Canadian Approaches to Energy Efficient Housing

Tony Colantonio

On behalf of Karen Pero
Acting Director, Sustainable Building and Communities
CanmetENERGY – Ottawa
Natural Resources Canada
Agenda

- Canadian Housing Stock
- Canadian consumption habits
- Thermal characteristics
- Path to Net Zero Energy Efficiency Housing – Framework
- Discussions
Canadian Housing Stock

CanmetENERGY
Leadership in ecoInnovation
Canadian Housing Stock

- 13.2 million (MB – 0.53 million)
- New homes – 190,000/year.
- About 85% of housing stock is at least 15 years old.

Apartment < 5 storeys 18%
Semi-detached 5%
Row 11%
Single-detached 55%
Apartment > 5 storeys 9%
Mobile 2%
Canadian Energy Use

- Annual residential energy use is about 1,421 PJ (1.35 Quad) – about $21.3 billion a year. (2008 data)
- Annual commercial and institutional building use – 1172 PJ (1.2 Quad) – about $22.6 billion a year

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy Use (PJ)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>1172</td>
<td>14%</td>
</tr>
<tr>
<td>Residential</td>
<td>1421</td>
<td>17%</td>
</tr>
<tr>
<td>Industrial</td>
<td>3278</td>
<td>38%</td>
</tr>
<tr>
<td>Transportation</td>
<td>2465</td>
<td>29%</td>
</tr>
<tr>
<td>Agricultural</td>
<td>209</td>
<td>2%</td>
</tr>
</tbody>
</table>
Annual Energy Use in Typical Home

- Based on the current conventional construction practices, the average per household is about 137 GJ - average cost of $2,100 per household.

- Space heating: 63%
- Appliances: 17%
- Hot water: 14%
- Lighting: 3%
- Space cooling: 3%
Trends in Housing

Energy Consumption Index (MJ/DD • m² Floor Area)

- NZEH
- R-2000
- 1991-08
- 1981-90
- 1971-80
- 1961-70
- 1946-60
- 1920-45
- 1920

CanmetENERGY
Leadership in ecoInnovation
Canadian GHG Emissions – 2007

Source: NRTEE, Energy Related Greenhouse Gas Emissions in Canada in 2050, Appendix A Table A-9
Energy Related Greenhouse Gas Emissions in Canada in 2003 by Sector and End Use Allocation

Source: NRTEE, Energy Related Greenhouse Gas Emissions in Canada in 2050, Figure 3-4
Thermal Characteristics
Data Analysis from Highly Successful ecoENERGY Retrofits – Homes Program
**ecoENERGY Retrofits - Homes**

- Program reach:
  - 1998 to 2006: 257,400 home evaluations and 176,368 received incentives
  - 2007 to March 2010: 609,260 homes evaluated and 293,710 qualified for incentives
- Program reach – near to a 1 million dwellings evaluated (1 in 8 homes)
- Popular with homes built before 1990 – almost 88% of all evaluations

![Bar chart showing age groups and number of house evaluations](image)
Retrofit Measures

- Replace heating system with ENERGY STAR qualified model: 67%
  - installation of 92% AFUE furnace with energy efficient motor
- Add insulation to attic: 27%  Insulate basement: 28%
- Reduce air leakage (air sealing):  45%
- Replace windows, doors with ENERGY STAR qualified units: 35%

- Homeowners typically undertake more than one action
- Solar DHW ~ 950 installations
- GSHP ~ 6,745 installations
The average heated floor space is increasing
Since 1960s, house size has increased by about 430 sq ft.
Attic/roof insulation levels are steadily increasing.
Wall Insulation

Above-grade Wall Insulation (m²K/W, RSI)

<table>
<thead>
<tr>
<th>Vintage (Year of Construction)</th>
<th>0.0</th>
<th>0.5</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1945 or older</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1946 - 1960</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1961 - 1970</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1971 - 1980</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981 - 1990</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991 - present</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Below-grade Insulation (m²K/W, RSI)

<table>
<thead>
<tr>
<th>Vintage (Year of Construction)</th>
<th>0.0</th>
<th>0.3</th>
<th>0.5</th>
<th>0.8</th>
<th>1.0</th>
<th>1.3</th>
<th>1.5</th>
<th>1.8</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1945 or older</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1946 - 1960</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1961 - 1970</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1971 - 1980</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981 - 1990</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991 - present</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Leadership in ecoInnovation
Airtightness

- Envelope tightness indicated in air change per hour at 50 Pa pressure difference.
- Houses are becoming more airtight. Shows the trend towards better sealing methods.
- The normal natural air infiltration rate dropped from over 0.6 to 0.15.
- Necessitates mechanical ventilation.
Comparison of Space Heating Energy Use

Vintage (Year of Construction)

Annual Space Heat Energy Index (MJ/m²)

Space Heating Index (MJ/m² of floor space)

CanmetENERGY
Leadership in ecoInnovation
Strategic vision for housing

To enable Canadian Housing to move towards using Net Zero Energy on an annual basis

CanmetENERGY
Leadership in ecoInnovation
Definition

Path to Net-Zero ...

