh per year, much of which may be exported to the grid. In the first 18 months, the home had an average monthly electrical utility consumption of only 150 kWh, with two people in the home and office 24 hours a day and another person there 12 hours a day.

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