As Canada strives to reduce emissions from the built environment through energy efficiency improvements, there are many uncertainties with the feasibility of reaching near-net zero performance in the challenging climate of Canada’s North due to factors such as availability of resources and high heating demand. This presentation outlines the results of research to understand solutions for achieving goals such as Net Zero Ready construction, Passive House and the upper steps of the BC Energy Step Code for residential buildings in Canada’s north. This research is also highly impactful for in setting energy efficiency targets within Yukon and across Canada. Specifically, the presentation will outline:

- Challenges with, and key solutions for, using different energy modelling tools for code compliance in the north, with a focus on aligning assumptions for northern regions.
- Practical building enclosure and mechanical design solutions to overcome the challenges of implementing near-net zero energy targets in Canada’s Far North.
- Where the near-net zero energy targets cannot be feasibly met with current practices or cost-effective means, potential new technologies and adaptations to energy performance targets will be discussed to assist policy makers.
Outline

→ Background for the Research
→ Energy Modeling Tools
→ Achieving High Performance
→ Incremental Cost Estimates
→ Northern Barriers and Solutions
→ Further Work

Overarching Research Question

→ What is the feasibility of achieving Passive House and near-net zero levels of energy performance (e.g. Steps 4 & 5 of the BC Energy Step Code) for residential buildings within Canada’s challenging northern climate including all communities and regions within the Yukon, Northwest Territories and Nunavut (climate zones 7A to 8).
The North is Big

Canada's largest but least populated CZ is 8

The North is Very Cold

CZ 8 has huge range of HDD - lumped together for "Southern Canada’s simplicity"
The North has Challenging Access

More Insulation is Required
Challenged by the Terrain

What Would it Take in the Far North to Build to Passive House or Net Zero Standards?
What Would Happen in the North if Canada Adopted a National Energy Step Code?

Initiatives that led to the Energy Step Code in BC

- **Climate Leadership Plan**
  - BC Building Code
    - Net Zero Ready by 2032

- **Pan Canadian Framework**
  - National Building Code
    - Net Zero Ready by 2030
    - National “Stretch” Code

- **Clean Efficient Buildings – Intentions Paper**
  - BC Building Code proposed changes
    - Step 3 - 2022
    - Step 4 - 2027
    - Step 5 - 2032
National Building Code of Canada Direction

→ Pan-Canadian Framework on Clean Growth and Climate Change calls for adoption of “net-zero energy ready” by 2030

GOAL: Federal, provincial, and territorial governments will work to develop and adopt increasingly stringent model building codes, starting in 2020, with the goal that provinces and territories adopt a “net-zero energy ready” model building code by 2030.

Critical Path to 2030


→ **Near Net Zero**: A building with low energy usage such that it approaches the annual energy consumption of Net Zero Energy buildings, and, with additional measures, **COULD** produce nearly as much renewable energy as it uses on an annual basis.

→ **Net Zero Energy Ready**: A building with low energy usage such that, with additional measures, it **COULD** generate as much renewable energy as it uses on an annual basis.

→ **Net Zero Energy**: A building with low energy usage such that, with the use of active energy generation equipment (i.e. solar PV etc.), it can generate as much renewable energy as it uses on an annual basis.
The Problem with the “Net Zero Energy” Definition

Common Attributes of Net Zero Energy Buildings

Average energy savings over code:

- Houses -64 %
- Educational -76 %
- MURBs -50 %
- Offices -84 %

Energy Savings of Case Studies

- New Construction
- Retrofit

64 % av. savings
76 % av. savings
50 % av. savings
84 % av. savings
Case Example 3: Single-family home

Strategy
- Small, airtight home, based on Passive House standard, 590 sf

HVAC
- HRV, heat pump water heater, electric space heater is barely needed (internal heat from occupants, lighting etc.)

