Net Zero Energy Housing - Lessons Learned

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Objectives: To prepare a "Lessons Learned" analysis of recent Net Zero Energy House design and construction experiences to discover

- What worked
- What did not work
- What designers & builders would change
- How much things cost

Scope

Six recently completed NZE houses were studied; focus on qualitative, rather than quantitative lessons (since most still in monitoring phase).

Factor 9 House (Regina, Sask.; 2007)
EcoTerra™ (Eastman, Quebec; 2007)
Inspiration Ecohome™ (Ottawa, Ontario; 2008)
Riverdale NetZero (Edmonton, Alberta; 2007)
Avalon Discovery 3 (Red Deer, Alberta; 2007)
Metro Denver Net Zero (Denver, Colorado, 2006)

The Basic Principles Of Net Zero Energy House Design

1. **Minimize envelope heat loss by using a simple architectural layout, massive amounts of insulation and a high degree of airtightness.**
2. **Select the most efficient types of space heating, water heating and ventilation systems.**
3. **Use energy efficient lighting and appliances.**
4. **Maximize passive solar gains (while still respecting the 6% rule).**
5. **Use renewable energy systems to provide the balance of the energy requirements.**

What Was Learned:

Overall Design
Design Constraints
Building Envelope
Airtightness
Overheating
Thermal Mass
Window Selection
Solar Energy Systems
Mechanical System Complexity
Incremental Costs

What Was Learned: Overall Design

- Keep the design as similar to possible to conventional designs while still meeting NZEH objectives (e.g. use standard window sizes which are cheaper than unique sizes and have shorter delivery times).
- Establish design objectives in writing, in advance, so that goals are clear to everyone on the design team.
- Be wary of design tangents and “design-creep”.

What Was Learned: Design Constraints

- Cost – obviously, but how should innovation be budgeted?
- Commercial availability – some projects tried to use products which were readily available from standard suppliers
- Orientation – optimum orientation not always available
- Integration with adjacent architecture
- Homeowner-imposed constraints (“I can get a deal”)
- Desire for modular construction

What Was Learned: Building Envelope

- Foundations – Nothing unusual other than high R-values, RSI 6.6 to 8.8 (R-37 to R-50).

- Walls – RSI 6.6 to 12.3 (R-37 to R-70). Various wall systems have been used and work, biggest issue is cost (upgrading from RSI 3.52 (R-20) costs $20 to $70/m^2).

- Roofs - High heel trusses popular for reducing heat loss and controlling ice-damming.

What Was Learned: Airtightness

Airtightness, general observations:

- Focus on the big leaks
- Concentrate on the upper part of the building
- Importance of air leakage control increases with building height
- Draw out complicated details ("if you can't draw it, you can't build it")
- Perform an airtightness test (2 reasons)

What Was Learned: Airtightness (con't)

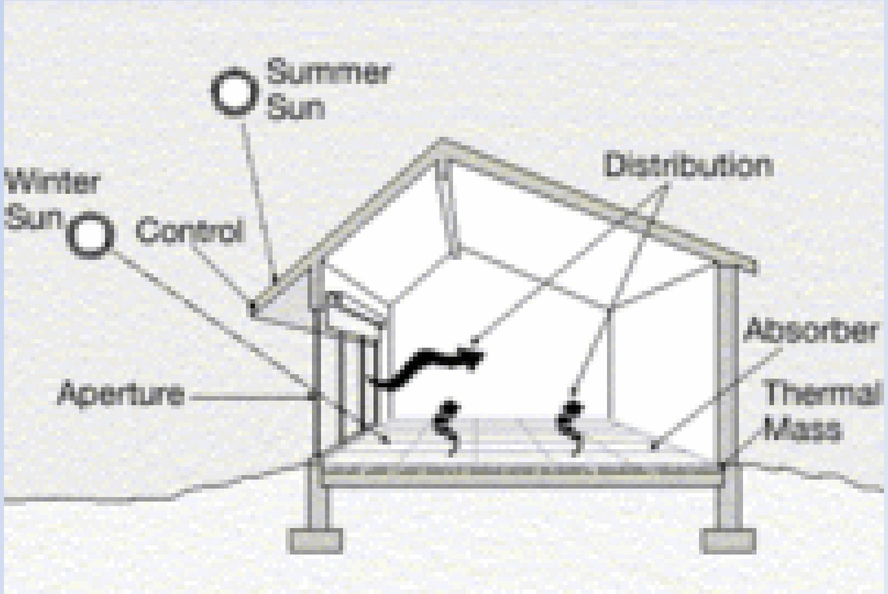
- Avoid, or plan around, problem areas such as:
  - Attached garages, esp. those under heated rooms
  - 1 ½ storey floor/kneewall intersections
  - Recessed ceiling fixtures (pot lights)
  - Cantilevers
  - Irregular-shaped protrusions
  - Fireplace chases
  - Three-sided intersections
  - Suspended basement floors
  - Duct penetrations, esp. those for air-based solar systems