- A home that produces as much energy as it uses on an annual basis (*All energy used in a home*, including that for heating, hot water, ventilation, air conditioning and all miscellaneous electrical consumption)

New Communities Self-Sufficient and Sustainable

Marketable Innovations and Industry Capacity for Net Zero

<table>
<thead>
<tr>
<th>Year</th>
<th>Code Requirement</th>
<th>Industry Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>72-74 (80)</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>80 (86)</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>83 (90)</td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td>90 (100)</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>100 (100)</td>
<td></td>
</tr>
</tbody>
</table>
Getting to Net Zero

Energy Consumption

EnerGuide Rating

Current
Average
New
Construction

R-2000/
EnergyStar
performance

Approx.
Maximum
Performance
w/ Efficiency Alone

Net Zero
Energy
Performance

Energy Efficiency

Renewable Energy Supply

Optimization

Approx. Maximum Performance w/ Efficiency Alone

Net Zero Energy Performance

EnerGuide Rating

Leadership in ecoInnovation
Proven Demonstration – New Home

Inspiration — The Minto EcoHome

Note: Energy estimates from ‘as-built’ specifications.
Proven Demonstration – New Home

Inspiration — The Minto EcoHome

CanmetENERGY
Leadership in ecoInnovation

Note: Energy Estimates from ‘as-built’ specifications and without any cost optimization.
Path to net zero-energy house...

- **Minimise**
  - space heat and hot water loads
    - How? - passive solar design, insulation levels, airtightness, heat generators…… also consider cooling needs
  - electricity consumption
    - How? – ventilation systems, appliances, energy and load management, integrated approaches

- **Maximise**
  - Renewable energy (solar thermal, solar electric, wind, bio-mass and other) contribution to the house’s heating and electricity supply
Building Envelope

- Advanced framing layouts
  - Rationalized framing
  - Standard sizing and field guides
  - Well defined training and guides available

- Insulation methods

- Windows – optimize
  - Solar gains for heating / shades for cooling
  - Window/wall interface – design details and construction

- Attic ceiling – insulation opportunities

- Airtightness
Outside of wall

Inside of wall

Space for cellulibre insulation

(405 mm, 16 inches)

Polyethylene air barrier stub (as per building code)

Air barrier is on the warm side of the inside stud
Space for the window’s structural support plus lots of insulation

Need insulation here, not wood, but also need structural support for window
50% fly-ash concrete

Expanded polystyrene insulation (R8)

Isocyanurate Insulation (R13)

Space for cellufibre insulation (R33)
Getting to Net Zero...

- Efficient Building Envelope
  - R51 Walls (Double Stud)
  - R48 Foundation Walls
  - R90 Ceiling
  - Triple Glazed Windows (W,S, E)
  - Quad Glazed Windows (N)

- Achieves ERS 86
What to do with thick walls?

- Living space – penalty
  - Ranges from 3% to 9% of living space area
  - even at a low-cost of $150/sqft - $9K to $30K real estate cost penalty

- So, there is a need for ‘high R-value dense’ insulation materials…
Insulation Options

Fiberglass

EPS

VIP

R36
Vacuum Insulation Panel
Wall Mock Up
Concept 1a Thermal Test Results
(9 ¼” double stud – no batt insulation)

- VIP-1A
  - -20°C: RSI 6.62 (R-37.6)
  - -35°C: RSI 6.69 (R-38.0)
Concept 1 Thermal Test Results
(9 ¼” double stud; 3.5” batts both cavities)

- **VIP-1C**
  - -20°C: RSI 11.22 (R-63.7)
  - -35°C: RSI 10.87 (R-61.7)
The Power of Solar

- Solar thermal solar electric systems
  - Integration of passive solar design
  - Active solar systems for DHW & space heating
  - PV electric supply systems
  - Improved daylighting (for improved living quality)
  - Natural cooling and solar/glare control

- Clean energy solutions
  - Micro wind generator
  - Combined heat and power
Getting to Net Zero through Technology

- **Solar Thermal System**
  - Combined home and water heating
  - High-efficiency flat-plate collectors mounted on a vertical tilt
  - 17,000 litres of water storage in basement for home heating
  - 300 litres of hot water storage for water heating
  - Result EGH 96

- **PhotoVoltaic System**
  - 28 Sanyo 200 W PV modules
    - 5600 W in bright sunshine
  - Grid-dependent, exports to grid every day of the year
  - No battery bank
  - Result EGH 100.4
What we do now?
Ready for moving towards Net Zero House!

- Build houses as **energy efficient and solar friendly** as possible!

- Start with a comprehensive integrated approaches
  - ‘House as a System’ approach provides cost-effective solutions

- Engage service providers, trades and owners and various stakeholders

- Our challenge is to…
Next Generation of Housing

from relevance

Technology Opportunity -> Strategic Planning

through impact

Product Innovation -> Testing Standards & Simulation

Marketing Incentives -> Policy Development

NET ZERO ENERGY HOMES & COMMUNITIES

to excellence

ultimately objective

NET ZERO ENERGY HOMES & COMMUNITIES
Approaches

Whole House
- CMHC’s EQuilibrium™Housing
- Regional road to NZE housing studies and demonstrations
- Residential electrical audit process
- IEA Zero Energy Solar Buildings
- Sustainable Housing Technology Roadmap
- Model developments to support NZEH

Technologies
- Next generation technologies with GHG reduction potential – a comparison
- Annual home energy performance – comparing 3 mechanical options
- Utility grid peaks – can zoned forced air help mitigate A/C related spikes
- Cold climate and solar assisted air source heat pumps
- Solar Ready
- Vacuum insulation lab & field research
- LEEP™ - Local Energy Efficiency Partnerships Initiative
- Mechanical PV awnings
Whole Housing Research Areas

- Strategies and applications of the following technologies need to be expanded in a whole building context:
  - Electricity - (load reduction / demand response):
    - Plug loads and equipment/appliance energy reductions;
    - Lighting (& daylighting), Equipment & Controls;
  - Strategies for cost-effective exterior shading;
  - Solar cooling (passive & active shading first):
    - Use of solar heat coincident with highest cooling load;
    - Absorption, adsorption, and desiccant-based cooling from solar thermal sources;
  - Community energy networks:
    - Electrical;
    - Thermal (DES);
    - Distribution grid may be more important than fuel source.