A Short History of Low Energy Houses for Cold Climates

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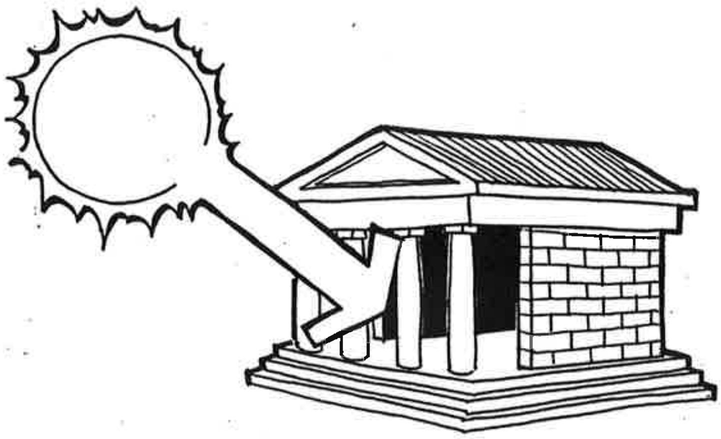


It's impossible to write a history of low energy housing without recognizing the knowledge accumulated over 25 centuries of civilization. The most outstanding early contribution was the emphases placed on the orientation of the houses to improve the solar heat gains.

The ancient Greek philosopher Socrates said: *"In houses that look toward the south, the sun penetrates the portico in winter, while in summer the path of the sun is right over our heads and above the roof so that there is shade".*

The playwright Aeschylus suggested that a south-facing orientation was a normal characteristic of Greek homes of his time. It was a sign of a *"modern"* or *"civilized"* dwelling as opposed to houses built by primitives and barbarians who, *"though they had eyes to see, they saw to no avail; they had ears, but understood not.... They lacked knowledge of houses.... turned to face the sun, dwelling beneath the ground like swarming ants in sunless caves.*

In the 20th century there have been many breakthroughs or inventions that have allowed us to improve the energy efficiency of houses, but it is still the orientation of the house towards the sun for passive solar heating that is the key to achieving superior performance.

From the 1930's to the 1970's a small amount of innovation took place in the area of energy efficient buildings. Sealed pane windows, vapour barriers and forced warm air furnaces were developed. Very little progress occurred in the use of higher insulation levels. As late as 1975 houses were being built in Saskatchewan with as little as 2½" (60 mm) of wall insulation.

Innovative houses of the 1970's

A little known super energy efficient house was built in 1975 near Copenhagen, Denmark. Professor Korsgaard of the Technical University of Denmark was the key technical innovator on this project. Called the *Zero Energy House*, this house was unique in that it was probably the first superinsulated house in the world.

The Saskatchewan Conservation House built in 1977 in Regina, Saskatchewan, (a cold climate - 5901 heating degree-days/18°C) incorporated a number of innovative energy conserving features: including high performance evacuated tube solar collectors, a grey water heat exchanger, an air to air heat exchanger using plastic heat transfer surfaces, exterior, motor driven insulating shutters, and a well sealed air-vapour barrier.

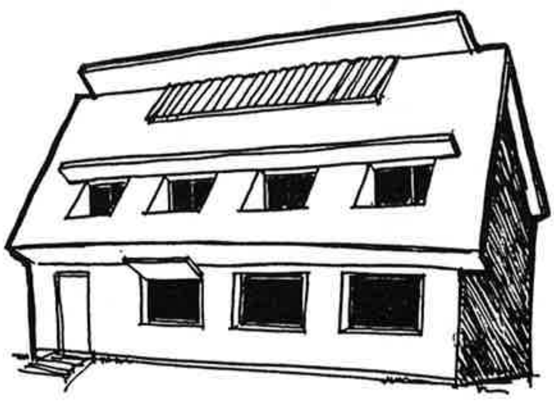
Based on test results this was the tightest house constructed in Canada with 1.3 air changes per hour at 50 Pascals pressure difference; under natural conditions, the average air change rate is less than 0.1 changes per hour.

The house had modest south-facing windows for passive solar gain in a light frame building with no additional thermal mass, and was designed for 100% solar heating.

The insulation levels were very high for houses at that time. R40 (RSI 7) cellulose insulation was used in the floor, R60 (RSI 10.7) ceiling and R47 (RSI 7.7) fibre glass bats in the walls.