What Was Learned: Overheating

- Several designers expressed concern about this becoming an issue for their houses.

- Overheating is often a localized event in one or two rooms, not the whole house.

- Problem is exacerbated because we do not have a *proven* tool for predicting overheating.



What Was Learned: Thermal Mass

- Another key component of NZE housing.
- Thermal mass only saves energy by cycling through a temperature range – which is usually fairly small 3 ^{o}C to 5 ^{o}C.
- Thus, a large mass is needed.
- But mass is expensive (masonry) or requires expensive. containment (water). For example, concrete costs \$150 to \$200 m^3.

Savings Due To Thermal Mass

- One HOT2000 analysis indicated savings of 100 to 700 kWh_e/yr. (assuming no shading and modest overhangs).
- How much can you spend to save \$7 to \$50 /yr?

What Was Learned: Window Selection

- How much window area, what type of windows, how much can face south???
- While passive solar is a key feature of NZE housing, windows are expensive…
  - RSI 3.52 (R-20) wall costs about \$50 to \$100 /m^2
  - Replacing 1 m^2 of wall with a good window saves about \$1 /yr (assuming NO shading), however…

  - Double-glazing costs \$200 to \$600 /m^2
  - Triple-glazing costs \$300 to 700 /m^2
  - Low E coating costs \$30 to \$40 /m^2
  - Argon fill costs \$30 to \$40 /m^2

What Was Learned: Window Selection, Consider…

Costs

- 167 m^2 NZE house located in Winnipeg with RSI 7.75 (R-44) walls
- Cost of purchasing and installing 1 m^2 of T/G picture window with 1 lowE, argon fills and insulated spacers is $488
- Cost of wall $170 /$m^2$
- Incremental cost of window = $488 - $170 = $318

Savings

- Space heating load, w/o 1 m^2 window: 1462 kWh/yr
- Space heating load, with 1 m^2 window: 1443 kWh/yr
- Saving: 19 kWh/yr; worth $1.90/yr (at $0.10/kWh)

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Simple Payback Period = 167 years

What Was Learned: Window Selection

- Also, windows have a relatively short life (20 to 25 years) after which they have to be replaced.

- Overall, windows have poor cost-effectiveness (Value Indices) which suggests that passive solar may not be as important to the design of NZEH as first thought.

- Possible recommendation – use a "good" window, but one which has a high Temperature Index (to resist condensation).

$$I = [T - T_c] / [T_h - T_c] \times 100$$

What Was Learned: Solar Energy Systems

- **Reduced Solar Energy System Production.**
- **Snow cover on solar collectors and/or PV arrays.**
- **One NZEH with a low slope roof lost PV production for a month due to heavy snow cover.**
- **Trees and other shading are more problematic than first anticipated and can be very expensive to deal with.**