Walls
- 28” thick walls R-90, ceiling R-140, air sealed,

Window
- Triple-pane, argon-filled, two low-E coatings, with fiberglass frame

→ 0.05 ACH50 air tightness – world record for tightest residential building (at the time)
→ When it’s 0 °F outside, it’s still 50 °F inside (without heating)
→ Solar-ready

Common Design Features of NZE Buildings

Most common high performance design features for new and retrofit buildings
High Performance Features = Energy Efficiency

Construction Cost Increase vs Energy Savings

A lot of PV
The most energy efficient
Baseline cost for new construction
Construction Cost Increase from Adding Features

Market Impact Study – BC Step Code
Passivhaus / Passive House

→ Voluntary design standard for highly energy efficient buildings with prescriptive targets for whole building airtightness, thermal energy demand and total energy use. Plus requirements to achieve thermal comfort criteria, avoid overheating and maintain mould-free indoor environment.

→ Two Standards and Certification Bodies: Passive House Institute (PHI) and Passive House Institute US (PHIUS) with similar though different metrics

→ In Canada, Passive House Canada is an organization that provides education and promotion for Passive House Projects.

Other Benefits to Passive and Net Zero Energy Ready – Thermal Comfort, Future-Proof, Resilience
Passive House Certification Worldwide

Passive House Certification in the North?
Some of our Northern BC Passive House Projects (CZ 7A/7B)

Whatever The Goal – The Approach is the Same

Reduce loads (Building Enclosure First approach) (TEDI)

Use Energy Efficiently (TEUI/MEUI)

Renewable Energy Supply
So Let’s Figure It Out in the North!

Northern Canada Research Study Questions

1. What are major challenges to achieving near net zero or passive house levels of energy efficiency in Canada’s North
   → Are there locally available resources (labour, materials) and do technologies exist to hit targets

2. What are strategies to achieve targets including changes to design, enclosure or mechanical systems
   → What is practical or feasible in Northern construction?
   → What kind of future technologies need to be developed to hit targets in colder climates?
   → Do the targets need to be adjusted?
Northern Canada Research Study Questions

3. How do different energy modeling tools compare at assessing these energy efficiency targets, do standard assumptions apply to housing in Northern Canada?
   → Can results from PHPP, HOT2000, and EnergyPlus™ be used as comparable compliance paths?

4. What are the incremental costs of such high performance buildings in Northern Canada, including remote locations?
   → How could costs compare between different architectural styles and levels of articulation and between remote and urban locations?

Research Study Methodology

→ Literature Review
   → What has been done in other Arctic and Antarctic buildings worldwide to achieve very high levels of energy efficiency?
   → How have other countries adapted energy targets/requirements?

→ Energy Modelling Tool Comparison
   → How do different tools compare? Do they align?

→ Compliance Modeling
   → What Energy Conservation Measures (ECMs) are needed to hit different levels of energy efficiency?

→ Costing Analysis
   → What does it cost across the North to hit different energy targets?

→ Analysis of Barriers
   → What challenges exist, what solutions are or could be available?
Step 1: Select Representative Housing Archetypes Appropriate for the North and Consider Full Range of Northern Climate Zones

Representative Housing Archetypes for Modeling

- Single Family Dwelling (SFD)
  - Simple & Articulated Form Factor
- Multi-Unit Residential Building (MURB)
  - Simple & Articulated Form Factor
- 5-Plex Row House
**SFD Archetypes & Foundations**

**SIMPLE**
- Slab on Grade
- Footing on Bedrock
- Elevated (Permafrost)

**ARTICULATED**

**MURB Archetypes**

**SIMPLE**

**ARTICULATED**
5-Plex Multi-Family

Northern Locations for Analysis

Fort St. John (climate zone 7a, 5,750 HDD), Whitehorse (climate zone 7b, 6,580 HDD), Yellowknife (climate zone 8, 8,170 HDD), and Resolute (climate zone 8, 12,360 HDD).
Step 2: Select Appropriate Building Enclosure and Mechanical Equipment Energy Conservation Measures Applicable to Northern Housing

Energy Conservation Measures (ECMs)

→ Start with National Building Code (NBC 2015) and National Energy Code of Canada (NECB 2011) as minimum criteria for building enclosure & mechanical equipment efficiencies

→ Building enclosure ECMs as levers to reduce loads to meet more stringent targets
  → Increasing insulation R-values within wall, roof, floor assemblies
  → Improving airtightness
  → Improving window U-values (double, triple, quad pane)

