Low Energy Monitoring Research

North Park Passive House, Victoria, B.C.

INTRODUCTION

The Passive House standard provides a framework for high-performance buildings. A Passive House-certified building is required to achieve specific performance values for space heating energy use intensity, total energy use intensity, spatial temperature variation, ventilation performance and air leakage rate. The co-benefits of a Passive House include thermal comfort and indoor air quality. While the Passive House standard has been applied to many single-family dwellings, less is known in Canada about its application to multi-unit residential buildings (MURBs) and the impact on their energy consumption performance.

The objective of this research project was to evaluate the in-situ performance of a six-unit multi-family Passive House building (known as the North Park Passive House, figure 1) located in Victoria, B.C. The evaluation included energy and water consumption, occupant comfort and air quality, hygrothermal performance of the enclosure and financial metrics.

Figure 1: North Park Passive House

FINDINGS

Energy and water consumption

- The measured, weather-normalized annual energy consumption (figure 3) was found to be 72 kWh/m^2·yr (33,570 kWh total); 66% higher than the consumption predicted by the Passive House Planning Package (PHPP) model (43 kWh/m^2·yr or 20,170 kWh total). However, this was still well below the energy consumption of a typical code-compliant building at 132 kWh/m^2 yr.[1]
- Most of the additional energy consumption can be attributed to baseline consumption (that is, all non-space heating-related energy consumption). The building's space heating demand more closely reflects that of the PHPP model as shown in table 1.
- The overall building annual water consumption was found to be approximately 669,000 litres with an average daily water use of 183 litres per person, which is lower than the national average of 251 L/person in 2011.[2]

Table 1: Summary of End-Use Energy Breakdown

End-Use Energy	PHPP Modelled Energy (kWh/m^2·yr)	Actual Energy (kWh/m^2·yr)
Heating	8.8	10.0
Baseline	34.2	61.6

Occupant comfort and air quality

- Interior temperatures were generally within comfortable levels, the relative humidity appeared to be well controlled, falling below 50% for most of the year and the CO_2 levels were generally low indicating good ventilation was achieved in the units.

Building enclosure

- Highly insulated wall and roof assemblies can be susceptible to moisture problems as a result of reduced drying potential throughout the wall assembly. The sheathing moisture content at all monitoring locations in the North Park project remained below 20% throughout the monitoring period (figure 2). This and other envelope monitoring indicated that there is a low risk of moisture problems, such as long-term mould growth at all monitored exterior envelope locations.

[1] Carbon Neutral 4-6-Storey Multifamily Buildings, March 2016, by RDH for the City of Vancouver Sustainability Group, including updates

[2] https://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=7E808512-1

Figure 2: Sheathing Moisture Content for North and South Walls, on Floors 2 and 3.