What Was Learned: Solar Energy Systems

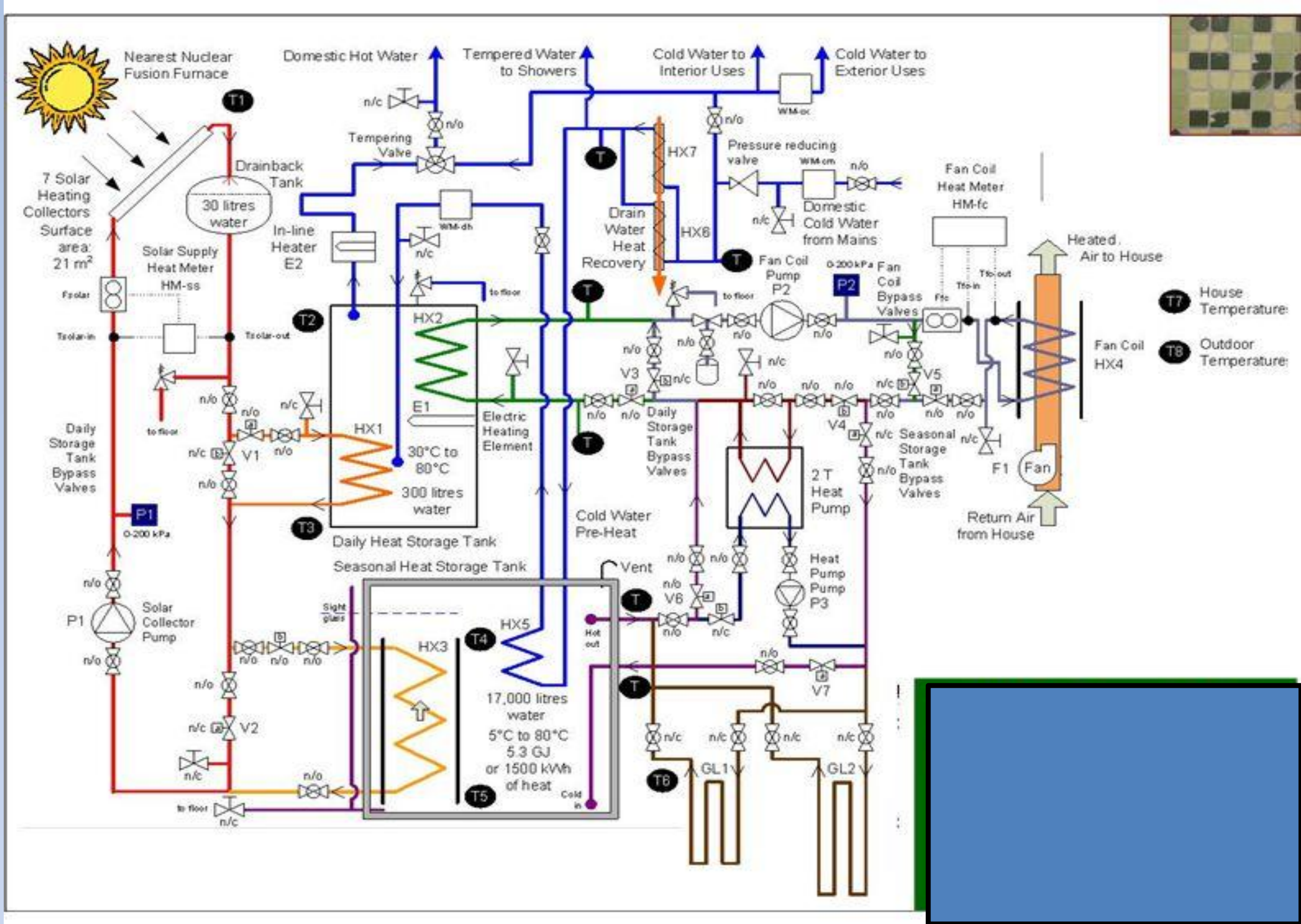
- Inadequate Roof Area For Solar Systems (although adequate roof area was available, a significant portion may have had the wrong orientation, been shaded or was otherwise not available).

What Was Learned: Mechanical System Complexity

- Mechanical system complexity was one of the biggest, and most often reported, problems.
- Should we attempt to use every thermodynamic opportunity?
- Controls were a particular problem (did not work, were too complicated to understand, caused customer complaints).
- Dehumidistats were unable to provide the desired control over relative humidity.
- Builders felt that all the controls must be available from one supplier to ease maintenance, warranties, etc.