→ Mechanical system ECMs to improve energy use efficiencies to meet targets
  → Heating systems - fuel, electric resistance, heat pumps
  → Domestic hot water - fuel, electric, heat pump & heat recovery
  → Ventilation Heat Recovery
Practical Limits to Upper ECMs in the North

<table>
<thead>
<tr>
<th>Component</th>
<th>Upper Limit of Performance &amp; Why?</th>
</tr>
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<tbody>
<tr>
<td>Roof R-value</td>
<td>R-100 (36&quot; of fibrous insulation)</td>
</tr>
<tr>
<td>Wall R-value</td>
<td>R-80 (2x6+16&quot; ext. insulation w/ long screws or 24&quot; double wall)</td>
</tr>
<tr>
<td>Slab on Grade R-value</td>
<td>R-40 (8-10&quot; of foam)</td>
</tr>
<tr>
<td>Suspended Floor R-value</td>
<td>R-80 (24&quot; deep truss)</td>
</tr>
<tr>
<td>Window U-value</td>
<td>U-0.12 (best available quad pane unit)</td>
</tr>
<tr>
<td>Door R-value</td>
<td>R-8 (best available insulated units)</td>
</tr>
<tr>
<td>Airtightness</td>
<td>0.15 to 0.30 ACH(_{50}) (SFD to MURB, 4x tighter than PH, extremely tight)</td>
</tr>
<tr>
<td>Space Heating</td>
<td>Up to 1.5-2.1 COP CCASHP</td>
</tr>
<tr>
<td>HRV Efficiency</td>
<td>Up to 81% (best avail cold-climate w/o pre-heat)</td>
</tr>
<tr>
<td>DHW</td>
<td>Up to CO2 Heat Pump, 2.5-3.0 COP</td>
</tr>
<tr>
<td>Drain Water HR</td>
<td>65%</td>
</tr>
</tbody>
</table>

Why Practical Limits? What About Future Tech?

[Images of various building components and technologies]
**Step 3: Assess Net Zero Energy Ready Performance Targets**

<table>
<thead>
<tr>
<th>Program</th>
<th>Target Type</th>
<th>Compliance Structure</th>
<th>End Goal</th>
<th>Applicability</th>
<th>Origin</th>
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<tbody>
<tr>
<td>BC Energy Step Code</td>
<td>Energy metrics</td>
<td>4 or 5 Steps, targets vary by climate</td>
<td>Net-zero ready</td>
<td>BC*</td>
<td>BC</td>
</tr>
<tr>
<td>Passive House</td>
<td>Energy metrics, &amp; comfort</td>
<td>Classic, Plus, Premium</td>
<td>Net-zero ready</td>
<td>All</td>
<td>Germany</td>
</tr>
</tbody>
</table>

*May be adopted on National scale*
Metrics to Evaluate Energy Efficiency

Airtightness | Building Enclosure | Mechanical Equipment & Systems | Total Energy Use & Greenhouse Gas Emissions
---|---|---|---


<table>
<thead>
<tr>
<th>Airtightness</th>
<th>Equipment &amp; Systems</th>
<th>Thermal Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step Code for SFD: Step 5</td>
<td>≤1.0 ACH&lt;sub&gt;50&lt;/sub&gt;</td>
<td>MEUI ≤ 55-75 kWh/m²</td>
</tr>
<tr>
<td>Step Code for MURB: Step 4</td>
<td>N.R.</td>
<td>TEUI ≤ 100 kWh/m²</td>
</tr>
<tr>
<td>Passive House</td>
<td>≤0.6 ACH&lt;sub&gt;50&lt;/sub&gt;</td>
<td>PER ≤ 60 kWh/m²</td>
</tr>
</tbody>
</table>
Problem: Different Energy Modeling Tools Estimate Different Energy Consumption

Energy Modeling Tools in Canada

→ SFDs (Part 9 of code)
  → HOT2000 for Part 9 Energy Code Compliance/EnerGuide Program using NBC/NRCan baseline assumptions and protocols
  → PHPP used for Passive House certification using European baseline assumptions and protocols

→ MURBs (Part 3 of code)
  → Hourly energy models such as Energyplus™ used for Part 3 Energy Code Compliance using NECB baseline assumptions and protocols
  → PHPP used for Passive House certification using European baseline assumptions and protocols
Research Questions

→ Acknowledgement that different energy models using different calculation procedures with different inputs will produce different results

→ Research undertaken to assess whether models could be aligned and better understand why differences do exist
  → Alignment attempts made, but still large differences exist due to different calculation algorithms

→ Why? To assess whether different tools could be used for energy code compliance and if PHPP can be used as alternate to HOT2000?