Technical input for the house was spearheaded by: Professor Robert Besant of the University of Saskatchewan, Harold Orr of the National Research Council and David Eyre of the Saskatchewan Research Council.

Because of the relatively high cost for the solar collectors, the teething problems with pumps, sensors, and control-



Saskatchewan Conservation House

lers, the use of solar collectors for space heating did not seem attractive. Use of solar panels for space heating never became popular in Canada, but many of the other conservation features used including the air-to-air heat exchanger, the well-sealed envelope, the modest south-facing windows and the use of high insulation levels proved to be more attractive.

Passive Solar Heating

The use of large south windows with large amounts of thermal mass was very popular in the south-west of the US (sometimes referred to as the "mass and glass" approach to solar design). The use of modest south facing windows along with large amounts of insulation and a well sealed building envelope is known as the "light and tight" approach. But even in a well insulated house a standard double glazed window facing south in a Saskatoon home will actually have a net heat loss over the winter months.

In the 1980's, much improved high performance windows reached the market. Windows incorporating low emissivity (low-e) coatings and low conductivity gases such as argon became commercialized. One Canadian manufacturer is constructing windows with centre-of glass R values as high as R8.3 (RSI 1.5). For comparison purposes the thermal resistance of a standard double pane window is only about one-quarter that amount.

In 1980, following on the success of the Saskatchewan Conservation House, a project of 14 houses called the Energy Showcase was built in Saskatoon.

A major innovative feature of the project was the use of a performance target for space heating instead of prescriptive targets. For these 14 houses, the annual space heating target was set at 20(MJ/m² (55.5 kWhr/m2) or about 1/3 tha of conventional houses. In addition, th air tightness target set for the houses wa 1.5 air changes/hour at 50 pascals.

Because of the absence at that time o easy to use tools to calculate the annua heating performance, a series of compu ter programs were written - which be came the base for HOT2000, which al lows the builder or designer to estimat the yearly space heating consumption o a house before construction.

At the Energy Showcase project number of innovations were tried. Thes included the use of a single hot wate heater to provide both space and wate heating, use of quadruple pane window various window insulating schemes, an very high insulation levels - one hous had R60 (RSI 10.5) walls.

A Brief History of Low Energy Housing in Canada

Building	1970's Average New Home	1978 Saskatchewan *Conservation House*	1980's *R2000 Homes*	1989 Brampton *Advanced House*	1993 Waterloo *Green Home*[1]
Design Objectives		Reduce energy consumption	Reduce energy consumption	Reduce non-heating energy consumption	Minimize energy & water use & ozone-depleting materials Maximize use of re-cycled & waste building materials
Construction Details	Single stud walls 100 mm insulation Single pane windows Unsealed vapor barrier Incandesant lighting	Double stud walls 300 mm insulation Double glazed windows w/ insulated shutters Air-tight vapor barrier Hand-built heat-recovery ventilator (HRV)	Double stud walls 300 mm insulation Double glazed windows Air-tight Vapor barrier Heat Recovery Ventilation	Double stud walls Insulated basement walls and floor Windows: triple glazed, gas filled, low-e, insulated edge spacers Air-tight vapor barrier Integrated mechanical system with heat pump to capture waste heat & Ventilation air preheated in sun-space Low water-use appliances/fixtures Energy efficient criculation & exhaust fans Low-energy fridge (20kWh/mth) Fluorescent lighting	•Basement walls: pre-cast concrete/mesh reinforced—50% less concrete than poured walls •Above grade walls/main floor: high strength, laminated I-beams–30% reduction in lumber usage •Highly insulated building shell •High performance windows •Solar water heater •Energy-efficient appliances & lighting •Integrated furnace/HRV system •75% reduction of water use: low-water appliances/fixtures; rainwater cistern for toilets, washer, outside taps; drought resistant landscaping •HFC R134a fridge & CFC-free cooling system •Recycled Bldg materials[2]
Airtightness ACH*	7	less than 1	1.5		
Energy Load kWh/m²**	200	78	100 only 40% space heating	40	50

*Air change per hour (at 50 Pascals of pressure)
**Kilowatt hours (of energy use) per square meter of heated floor space

