Prefabricated Exterior Energy Retrofits

Spring Training
April 23, 2018

Jeff Armstrong
Cold Climate Building Inc.
Canada’s commitment to the Paris Agreement

Reduce GHG emissions 30% below 2005 levels by 2030

Reduce sector-wide emissions from 747 to 523 Mtonnes CO$_2$ e
<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Canadian GHG emissions in 2015</td>
<td>747</td>
<td>Mt CO$_2$ eq.</td>
</tr>
<tr>
<td>2030 Target (Paris Agreement)</td>
<td>523</td>
<td>Mt CO$_2$ eq.</td>
</tr>
<tr>
<td>Reduction required to meet target (747 – 523)</td>
<td>224</td>
<td>Mt CO$_2$ eq.</td>
</tr>
<tr>
<td>Current Residential emissions @ 9% of 747</td>
<td>67</td>
<td>Mt CO$_2$ eq.</td>
</tr>
<tr>
<td>No. of Canadian households in 2015</td>
<td>13.3 Million</td>
<td></td>
</tr>
<tr>
<td>Annual household avg. GHG emissions (67/13.3)</td>
<td>5</td>
<td>tonnes CO$_2$ eq.</td>
</tr>
<tr>
<td>Reduction target for the housing sector (9% of 224)</td>
<td>20</td>
<td>Mt CO$_2$ eq.</td>
</tr>
<tr>
<td>Total no. of households to Net Zero Carbon! (20/5)</td>
<td>4 Million</td>
<td></td>
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So let’s keep going...

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
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<tbody>
<tr>
<td>4 million NZC houses by 2030 / 12 years</td>
<td>330,000</td>
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<tr>
<td>Annual starts built to NZC each year - let’s say... 10% of 200,00</td>
<td>20,000</td>
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<tr>
<td>Total no. of NZC RETROFITS per year</td>
<td>310,000</td>
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That’s the scale of this Challenge / Opportunity
The first place to look... is space heating

How good are we at energy retrofits?

ecoENERGY Retrofit – Homes Program
Total Average annual energy savings – 21%

- HVAC system replacements (heating, cooling, hot water and ventilation) - 53%.
- Windows, interior insulation (mainly attics and foundations) and air-sealing – 43%.
- Exterior wall retrofits - 4%.
...how significant is wall insulation?

Those renovations that included **wall insulation** doubled their EGH rating improvement over renovations that didn’t.
The Problem

Exterior wall retrofits are hard to do, they are too...

- expensive - low return on investment
- disorderly – slow, noisy
- piece-meal - few specialist contractors
- much risk - financial & technical
ENERGIESPRONG

Is characterized by **DISRUPTION!**

- a social-housing stock of simple, repetitive forms
- large no’s of units amassed to create an instant market to attract…
- …very large builders who must provide a 30 year energy guarantee
- a Net Zero Energy target (enclosure, mechanicals, renewables)
- innovative prefab panels geared to automated production
context counts

<table>
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<th>Moderate climate, 1 zone</th>
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<tbody>
<tr>
<td>High population density (488/km²)</td>
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<tr>
<td>Masonry / concrete tradition</td>
</tr>
<tr>
<td>High energy costs</td>
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<tr>
<td>Long history of off-site fabrication</td>
</tr>
<tr>
<td>One building code</td>
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</table>

<table>
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<th>Cold, humid climates, 4 zones</th>
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</thead>
<tbody>
<tr>
<td>Low population density (4/km²)</td>
</tr>
<tr>
<td>Wood-frame tradition</td>
</tr>
<tr>
<td>Moderate energy costs</td>
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<tr>
<td>Recent history of off-site fabrication</td>
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<tr>
<td>Several codes</td>
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Who does what?

Panel manufacturer:
builds Base Panels, e.g. SIPs, wood-frame

Fabricator:
takes Base Panels and adds W&D, membranes, strapping, cladding, etc. and installs Finished Panels

Builder (General Contractor or Const. Mgr.):
overall project responsibility
We see a prefab continuum

- Increasing Industrialization
- Decreasing Cost & Occupant Disruption
- Increasing Market Size & Funding Certainty

Current Methods → Site Finished Base Panels → Shop Finished Base Panels → Factory Finished Panels