→ Which model is more accurate for modeling low energy building consumption in the North?

Example – Differences in Energy Efficient SFDs using Part 9 Software
First Attempt – Using Same Performance Inputs and Standard Modeling Protocols

After Many Iterations – Best Alignment?
Example – Differences in High Performance MURBs using Part 3 Software

Hourly Software
- EnergyPlus™

First Attempt – Using Same Performance Inputs and Standard Modeling Protocols

Modelling results
After Many Iterations – Best Alignment?

![Bar chart showing energy consumption comparison between PHPP and EnergyPlus models.]

Further Challenges: Northern Considerations

→ Standard occupancy assumptions within HOT2000 and PHPP not always applicable to the North
→ 3 people (@50% of time) per dwelling unit. Tend to see higher occupancies and home more of the time in remote regions. Plus animals
→ Impacts interior gains (offsets heat) and increases ventilation requirements (adds energy)
→ Lack of standard assumptions for plug loads in the North
→ Car block heaters, heat tracing equipment, cooking practices etc.
→ Ventilation air pre-heat/HRV defrost calculations?
→ Performance of Cold Climate ASHP equipment at low temperatures?
What if Northern Occupancy Densities Were Included within Energy Modeling?

PER for the SFD in Yellowknife using the theoretical ECMs beyond the highest performing practical ECMs, using double the standard occupancy rate (orange) vs with standard occupancy (blue).

Does Increasing Occupant Density Actually Reduce Energy?

Sensitivity analysis for occupancy for the SFD in Yellowknife. The PER increases with increased occupancy, while the heating demand decreases.
**Conclusion:** Available models are not perfect, though the best tools we currently have for code compliance. Need to measure actual energy use in high performance / net zero northern homes to refine future model inputs.
Step 4: Model the Baseline (Code Minimum) Energy Consumption

Single Family Home Energy Modeling Results
Using Baseline NBC 9.36 Minimum Enclosure & Mechanical Equipment

- Articulated SFD
- Simple Form SFD
Single Family Home – Heating Energy (TEDI)

- Climate Zone 7a - Fort St. John
- Climate Zone 7b - Whitehorse
- Climate Zone 8 (urban) - Yellowknife
- Climate Zone 8 (remote) - Resolute

The Challenge with Heating Degree Days (HDD)

- Baseline TEDI (Articulated)
- Baseline TEDI (Simple Form)

R² = 1.00

- Resolute
- Yellowknife
- Whitehorse
- Fort St. John
MURB Energy Modeling Results
Using Baseline 2011 NECB Minimum Enclosure & Mechanical Equipment

MURB Energy Modeling Results - TEDI

National Energy Code for Buildings 2011
Whitehorse Energy Modeling Results - SFDs

→ Baseline Energy Consumption: Articulated and Simple Form SFD

![Pie charts showing energy consumption for Articulated and Simple Form SFD.]

Upper Steps of Step Code – Near Net Zero SFDs

→ Baseline, NBC 2015 (9.36)
→ Reduction in air leakage rate from 2.5 ACH50 to 0.3 ACH50 (articulated) or 1.0 ACH50 (simple form)
→ Increased insulation levels within enclosure
  → Walls from R-17.5 to R-30 (articulated) or R-25 (simple form)
  → Slab from R-16 to R-35 (articulated) or R-30 (simple form)
  → Windows from low-conductivity doubles U-0.25 to triples U-0.17
  → Doors from R-4 to R-6
→ Increase HRV efficiency from 60% to 81% dual core no preheat (articulated) or 70% (simple form)
→ Add R-12 blanket to DHW tank (articulated, only)
→ Add drain water heat recovery at 65% effectiveness (articulated, only)
Total Energy Use Intensity (TEUI) - SFDs

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Articulated SFD</td>
<td>190</td>
<td>110</td>
<td>80</td>
</tr>
<tr>
<td>Simple Form SFD</td>
<td>180</td>
<td>100</td>
<td>70</td>
</tr>
</tbody>
</table>