[1]Waterloo *Green Home* is one of the ten Advanced Concept Houses presently under construction.
[2]Cellulose insulation –100% recycled newspapers; Masonite siding–compressed sawdust wast; Perimeter drainage– crushed glass& concrete waste; Steel roofing –25% old cars

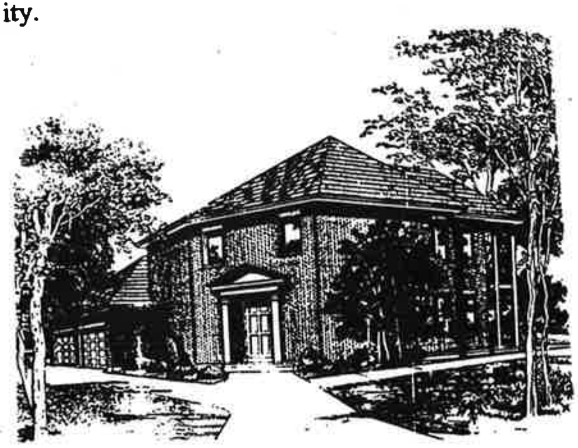
Unfortunately, in 1980 there were almost no high efficiency residential water heaters.

The R-2000 Program

A major initiative in low energy housing was announced in 1980 by the Canadian Federal Government Department of Energy, Mines and Resources (EMR). The program became known as the R-2000 program. Mark Riley of EMR played a key role in the development of R-2000.

The program had a strong emphasis on performance, as opposed to prescriptive standards for energy use for space heating. In the Saskatoon and Regina climate zones, the annual space heating performance target is about 60 kWhr/m^2.

Perhaps the greatest contribution of the R-2000 program has been the education programs for the contractors and trades people. In addition, excellent standards work was done in the area of heat recovery ventilators and indoor air quality.



The Advanced House (Brampton)

In 1989 a second generation low energy house was built in Brampton, Ontario (near Toronto). Elizabeth White and Greg Allen were the key people on this project.

The Advanced House incorporated state of the art energy efficiency measures and has a total energy consumption of about 40 kWhr/m2. per year. A major innovation in this house was the use of very efficient lights and appliances to reduce the base electricity consumption of the house. In addition, an innovative heat pump system is used to provide space heating, water heating, ventilation, and cooling.

In 1991, a program to build a series of Advanced Houses was initiated by EMR and the Canadian Home Builders' Association. In addition to reduced space heating loads, the program also targets reduced energy use for domestic water heating, lighting, and appliances. The target is to reduce the total energy consumption of the houses by 50% compared to the R-2000 target. It also includes reducing water consumption, using recycled products, addressing indoor air quality guidelines, and providing facilities for recycling of materials.

Is a Zero Energy House possible in a Cold Climate?

A reasonable question to ask is whether it would be possible to extend the energy conservation and renewable energy features and build a house in a cold climate such as Saskatchewan that was completely autonomous in its energy supply.

Technically, it's feasible. Here's how.

Water Heating

The water heating load could be provided by a solar system coupled with water storage. An average house with water saving features uses about 4000 kWhr/yr for domestic water heating. A solar collector with 40% annual efficiency can collect about 550 kWhr/m^2. of useful heat, so 7 square meters, with larger water storage, could provide the domestic hot water.

Space Heating

Space heating could be provided by using a highly energy efficient envelope for the building coupled with super-window technology.

Electricity for Lights and Appliances

The supply of electricity is the most expensive element. In a windy location in a rural area, a wind electric system could be used. In an urban area, it would appear that photovoltaic cells would be the most attractive. The price of cells will soon approach $ 2.00 per peak watt (presently it's about $8 - 10.).

Is it economically justified to build a completely autonomous house? What is the real cost of energy?

In addition to the cost of extracting, processing, and delivering energy, there are very substantial environmental costs which today are not being paid. There is no charge to the consumer of energy for all the pollutants released into the atmosphere from the burning of fossils fuels. (Carbon dioxide levels in the atmosphere are now 25% higher than a century ago, and are rising each year).

Much progress has occurred since the 1970's in our understanding of how to build energy efficient houses. Houses that use 80% less energy than conventional 1970 houses have been built.

With concern about the harmful environmental effects of fossil fuel burning increasing, it is possible that cold-climate houses that are completely autonomous in their energy supply using solar energy will be built in the 1990's.