Passive House: Barriers Removed
Lessons From Calgary’s First Passive Houses
Passive House Alberta

*Passive House is the standard for the built environment in Alberta, accessible and affordable for all*

For follow up question and additional info:

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or

www.passivehousealberta.com
Presenters

Frank Crawford, P.Eng, GSC
- Civil Engineer
- 12 years commercial construction project manager
- Owner / designer / builder of the Montgomery Passive House

David Smith, BASc, MBA
- 12 years residential builder and developer
- Certified Passive House Designer
Agenda

- Reminder of Why Passive Houses are Great
- Meet 3 of Calgary’s First Residential Passive Houses
- Perceived Barriers:
  1. Passive Houses Cost Too Much
  2. Concerns About Energy Model Accuracy
  3. Lack of Certified Materials
  4. Lack of Knowledgeable Trades and Designers in Alberta
  5. City Permitting is Complicated
- Tips and lessons learned
- Closing & Questions
Why Passive Houses are Great

- 90% less energy for space heating vs conventional homes
- Comfortable
  - no drafts
  - quiet
  - excellent air quality
- Durable
- Predictable results
- New construction & Renovation
- All types of building

Photo credit

Montgomery Passive House

- Occupancy: Feb 2016
- Total Developed Area: 2900 ft$^2$ (includes legal secondary suite)
- Cost: $550,000 (*) $314 / AG ft$^2$, $190 / Dev ft^2$
- Specific Space Heat Demand: 12 kWh/(m$^2$a)
- Pressure Test Result: 0.28 ACH at 50Pa
- Envelope:
  - R41 above grade walls & R60 roof
  - R37 below grade walls & slab, R7+ windows
- Additional Features:
  - 7.2kW photovoltaic array
  - rain water harvesting for irrigation
  - permaculture food forest and annual food garden

(*) excluding land

PV array provides 62% of total energy need
Total utility bills $1600 per year (both units)
Richmond Passive House
One House Green

- Occupancy: 2016
- Total Developed Area: 2,171 ft²
- Cost: $685,000 (*), $355 / AG ft², $315 / Dev ft²
- Specific Space Heat Demand: 15 kWh/(m²a)
- Pressure Test Result: 0.43 ACH at 50Pa
- Envelope:
  - R48 above grade walls & R89 roof
  - R36 below grade walls & slab, R7+ windows
- Additional Features:
  - excellent solar exposure on one of the highest natural points in Calgary
  - roof designed for solar array (client to install)
  - rainwater harvesting
  - ground loop based HRV defrost

(*) excluding land

www.onehousegreen.com
Rosedale Passive House
One House Green

- Occupancy: 2016
- Total Developed Area: 2,778 ft²
- Cost: $845,000 (*), $440 / AG ft², $304 / Dev ft²
- Specific Space Heat Demand: 15 kWh/(m²a)
- Pressure Test Result: 0.3 ACH at 50Pa
- Envelope:
  - R55 above grade walls & R79 roof
  - R48 below grade walls & slab, R6.5+ windows
- Additional Features:
  - infloor heat (basement, main and upper) with small-load electric boiler
  - boiler assist for HRV defrost

(*) excluding land
Perceived Barrier 1: Costs Too Much

- Better buildings do cost more
  - Added insulation
  - Better windows
  - Air sealing
- The increased cost to meet the Passive Standard can range from 2%-10%
  - Decreases with experience
  - 3%-4% in Vancouver
- LEED buildings also started off being more expensive

https://en.wikipedia.org/wiki/Passive_house
https://passipedia.org/basics/affordability/investing_in_energy_efficiency/are_passive_houses_cost-effective
http://www.ecohome.net/news/latest/new-brunswick-s-energy-efficient-home
Perceived Barrier 1: Costs Too Much Continued

At the 15kWh/m².yr heat demand the mechanical systems get significantly less complicated.
Removing the Cost Barrier: Design Optimisation