- Articulated SFD: -41% reduction
- Simple Form SFD: -28% reduction

Thermal Energy Demand Intensity (TEDI) - SFDs

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Articulated SFD</td>
<td>120</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Simple Form SFD</td>
<td>110</td>
<td>50</td>
<td>30</td>
</tr>
</tbody>
</table>

- Articulated SFD: 60% reduction
- Simple Form SFD: 50% reduction
SFD Passive House Targets – Not Achieved with Highest Practical ECMS in Whitehorse

The heating demand (left), heating load (middle), and PER (right) of both articulated and simple form SFD models in Whitehorse. The Passive House targets are shown in orange dashed lines.

Whitehorse Energy Modeling Results - MURBs

→ Baseline Energy Consumption: Articulated and Simple Form MURB
Upper Steps of Step Code – Near Net Zero MURBs

→ Baseline, NEBC 2011
→ Reduction in air leakage rate from 0.25 L/s-m² at 5 Pa (2.2 ACH50) to 0.020 L/s-m² at 5 Pa (0.15 ACH50)
→ Increased insulation of opaque assemblies:
  → Roof from R-40 to R-76 (articulated) or R-48 (simple form)
  → Walls from R-31 to R-61 (articulated) or R-40 (simple form)
  → Exposed floors from R-40 to R-70 (articulated) or R-41 (simple form)
  → Windows from double glazed (U-0.39) to quadruple glazed (U-0.12)
→ Ventilation strategy changed from in-suite HRVs with pre- and post-heat and MUA unit supplying corridors with tempered air, to centralized/zoned ventilation system with 81% heat recovery (by dual core units with no preheat required) for suites and corridors.
→ Reduced make-up air flow rate to corridor from 20 cfm/door to 10 cfm/door (articulated)

Total Energy Use Intensity (TEUI)

![Total Energy Use Intensity Graph](image)

- NECB 2011
- 25% < NECB
- Step 4

58% reduction in TEUI for Articulated MURB
52% reduction in TEUI for Simple Form MURB
Thermal Energy Demand Intensity (TEDI)

Articulated MURB Simple Form MURB

Passive House Levels of Performance

- Articulated MURB:
  - Did not meet Passive House

- Simple form MURB:
  - Reduction in air leakage rate from 0.25 L/s-m² at 5 Pa (2.2 ACH50) to 0.020 L/s-m² at 5 Pa (0.15 ACH50)
  - Increased insulation of opaque assemblies:
    - Roof from Reff-40 to Reff-100
    - Walls from Reff-31 to Reff-80
    - Exposed floors from Reff-40 to Reff-80
  - Windows from double glazed (U=0.39) to quadruple glazed (U=0.12)
  - Ventilation system changed from in-suite HRVs with pre- and post-heat and MUA unit supplying corridors with tempered air, to centralized/zoned ventilation system with 81% efficient dual core HRV for suites and corridors.
  - Reduced outdoor air rate to corridors from 20 cfm/door to 10 cfm/door.
  - Space heating system changed from electric baseboards to cold climate air source heat pumps with a VRF distribution system.
  - Domestic hot water system changed from electric tank to CO2 heat pumps.
Passive House Levels of Performance

The heating demand (left), heating load (middle), and PER (right) of both articulated and simple form MURB models in Whitehorse with the maximum ECMs. The Passive House targets are shown in orange dashed lines—only the simple form MURB meets the Passive House targets.

Northern BC Smithers & Ft St John MURB Passive House Projects
Whitehorse Summary of Compliance Results

SUMMARY OF COMPLIANCE WITH HIGH PERFORMANCE TARGETS USING HIGHEST PERFORMANCE PRACTICAL ECMS FOR THE NORTH

<table>
<thead>
<tr>
<th>Whitehorse CZ 7b</th>
<th>25% CODE</th>
<th>STEP CODE</th>
<th>PASSIVE HOUSE (PHI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFD – articulated</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SFD – simple form</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MURB – articulated</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A*</td>
</tr>
<tr>
<td>MURB – simple form</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A*</td>
</tr>
<tr>
<td>5-Plex</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*The highest compliance target for Part 3 buildings within the BC Energy Step Code is Step 4

