What is net zero and net zero ready?
Case study: Net Zero
Case study: Passive House
Case study: Net Zero Ready Strategy Development
Net Zero and the Climate Leadership Plan

→ “Promote more energy efficient buildings”, “developing requirements to encourage net zero ready buildings”
→ Accelerating increased energy requirements in the BC Building Code by taking incremental steps to make buildings ready to be net zero by 2032;
→ Developing energy efficiency requirements for new buildings that go beyond those in the BC Building Code, called Stretch Codes, that interested local governments could implement in their communities
What is Net Zero? Net Zero Ready?

→ Net Zero: Facility generates *on-site* all the energy required to power its functioning through the course of the year

→ Any project can be Net Zero
  → Provided you have enough $$$

→ Or modest expectations for comfort, environmental quality, amenities, etc.
Toward Net Zero the “Right Way”

- Passively Manage Loads
- Use Energy Efficiently
- Renewable Energy Supply

Each level defines the boundary condition energy performance potential of the next level.
Toward Net Zero the “Right Way”

Each level defines the boundary condition energy performance potential of the next level.
Net Zero Rules of Thumb

→ Achieve Base building less than 100 ekWh/m²-year

<table>
<thead>
<tr>
<th></th>
<th>Single Floor</th>
<th>2 Floors</th>
<th>4 Floors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Flat or Sloped Roofs Required for PV</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 ekWh/m²</td>
<td>1.4 flat / 1.2 shed</td>
<td>2.8 / 2.4</td>
<td>5.6 / 4.8</td>
</tr>
<tr>
<td>70 ekWh/m²</td>
<td>1.0 / 0.8</td>
<td>1.9 / 1.7</td>
<td>3.9 / 3.4</td>
</tr>
<tr>
<td>50 ekWh/m²</td>
<td>0.7 / 0.6</td>
<td>1.4 / 1.2</td>
<td>2.8 / 2.4</td>
</tr>
</tbody>
</table>

Typical PV output

72 kWh/year for every square meter roof area
Net Zero Rules of Thumb
Mohawk College Net Zero: Joyce Centre for Partnership and Innovation

→ Client: Mohawk College
→ Architects: B+H Architects, McCallum Sather (joint venture)
→ Energy and Enclosure Consultant: RDH
→ Mechanical: The Mitchell Partnership
→ Electrical: Mulvey and Banani International Inc.

→ CaGBC Pilot Project for “Zero Carbon Buildings Initiative”
The Building

→ 90,000 sqft
→ 4 storeys
→ 2 large lecture theatres
→ 8 electronics labs
→ Commons/ collaboration space
→ Café space
Mission: Net Zero

→ Definition: Net zero energy on annual basis
  → Roof top generation will equal consumption
    › Solar PV (~550 kW)
    › Solar thermal for domestic hot water
→ (No Renewable Energy Credits or offsets purchased)

The Process

→ Preliminary exercise to define an “Energy Budget” (75 kWh/m²)
→ Preliminary energy models, conceptual design
→ Pushed the envelope
→ Energy efficient HVAC
<table>
<thead>
<tr>
<th>End Use</th>
<th>3 Water Source VRF + GHSP</th>
<th>4 Water Source VRF + GHSP + Solar Thermal</th>
<th>7 Air Source VRF Heating / Cooling</th>
<th>Current Modelled Performance</th>
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</thead>
<tbody>
<tr>
<td>Interior Lighting</td>
<td>10.7</td>
<td>10.7</td>
<td>10.7</td>
<td>12.4</td>
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<tr>
<td>Receptacle and Process</td>
<td>19.3</td>
<td>19.3</td>
<td>19.3</td>
<td>18.9</td>
</tr>
<tr>
<td>Space Heating - Heat pumps</td>
<td>13.7</td>
<td>9.6</td>
<td>21.4</td>
<td>13.0</td>
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<tr>
<td>Space Cooling - Heat pumps</td>
<td>6.4</td>
<td>6.4</td>
<td>8.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Pumps and Aux</td>
<td>6.7</td>
<td>8.2</td>
<td>0.0</td>
<td>8.8</td>
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<tr>
<td>Fans</td>
<td>11.3</td>
<td>11.3</td>
<td>11.3</td>
<td>12.5</td>
</tr>
<tr>
<td>DHW</td>
<td>4.5</td>
<td>2.3</td>
<td>4.5</td>
<td>1.2</td>
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<tr>
<td>Boiler</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Elevator Estimate</td>
<td></td>
<td></td>
<td>0.8</td>
<td>0.8</td>
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<tr>
<td>Microgrid Losses</td>
<td></td>
<td></td>
<td>0.3</td>
<td>0.3</td>
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<tr>
<td>Exterior Lighting</td>
<td></td>
<td></td>
<td>1.0</td>
<td>1.0</td>
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<tr>
<td><strong>Total (ekWh/m²)</strong></td>
<td><strong>72.5</strong></td>
<td><strong>67.6</strong></td>
<td><strong>75.9</strong></td>
<td><strong>70.5</strong></td>
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<tr>
<td>Rank (lowest to highest)</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Net Solar Thermal Effect (ekWh/m²)</td>
<td>-4.9</td>
<td><strong>-0.9</strong></td>
<td>1.0</td>
<td>1.0</td>
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<tr>
<td>Total ekWh</td>
<td>624,000</td>
<td>582,000</td>
<td>653,000</td>
<td>607,000</td>
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<tr>
<td>Annual Energy Cost</td>
<td>$74,880</td>
<td>$69,840</td>
<td>$78,360</td>
<td>$72,840</td>
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<tr>
<td>Size of PV Array (kWp)</td>
<td>567</td>
<td>529.09</td>
<td>594</td>
<td>545</td>
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<tr>
<td>Size of PV Array (m²)</td>
<td>4,727</td>
<td>4,409</td>
<td>4,947</td>
<td>4,542</td>
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<tr>
<td>Flat Roof Area (m²)</td>
<td>9,455</td>
<td>8,818</td>
<td>9,894</td>
<td>9,084</td>
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<tr>
<td>Cost of PV</td>
<td>$1,420,000</td>
<td>$1,330,000</td>
<td>$1,490,000</td>
<td>$1,370,000</td>
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<tr>
<td>NREL Recommended O&amp;M / year</td>
<td>$10,650</td>
<td>$9,975</td>
<td>$11,175</td>
<td>$10,275</td>
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<tr>
<td>Linear m of Borehole</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
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<tr>
<td># of 600' boreholes</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
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<tr>
<td>m² Area of Field using 6 m spacing</td>
<td>984</td>
<td>984</td>
<td>984</td>
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<tr>
<td>Weeks to install</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
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<tr>
<td>Cost of Borehole</td>
<td>$250,000</td>
<td>$250,000</td>
<td>$250,000</td>
<td>$250,000</td>
</tr>
</tbody>
</table>
The Design