- Can’t cost effectively make any design Passive House
- Passive House is a requirement from the start
- Need thorough planning up front

Photo credit
https://www.westhomeplanners.com/db/images/4618_floorplan_basement1.gif
Removing the Cost Barrier: Design Optimisation Continued

Improve layout efficiency to reduce size:

- With a Passive House all rooms are comfortable year round (even basement)
- Move bedroom into the basement
- Move storage to unheated outdoor garage or shed
- Smaller mechanical room
- Montgomery Passive House custom designed and built for $190/developed ft2
- One House Green high-end custom homes are around $315/developed ft2

Slow homes – What’s Wrong with this House

Photo credit
https://www.westhomeplanners.com/db/images/4618_floorplan_basement1.gif
Removing the Cost Barrier: Utility Cost Savings

- Utility cost savings can offset higher construction costs / mortgage payments
- 90% reduction in heat demand over first year occupancy of Montgomery Passive House resulted in:
  - 64% reduction in total energy used vs a code minimum house
  - 43% reduction in monthly utility cost (~$60 per month)
- High fixed utility costs in Alberta mean utility cost savings % are less than energy saving %
- Increased energy costs will increase the monthly savings
### Incremental Mortgage Costs vs Utility Savings

<table>
<thead>
<tr>
<th>Mortgage Value</th>
<th>Monthly Payment (3% interest, 25 year term)</th>
<th>Monthly Increase for 2% Larger Mortgage</th>
<th>Monthly Increase for 10% Larger Mortgage</th>
</tr>
</thead>
<tbody>
<tr>
<td>$300,000</td>
<td>$1,420</td>
<td>$30</td>
<td>$140</td>
</tr>
<tr>
<td>$400,000</td>
<td>$1,890</td>
<td>$40</td>
<td>$190</td>
</tr>
<tr>
<td>$500,000</td>
<td>$2,360</td>
<td>$55</td>
<td>$240</td>
</tr>
<tr>
<td>$600,000</td>
<td>$2,840</td>
<td>$60</td>
<td>$280</td>
</tr>
</tbody>
</table>

Monthly utility costs savings of $60 will cover around $12,000 of addition construction costs on a 3% mortgage.
Removing the Cost Barrier: Current Government Incentives

- In Alberta currently up to $6000 in incentives are available for energy efficient upgrades (renovations only) plus the LED light bulb rebate
  - Up to $3,500 for added insulation
  - Up to $1,500 for windows
  - Up to $1,000 for hot water heaters

- There is a $0.75 /Watt or approximately 30% rebate on photovoltaic solar panel systems

https://www.efficiencyalberta.ca/home-improvement/
https://www.efficiencyalberta.ca/solar/
## Removing the Cost Barrier: New Energy Codes Brings Baseline Up

Cost increase data is compared to old building code

<table>
<thead>
<tr>
<th>Item</th>
<th>Passive House</th>
<th>NECB 2011 *</th>
<th>Old Code **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air changes per hour at 50 Pascal</td>
<td>&lt;0.6</td>
<td>2.5 to 3.2</td>
<td>none</td>
</tr>
<tr>
<td>Effective wall R value</td>
<td>R40+</td>
<td>R17 to R28</td>
<td>R12</td>
</tr>
<tr>
<td>Effective Slab R value</td>
<td>R35+</td>
<td>R21</td>
<td>0</td>
</tr>
<tr>
<td>Effective Roof R value</td>
<td>R60+</td>
<td>R49</td>
<td>R36</td>
</tr>
<tr>
<td>Window R value</td>
<td>R7+</td>
<td>R3.5</td>
<td>R2</td>
</tr>
<tr>
<td>HRV</td>
<td>yes</td>
<td>yes</td>
<td>none</td>
</tr>
</tbody>
</table>

* Code minimums vary with design ** R value, not effective R value
Removing the Cost Barrier: Multi-Family Savings

- Share interior walls
- Share utility meters
- One heating system for all units
- Convert the now comfortable basement into a secondary suite

Cost Barrier Summary

Applying these strategies mitigates the extra costs to build a Passive House.