Incremental Costing Analysis

→ Energy Conservation Measures Costed using Northern Canadian costing data (Previous CMHC Costing Study), with local input and 2019 information

→ Focus on incremental material and labour costs (i.e. adding extra insulation plus associated detailing) and various mechanical equipment upgrade costs (or savings)
Costing – Pushing SFDs to Net Zero Ready

Largely a Building Enclosure Cost:
Air-Sealing & Testing, Insulation & Windows
Costing – Pushing SFDs to Net Zero Ready

<table>
<thead>
<tr>
<th>Target</th>
<th>Geometry</th>
<th>Location</th>
<th>ICC ($/m²)</th>
<th>Total Project Cost ($/m²)</th>
<th>% Incremental Cost</th>
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</thead>
<tbody>
<tr>
<td>Step 5 (2018)</td>
<td>Articulated</td>
<td>Fort St. John</td>
<td>324</td>
<td>2227</td>
<td>15%</td>
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<tr>
<td></td>
<td>Whitehorse</td>
<td>681</td>
<td>2580</td>
<td>26%</td>
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<td></td>
<td>Yellowknife</td>
<td>642</td>
<td>2927</td>
<td>22%</td>
<td></td>
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<tr>
<td></td>
<td>Resolute</td>
<td>1370</td>
<td>4734</td>
<td>29%</td>
<td></td>
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<tr>
<td></td>
<td>Simple Form</td>
<td>Fort St. John</td>
<td>315</td>
<td>2227</td>
<td>14%</td>
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<tr>
<td></td>
<td>Whitehorse</td>
<td>364</td>
<td>2580</td>
<td>15%</td>
<td></td>
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<tr>
<td></td>
<td>Yellowknife</td>
<td>432</td>
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<tr>
<td></td>
<td>Resolute</td>
<td>1043</td>
<td>4734</td>
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<tr>
<td></td>
<td>Articulated</td>
<td>Fort St. John</td>
<td>1186</td>
<td>2227</td>
<td>53%</td>
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<td></td>
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<td>1542</td>
<td>2580</td>
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<td></td>
<td>Yellowknife</td>
<td>1526</td>
<td>2927</td>
<td>52%</td>
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<td>Resolute</td>
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<td>2580</td>
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<td>1272</td>
<td>2927</td>
<td>43%</td>
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<td>Resolute</td>
<td>2194</td>
<td>4734</td>
<td>46%</td>
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Recall Passive House targets were not met for SFD Archetypes in Whitehorse or Further North

Costing – Pushing MURBs to Net Zero Ready

- 25% < NECB 2011
- Step 4
- Passive House
- Highest practical ECMs

\[\text{Incremental Capital Cost ($/m²)}\]

Fort St. John
Whitehorse
Yellowknife
Resolute

G.Finch - RDH - gfinch@rdh.com
### Costing – Pushing MURBs to Net Zero Ready

<table>
<thead>
<tr>
<th>Target</th>
<th>Geometry</th>
<th>Location</th>
<th>ICC ($/m²)</th>
<th>Total Project Cost ($/m²)</th>
<th>% Incremental Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Articulated</td>
<td>Fort St. John</td>
<td>84</td>
<td>1887</td>
<td>4%</td>
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<td></td>
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<td>156</td>
<td>2186</td>
<td>7%</td>
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<td></td>
<td></td>
<td>Yellowknife</td>
<td>Target not met</td>
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<tr>
<td></td>
<td></td>
<td>Resolute</td>
<td>Target not met</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Simple Form</td>
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<td>19</td>
<td>1887</td>
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<tr>
<td></td>
<td></td>
<td>Whitehorse</td>
<td>51</td>
<td>2186</td>
<td>2%</td>
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<tr>
<td></td>
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### Challenges & Solutions
Building Articulation Has Profound Impact on TEDI and Ability to Hit Energy Targets Cost Effectively

Impact of Articulation on Heating Demand

- CZ 7a Fort St. John
- CZ 7b Whitehorse
- CZ 8 Yellowknife
- CZ 8 Resolute
Impact of Articulation by Housing Type
Using Yellowknife Building Data as Example for PHPP Models

Window to Wall Ratio is Critical

Heating Demand versus window to wall ratio for the simple form SFD in Yellowknife. Each dot represents an addition of a 1.5m x 1.9m window to the façade as indicated on the graph.
Higher Performance Windows Will Grow in Demand

Window performance (U-value shown as W/m²K) modelled in the compliance modelling work to meet high performance targets for the simple form SFD and the MURB archetypes.