Enclosure:

→ R-40 roof: 2-ply modbit, polyiso
→ R-10 overall for window + wall
  → R-30 target for opaque wall elements
    › Spandrel glass system with thermal clips, roxul, interior sprayfoam
    › Precast sandwich panel with XPS; sprayfoam inboard
→ Triple glazed windows with 3 low-e coatings
→ ~40% window-wall ratio

→ Sensitivity analysis on nearly all aspects
The Design

Mechanical:
- Separate ventilation (DOAS) with ERV
- Distributed heating/cooling VRF, zone-to-zone heat recovery
  - Connected to geoexchange field
- Demand controlled systems (ventilation, heating/cooling) to handle variable occupancy

Electrical
- LED lighting
- Occupancy and daylight sensors
  - Daylight glazing panels
- Process loads?
The Energy Step Code and Net Zero Ready

- Proposed step code introduces targets for
  - Thermal Energy Demand Intensity (TEDI)
  - Total Energy Use Intensity (EUI)
  - Airtightness

Source: SCIWG Final Report
Passive House: Net Zero Ready?

→ Step code’s TEDI, EUI, airtightness requirements follow Passive House principles
Passive House: Net Zero Ready?

→ Passive House as a path to Net Zero
→ ~90% reduction in heating energy compared to typical building, low annual energy consumption
→ Higher levels of certification include renewables
Passive House in North America

Cumulative Units

Dual Certified - Projected
PHIUS - Projected
PHI - Projected
PHIUS - New
PHI - New
PHIUS - Cumulative
PHI - Cumulative

Source: Pembina Institute
Developing a Path to Net Zero

→ Archetype energy modelling studies
→ Organizations setting strategic goals to achieve net zero energy & carbon in the next 5 to 15 years
→ Important to develop a road map to get there
ECMs Using Readily Available Technology

→ Net Present Value (NPV) ranked from highest to lowest using utility energy prices
ECMs Using Readily Available Technology

→ Net Present Value (NPV) ranked from highest to lowest using **renewable** energy prices
Combining Measures into Bundles

→ NPV using *utility* energy prices

![NPV Diagram]

- **Bundle 1: Positive NPVs**
  - Best Case Costing: $24.31
  - Worst Case Costing: $10.37

- **Bundle 2: Best ECMs**
  - Best Case Costing: $0.43
  - Worst Case Costing: -$24.74

$24.31  $0.43
$10.37
$0.43
$24.74
$0 $10 $20 $30 $40 $50

NPV, $/m²

Best Case Costing
Worst Case Costing
Combining Measures into Bundles

→ NPV using renewable energy prices

![Chart showing NPV for Bundle 1 and Bundle 2. Bundle 1 has Positive NPVs with Best Case Costing at $76.55 and Worst Case Costing at $45.66. Bundle 2 has Best ECMs with Best Case Costing at $84.68 and Worst Case Costing at $10.51.]
Developing a Path to Net Zero

→ Energy conservation is typically more cost effective than renewable supply

→ Economics are good for long term building owners/operators

→ Road map to zero energy & carbon new buildings
  → Establish goals for 2020, 2025, 2030 and beyond
  → Identify capacity building and market transformation needs
Discussion + Questions

BCOUGHLIN@RDH.COM
WWW.RDH.COM