Regardless of additional capital expenditures, you will enjoy all the comfort benefits of living in a Passive House.

Energuide ratings on houses are likely to be required in the future increasing the resale value of Passive Houses.

Montgomery passive house updated energuide rating is around 60 before PV and 25 with PV.
Average Alberta home is 146.
Perceived Barrier 2: Concerns About Energy Model Accuracy

- First Passive House built in 1988
- Now 107 million ft$^2$ of buildings in 40 countries
- Passive House Planning Package (PHPP)
  - continually tested over the past 30 years
- PHPP model accounts for
  - all thermal bridges
  - air tightness
  - number of occupants
- Multiple studies substantiate PHPP accuracy

https://passipedia.org/operation/operation_and_experience/measurement_results/energy_use_measurement_results
https://www.linkedin.com/pulse/passive-house-standard-being-adopted-around-world-California

At Montgomery passive house the model resulted in 15Whr/m2yr at 0.6ACH but dropped to 12kWhr/m2yr at 0.28ACH
Perceived Barrier 2: Concerns About Energy Model Accuracy Continued

- Montgomery Passive House energy use
  - PHPP estimate: 16,800 kWh
  - Actual: 16,200 kWh

- Average Alberta house: 40,000 kWh

https://calgary.weatherstats.ca/metrics/hdd.html

July 2016 to July 2017 was slightly (3%) below the average annual heating degree days for Calgary for the last 25 years
Perceived Barrier 3: Lack of Certified Materials

- The Passive House Standard takes a “building envelope first” approach
  - No high tech mechanical or other systems are required
  - Simplicity keeps equipment and maintenance costs down
- European imports & Canadian producers continuously introducing new products for the N.American market
  - Windows & Doors
  - HRVs & Heat Pumps
  - Air & Vapour Barriers
  - Insulation
Certified or near Certified Windows & Doors Available in Canada

- Klearwall
- Euroline
- Gaulhofer
- Cascadia
- Optiwin
- ZZ construction / MS Beyond
- BEWISO
- Kolbe
- Unilux
- Innotech
- Kolhtech

http://www.klearwall.com/
http://www.gaulhoferwindows.com/
http://www.cascadiawindows.com/products/universal-series
http://www.optiwin.net/en/
https://www.kolbewindows.com/product-lines
http://doorstudio.ca/unilux.htm
http://www.innotech-windows.com/showrooms/where-to-buy-Calgary
http://www.kolhtech.com/
https://foursevenfive.com/bewiso-victoria-upload-form/
http://www.zzconst.com/windows-doors/
http://www.sarnawindows.eu/
Heat Recovery Ventilators (HRV) & Heat Pumps

HRV or ERV
- Zehnder
- Swegon
- LUNOS
- Tempeff
- Ventacity

Heat Pump and Mini Splits
- Sanden
- Mr. Slim Mini-Split by Mitsubishi
- Minotair (heat pump ERV)

https://foursevenfive.com/product-category/hot-water/
www.mitsubishielectric.ca
www.minotair.com
Air/Vapour Barriers

- Siga
- Prosoco
- Hanno-Band
- Intello
- Proclima

Insulation

- Roxul
- Fiberglass batt
- Quik-therm
- EPS and XPS foam
- Cork insulation
- Blown cellulose
- Wool
- Agean and Gutex wood fibreboard

http://www.smallplanetsupply.com/siga/
http://www.smallplanetsupply.com/prosoco/

http://www.smallplanetsupply.com/hanno-band/
http://www.quiktherm.com/
http://codebuildingsystems.com/
www.plastifab.com
westerninsulations@Hotmail.com
http://www.smallplanetsupply.com/havelock/

Any additional product supplied by 475 (www.foursevenfive.com/) including intello, proclima and Gutex fiberboard
Supplied by pinwheel (http://pinwheelbuilds.com) and 5thC (www.5thC.ca) – Ampak