A Reoccurring Theme – Need for Higher Performance Windows by 2032

Demand Forecast for Fenestration Products
New Construction, Metro Vancouver, 2019–2032

Window performance (U-value shown as W/m²K) modelled in the compliance modelling work to meet high performance targets for the simple form SFD and the MURB archetypes.
Future Window Technologies Beyond Quads May Help

![Graph showing heating demand and window thermal performance for different locations.](image)

Depreciating Returns - Wall/Roof/Floor Insulation

![Graph showing thermal performance of opaque assemblies for different locations.](image)
Depreciating Returns – Effective Opaque Enclosure R-value (Wall, Roof, Floor Combined)

The Continued Importance of Airtightness
**Need for Local Electrical Grid Reliability and Capacity**

PHPP PER from modelling the simple form SFD with both electric (COPs ≥ 1.0) and fuel oil (93% efficient) systems.

<table>
<thead>
<tr>
<th>Location</th>
<th>Fuel Oil Approx. doubles PER</th>
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</thead>
<tbody>
<tr>
<td>Electric Boiler</td>
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<tr>
<td>7a - Fort St John</td>
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<tr>
<td>Electric Boiler</td>
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<tr>
<td>7b - Whitehorse</td>
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<tr>
<td>Electric Boiler</td>
<td></td>
</tr>
<tr>
<td>8 (urban) - Yellowknife</td>
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<tr>
<td>Electric Boiler</td>
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</tr>
<tr>
<td>8 (remote) - Resolute</td>
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</table>

**Need for More Efficient HRVs without Need for Pre-Heat for Defrost**

Comparison of different high performance HRV options. The 81% efficient dual core unit was used as the highest performing practical ventilation ECM instead of a 95% efficient HRV due to the additional preheat energy that would be required in the north (shown in orange for SFD in Yellowknife).
Need for Reliable Cold Climate Air Source Heat Pumps at Arctic Design Temperatures

Northern Logistical Challenges – Cost and Availability of Materials & Labour

Community Airports
Regional Airports
Gateway Hubs
Flight Paths
Seaports
Mackenzie River/Barge

Ice Roads
Gravel Roads
Highway
Major Roads
Trans Canada Highway
3 Pathways to Achieving the Highest Building Energy Performance Targets in the North

1. Technology – Use best of today within practical and cost effective means, future technology may be, but is not guaranteed to be the solution, plus we can’t wait another 20 years

2. Minimum Energy Code Targets for Arctic need to be adjusted from Southern Canada. Passive House Practicality?

3. Think Bigger – Community Scale Net Zero Energy Ready

Theoretical Technological Developments Needed to Reach Passive House Heating Demand

Heating Demand of the simple form SFD archetype modelled in PHPP for ECMs beyond the highest performance practical ECMs, in Yellowknife. NBC 2015 baseline TEDI is shown for comparison (light blue), modelled in HOT2000.
Theoretical Technological Developments Needed to Reach Passive House PER

PER of the simple form SFD archetype modelled in PHPP for ECMs beyond the highest performance practical ECMs, in Yellowknife.

Adapt Energy Code Targets for Climate Zones 7 & 8 (plus new 9,10,11,12...?)
Net Zero Communities instead of Buildings

→ May be more practical way of achieving net zero energy goals in remote regions, and already becoming a necessity to reduce reliance on fossil fuels and reduce GHGs & cost

→ For buildings powered by community utility – would be reasonable to set a “near net zero” energy budget (i.e. Step 4/5 Levels?) factored by available generation capacity

Key Takeaways

→ Literature Review
→ Energy Modeling Tools
→ Energy Compliance with Upper Steps & Passive House
→ Costing SFDs and MURBs
→ Challenges & Solutions
Discussion + Questions

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OR CONTACT US AT
→ gfinch@rdh.com - 250-479-1110