What Was Learned: Mechanical System Complexity

"Just Say No!"



What Was Learned: Mechanical Systems

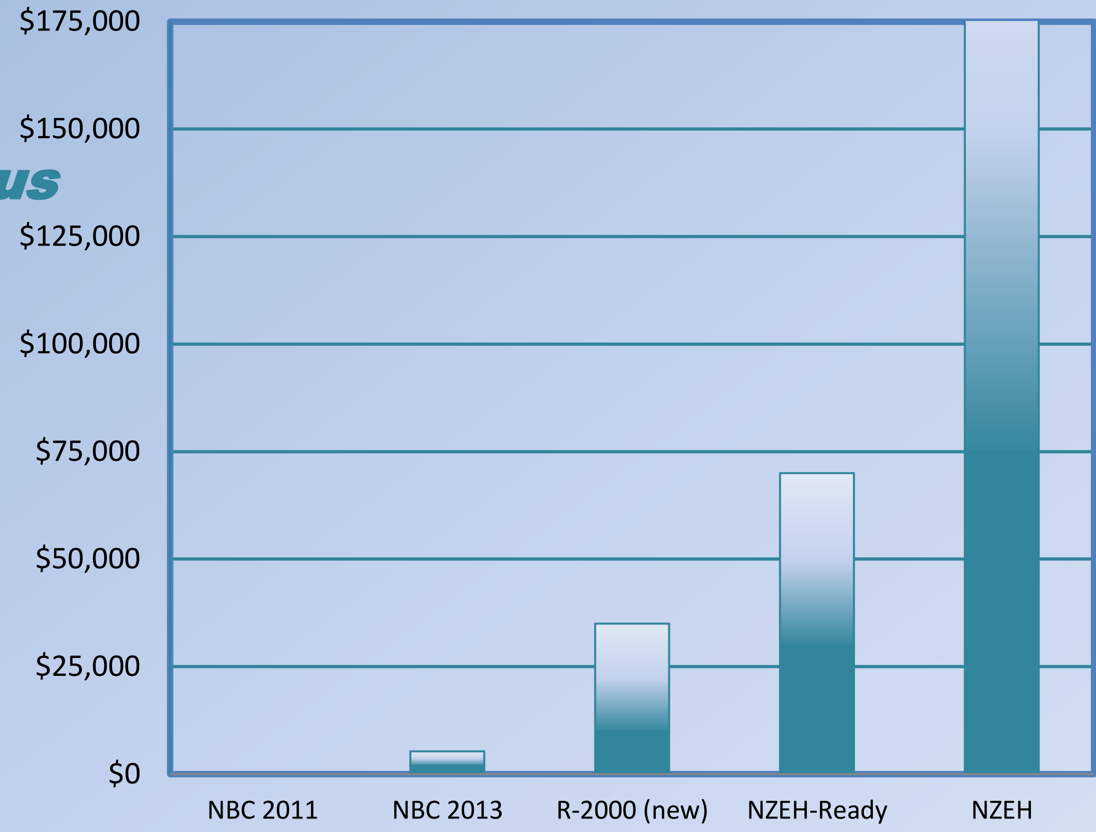
- Unanticipated interactions among mechanical components (instantaneous DHW heater would not fire since its inlet water, preheated by solar DHW, was too warm).

- Lack of available energy efficient HRV motors.

- Construction scheduling of innovative design features ("It not alway plug and play").

- Excessive floor space for mechanical systems (with a house costing \$1000 to \$2000 /m^2, how much space can be devoted to the mechanical system)?

What Was Learned:
Incremental Costs Of Various Conservation Standards



Cost per house, based on 1730 ft^2, two-storey house with full basement…

STANDARD	ERS	INCREMENTAL COST RELATIVE TO MBC 2011
MBC 2011	76 – 77	0
NBC 2013	78	$2000 - $3300
R-2000 (new)	86	$10,000 - $35,000
NZEH-Ready	90 – 94	$30,000 - $50,000
NZEH	100	$75,000 - $175,000