High Performance Measured: Modelled vs Measured Energy Use in Passive House Buildings

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Outline

→ Introduction
→ About Measurement & Verification of Whole Building Energy Performance
→ Comparing to Other “High Performance” Buildings
→ Summary & Conclusions
Introduction – Measured Data from Passive House in Europe

→ Results on numerous Passive House buildings available on Passipedia

https://passipedia.org/operation/operation_and_experience/measurement_results/energy_use_measurement_results
Introduction – Measuring Passive House in Canada

→ First generation of Canadian Passive House buildings are in use!
→ Let’s check in
  → How does measured heating and total energy use compare to PHPP models?
  → How do these compare to other high performance buildings in Canada?
A Note About Measurement & Verification

→ Why measure & verify?

→ Planning for M&V
   → Develop a plan
   → Think through metering, sub-metering, other data needs
   → Think through approach, eg. calibrated simulation or other

→ How to do it right
   → International Performance Measurement & Verification Protocol (IPMVP)
   → Consider all factors that may impact the results – eg. weather, occupancy, changes, etc.
   → Consider uncertainty

→ Understand the limitations of measured data!
Survey of Passive House Performance – Background

→ High-level “check in” of metered energy use at 9 Passive House buildings in Canada
  → Most in South West BC, few in colder climates (interior BC, Ontario)
  → All certified or certification pending
  → 3 single family, 3 duplex/triplex, 3 multifamily
→ Voluntary participation by owners who provided metered energy data as available
→ Not a full M&V study, so limitations to using this data
  → Eg. no weather normalizing, calibrated modelling, etc.
→ But, an interesting check-in…
Survey of Passive House Performance – Heating Energy

→ Only able to estimate measured heating energy for six of nine projects
→ Four of six projects had higher measured heating energy, but results are generally close in absolute difference

<table>
<thead>
<tr>
<th>Project</th>
<th>PHPP</th>
<th>Measured</th>
<th>Absolute Difference kWh/m²</th>
<th>Percent Difference %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>5</td>
<td></td>
<td>5</td>
<td>24%</td>
</tr>
<tr>
<td>Maximum</td>
<td>11</td>
<td></td>
<td>11</td>
<td>54%</td>
</tr>
<tr>
<td>Minimum</td>
<td>1</td>
<td></td>
<td>1</td>
<td>3%</td>
</tr>
</tbody>
</table>

*Note: Different from PHPP Heating Demand
Survey of Passive House Performance – Total Energy

- Measured total energy was higher for all buildings surveyed
- Difference more significant than heating energy
- No trend between building types or locations

### PHPP vs. Measured Total Energy Use

<table>
<thead>
<tr>
<th>Project</th>
<th>PHPP</th>
<th>Measured</th>
<th>Absolute Difference kWh/m²</th>
<th>Percent Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>28</td>
<td></td>
<td>28</td>
<td>30%</td>
</tr>
<tr>
<td>Maximum</td>
<td>80</td>
<td></td>
<td>80</td>
<td>55%</td>
</tr>
<tr>
<td>Minimum</td>
<td>3</td>
<td></td>
<td>3</td>
<td>7%</td>
</tr>
</tbody>
</table>

*Note: Different from PHPPPER*
Preliminary Sub-Metered Data

→ Shows significant range in use at different suites
Survey of Passive House Performance – Summary

→ Heating energy is relatively close, discrepancies likely due to a variety of factors
  → Weather, heating set points, equipment efficiencies, occupant use (eg. open windows/doors, internal gains, etc.)

→ Total energy use has higher discrepancies
  → Likely significant variation in occupant behavior
  → Likely different lighting, appliance, entertainment, and other baseloads than standard PHPP inputs

→ Measurement and verification recommended to better understand true modelled vs metered performance, and reasons for differences
Comparing Models to Other “High Performance” Buildings
How is Energy Used in a Passive House?

Modelled Energy Use

- Heating systems
  - Heat pumps
  - District systems
  - Electric baseboards
- DHW heating
  - Heat pumps
  - Natural Gas
- LED Lighting
- Central vs. Distributed HRVs and Pumping
- Elevators and Plug Loads
Metered Energy Use of LEED Gold Buildings

- Metered Energy Use
- PHPP Modelled Use

- Lighting
- Misc. Equip.
- Fans and Pumps
- DHW
- Cooling
- Heating

<table>
<thead>
<tr>
<th>10 Storey MURB</th>
<th>11 Storey MURB</th>
<th>11 Storey MURB</th>
<th>12 Storey MURB</th>
<th>22 Storey MURB</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
</tr>
</tbody>
</table>

5 Storey Passive House MURB
3 Storey Passive House MURB
Modelled Energy Use of Typical Canadian Buildings
Metered Energy Use Comparison

PHPP vs. Measured
Total Energy Use

Annual Energy Use Intensity, kWh/m²a
Passive House
LEED Gold Buildings

Multifamily Buildings

PHPP
Measured

Project

1 2 3 4 5 6 7 8 9 10 11 12 13 14
Summary & Conclusions

→ Measurement and verification of early Passive House buildings is important to inform the next generation
  → Important to plan for M&V early on in the project
→ Initial findings show good general alignment of heating energy, but mixed results for total energy
→ Modelled Passive House energy is significantly lower than building code models, metered existing buildings, and metered LEED buildings
  → Likely to see significant metered savings for larger Passive House buildings
  → But not likely to achieve full modelled energy savings due to increased lighting, DHW, plug loads
→ Need M&V of the next buildings!
Discussion + Questions

FOR FURTHER INFORMATION PLEASE VISIT
→ www.rdh.com
→ www.buildingsciencelabs.com

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