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<table>
<thead>
<tr>
<th>Phase</th>
<th>Tasks</th>
<th>Targeted Completion</th>
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</table>
| 1. Collect data and establish consortium | - Benchmark current retrofit best-practices to establish cost and performance targets  
- Convene Advisory Committee  
- Establish Consortium of Industry Partners and other stakeholders | Spring 2017 |
| 2. Analyze building stock, develop value proposition and business strategy | - Analyze existing stock energy use, cost and GHGs by vintage and geography  
- Review of international projects undertaking exterior home retrofits  
- Develop innovation and business strategy | Summer 2017 |
| 3. Develop concept and evaluate | - Develop digital workflow including building capture, Building Information Model (BIM), Computer Aided Manufacturing (CAM)  
- Develop panel concepts and designs  
- Conduct heat, air and moisture analysis  
- Evaluate hygrothermal and energy performance | Fall 2017  
| So far we have two of these | You are here | Spring 2018  
| Underway | Spring 2019 |
| 4. Demonstrate technology and commercialize | - Conduct controlled field test at CanmetENERGY Ottawa labs  
- Develop cost / benefit analysis, commercialization roadmap and industry guidelines for installers | October 2020  
| | | March 2021  
| We're working on this and this | Completed September 2017 |
Start small, Scale up
2017 pilot
2 Base Panel Types – both currently available

EPS nail-base panel

Wood-frame standoff panel
Panel layout

Nail-Base

Wood-Frame

NOTE:
NAIL BASE PANEL LENGTHS BASED ON 2" THICK FIBRE LAYER COMPRESSED 1" DURING INSTALLATION.

FILL THIS CAVITY WITH MINERAL WOOL BATT BEFORE PANEL INSTALL.

SEAL PANEL JOINTS WITH ACOUSTIC CALKING.

GLUE SPINE IN PLACE WITH PL300.

SEAL P1 / P7 PANEL JOINT WITH ACOUSTIC CALKING.

SEAL P4 / P5 PANEL JOINT WITH ACOUSTIC CALKING.

FILL THIS CAVITY WITH MINERAL WOOL BATT BEFORE PANEL INSTALL.

EXTERIOR OF EXISTING CLADDING.
EPS nail-base panel

Squishy Layer

Helps with plumb/square
Absorbs surface irregularities
Provides dimensional tolerance
Allows ext. electrical routing
Enhances drying potential

Squishy Layer

2x4” LSL

9-1/2” LSL

9’

4’

Up to 24’
EPS nail-base panel

OSB splines @ all vertical joints
Self-adhered exterior air barrier
Vertical strapping - rain-screen cavity
Pre-finished EW panel siding
“Access zones” top & bottom
Wood-frame Standoff Panel

Ply bottom & top plates support AB membrane

Roof-overhang extension

Site-installed frieze board

Base Panel
2x4 wood-frame wall w/ OSB sheathing

Panel support bracket

Site-installed water-board

Self-adhered air-barrier membrane

Site-installed fibrous insulation blown into wall cavity

Standoff cavity
Wood-frame Standoff Panels

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EPS nail-base panels
## Pilot Results

<table>
<thead>
<tr>
<th>Performance Metric</th>
<th>Baseline</th>
<th>Retrofit</th>
<th>% Improvement / Reduction</th>
</tr>
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<tbody>
<tr>
<td>Airtightness ((ACH@50Pa))</td>
<td>7.62</td>
<td>0.82</td>
<td>89%</td>
</tr>
<tr>
<td>Normalized Leakage Area @ 10 Pa ((cm^2/m^2))</td>
<td>1.84</td>
<td>0.20</td>
<td>89%</td>
</tr>
<tr>
<td>Heat loss – Walls (kWh)</td>
<td>4,118</td>
<td>1,102</td>
<td>73%</td>
</tr>
<tr>
<td>Design Heat Loss (@-25C) ((W))</td>
<td>5,629.0</td>
<td>2,334.0</td>
<td>59%</td>
</tr>
<tr>
<td>Thermal Energy Demand Intensity ((kWh/m^{2}a))</td>
<td>229.0</td>
<td>54.2</td>
<td>76%</td>
</tr>
</tbody>
</table>
Nail-base

Pros
• continuous insulation assured

Cons
• panel warp
• slightly more expensive...
• fewer sources of supply

Wood-frame

Pros
• slightly less expensive...
• more sources of supply

Cons
• panels more flimsy
• site-install of insulation more problematic
• insulation continuity less certain

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Next Pilot...
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Before

After
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- Roof panels include metal roofing & PV
- Vented AB membrane (continuous with wall AB membrane)
- Unvented
- Painted plaster ceiling finish provides vapour control
- Top-up attic insulation
- Add insulation to top of existing roof deck
PEER
Prefabricated Exterior Energy Retrofits

Questions?
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