Small planet., pinwheel, 5th C – Agepan
Steico - www.europeantimberframing.com/
Perceived Barrier 4: Lack of Knowledgeable Trades and Designers in Alberta

- 30+ Passive House Certified Designers in Alberta
- Training courses are readily available for Trades or Designers
  - 2 courses held in the last 2 months
- Air sealing techniques part of new energy code
- Most Passive House window suppliers have installers
- Zehnder includes ventilation design with their HRVs

https://www.passivehouse-international.org/memberSearch.php
Perceived Barrier 5: City Permitting is Complicated

- City of Calgary wants energy efficient building to become the standard
  - Looking into allowing 12” of insulation in building setbacks
  - Align skills of safety code officers to projects
  - Offer code review pre-BP application or inspection
  - Out of sequence ground inspection allowed with partial permit
- Passive House Alberta is partnering with building inspectors to improve their knowledge of efficient building techniques
Tips and Lessons Learned

These tips will aid in reducing the additional costs associated with first time Passive House builds from the 10% to closer to 2%.

- ERV vs HRV
- HRV tips
- Heating and ventilation
- Earth Tubes / Geo Loops
- Common assemblies
- Concrete toppings
- Window blinds and exterior shades
- Doors
- Sound transfer
- Radon mitigation
- Cladding anchor types
- Green house gas emissions
ERV vs HRV

- HRVs transfer heat only via a metal heat exchanger
- ERVs transfer both heat and moisture via a membrane heat exchanger
- ERVs transfer more energy than HRVs
- ERVs help maintain humidity in Calgary's dry climate
ERV vs HRV continued

- Understand pre-heat and defrost mode and thresholds
- ERVs enter pre-heat cycle at a lower temperature (-4 to -7°C compared to 0°C for HRV)
- In winter, set both ERV and HRV to low speed to keep humidity up
HRV Tips

▶ Supply air to bedrooms/living rooms and exhaust air from bathrooms/kitchen to remove smells and circulate heat
▶ Plan each duct run pre-construction
▶ Change or clean filters every 2-3 months

HRV Tips continued

- Use DHW for pre and/or post core coils
- For post core heat coils:
  - Place as far downstream as possible
  - Ensure air resistance does not affect HRV performance
  - Keep Glycol / water temperature within unit specification

Photo credit http://www.greenbuildingadvisor.com/sites/default/files/ComfoFond%20-%20Schneider.jpg
Heating and Ventilation

Standard residential construction combines heating and ventilation but this is not advisable in a Passive House in Calgary or other cold climates:

- Current equipment specification limitations
- Desire for open floor plans
- Large south windows
- Can temper (heat or cool) HRV supply air but insufficient for all heating needs
- Simple electric radiant heaters on basic thermostats work
- Programmable thermostats are not needed
Earth Tubes and Geothermal loops

- Soil 6ft down is around 6°C in Calgary
- Need min 100 ft of pipe
- Don’t cross water line, run adjacent to your foundation or below your slab to prevent freezing issues
- 4” non-perforated weeping tile can move 30cfm
- Calgary dry climate reduces mold growth / humidity concern
- Need booster fan
- Air diverter valve for shoulder seasons

Photo credit http://www.tractorbynet.com/forums/build-yourself/297901-earth-tubes-how-build-low.html
Earth Tubes continued

- Approximate 20% improvement in air temperature
- Payback in energy saved may never occur

Improvement is without a heat pump

http://www.greengaragedetroit.com/images/9/95/Earth-tube.jpg
https://www.earthfire-energy.ca/project/geothermal-installation/
Common Assemblies

- Building assemblies with common materials and processes:
  - Dimensional framing lumber and procedures
  - Wood fibre, cellulose and rock wool insulation

- Dense packed cellulose

- Siga VB
Use Common Assemblies continued

- Procedures not outside the current skill set of trades
- Improved details are learned quickly

Wood fiber board sheathing

Tapped OSB as VB

Roxul Cavity rock
Concrete Toppings

- Concrete toppings make excellent finished floors and are great thermal mass
- Design structure to carry the additional load
- Mitigate noise transfer with a taped and sealed acoustic underlay
- Ensure windows are open while concrete is curing to prevent spalling
Concrete Toppings Continued

- Use self-consolidating concrete mix with fibers to avoid cracking
- 2” is a good thickness
- Power trowel to push the fibers down into the mix
- Left over fibers can be scraped, sanded or burnt off
- Ensure door rough openings account for topping thickness
- The basement slab can also be sealed and left exposed
- Total topping supply, install and sealing cost $4/ft² at the Montgomery Passive House
Window Blinds and Exterior Shades

- Size exterior overhangs to keep out summer sun
- Exterior blinds may be needed to block low angle morning and afternoon sun
- Interior thermal blinds can add R2 to R4
- Thermal blinds must be opened on sunny days or trapped heat can break the glass
- Tilt and turn windows open inward - some window manufacturers have frame mounted blinds
Doors

- Passive House certified doors can be expensive ($2,000-$7,000+)
- South-facing doors with windows give additional heat gain
- Force on tilt and turn doors hinges may damage hardware
- Plan for bug screen if opening door for summer cooling
- Any multipoint locking door will suffice (negligible effect on energy model)
- Electronic locks on a standard door may frost up in winter

Sound Transfer

Passive Houses are very quiet. This means sounds inside the envelope are more noticeable. Suggested mitigations:

- Roxul Safe’n’Sound in interior walls and floor joists
- Concrete floors with acoustic underlayment
- Acoustic isolators on ceiling drywall
- Solid core or sound doors
- Acoustic air transfer grills between rooms
- HRV Silencer
- Quiet dishwasher
Radon Mitigation

- High air tightness and continuous balanced mechanical ventilation
- Sub-slab/perimeter weeping tile vented to atmosphere
- Post-construction radon readings:
  - Basement 12 Bq/m³
  - Upstairs 9 Bq/m³
Exterior Cladding Anchor Types

- Reduces Effective R value
- Ensure energy model accounts for this

RDH report TB-11-Cladding-Attachment-Solution

RDH report TB-11-Cladding-Attachment-Solutions-Web-Reduced
Exterior Cladding Anchor Types
Continued

- The Montgomery Passive House used:
  - Zinc plated steel screws at 16in by 12in
  - 6in of ROXUL Dual Density Cavity Rock in 2 layers
  - 2x4 wood strapping
  - Around 15% reduction in effective insulation R value
Greenhouse Gas Emissions Reductions

- One house built to the Passive House standard will save 6 tonnes of CO₂ emissions per year compared to a standard house

- Over 25,000 new homes are built in Alberta each year

- Potential annual savings of 150,000 tonnes of CO₂ per year if Passive House becomes building code for new homes

- 2015 total Canadian greenhouse gas emissions per person: 20 tonnes

Assumptions: home with 2500 ft² of heated floor space, natural gas heating, 15kWh/m² yr for Passive House and 150kWh/m² yr for standard house, 278 kWh = 1GJ, 1GJ of natural gas = 0.0562 tonnes of CO₂ emissions

Alberta Carbon Offset Emission Factors Handbook Version 1.0 March 2015, Statistics Canada
Closing

- With over 60 Passive House buildings in Canada, 4 in Calgary, built by local designers and trades people, local expertise is now available
- The cost increase is manageable
- Multiple options for all building materials and equipment
- The time is now to start building better buildings

Photo credit: http://www.passivehousecanada.com/projects/aspen-root-passive-house/
Questions?

For additional questions, inquiries or a copy of this presentation, email:
info@PassiveHouseAlberta.com

Thank You

Frank

Photo credit http://www.passivehousecanada.com/projects/cottonwood-passive-house/