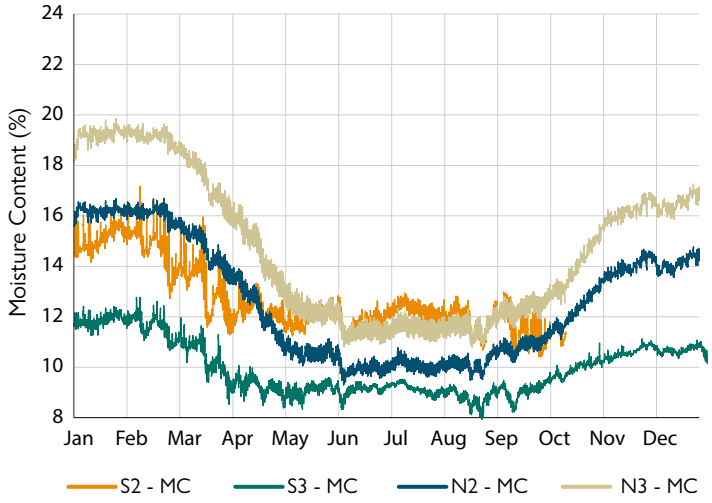


Figure 3: Actual and Modelled Monthly Energy Consumption

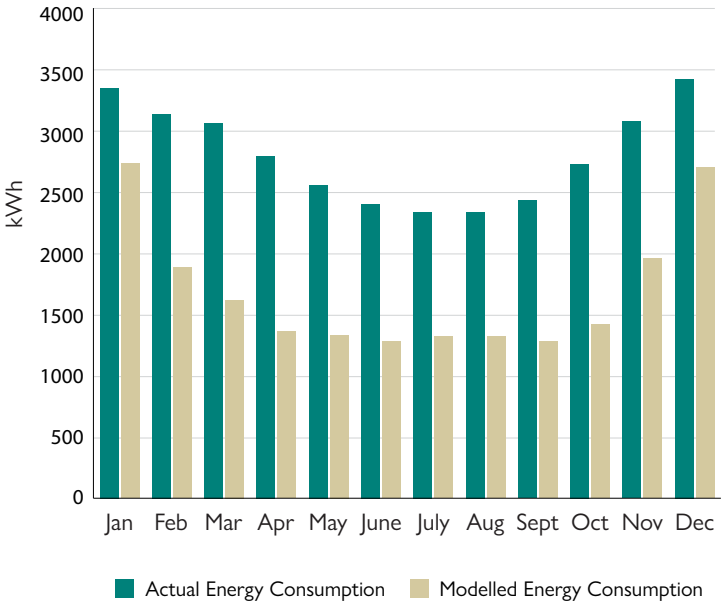


Figure 4: Cumulative Distribution Plot of Percent Hours Exceeding Limiting Temperatures

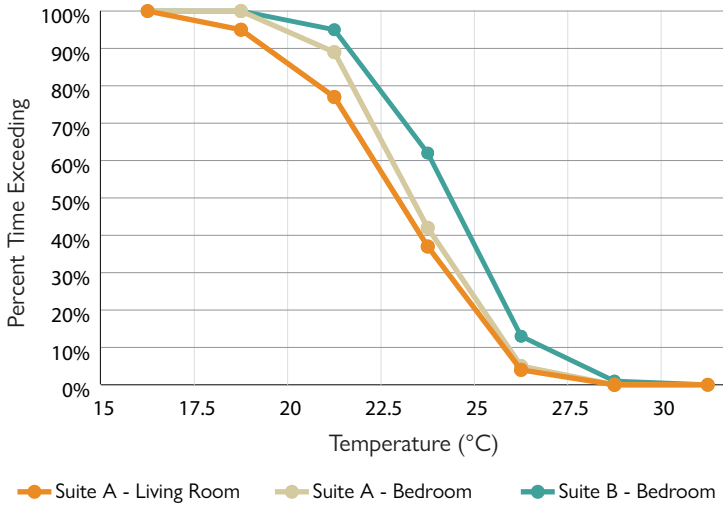
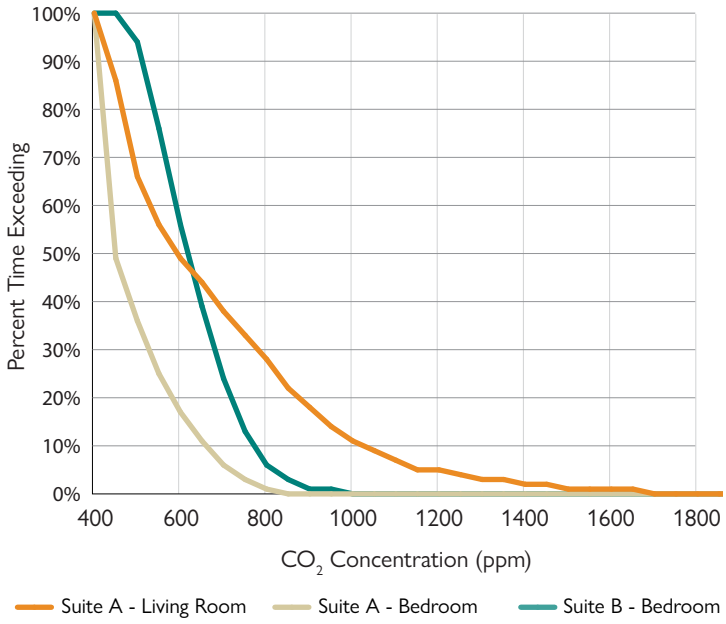


Figure 5: Percent Hours Exceeding Limiting CO_2 Values



Financial analysis

- The final construction (including soft) costs for the six-unit Passive House MURB were approximately $2,519/m^2 ($234/sq. ft.) or $1,134,000 total.
- The incremental cost increase above a non-passive house building of similar build quality was approximately 4%.
- The calculation of the NPV, IRR and discounted payback period based on incremental capital costs and energy bill savings are summarized in table 2.
- The incremental capital cost is marginally cost-effective over the 30-year analysis period.
- The NPV is slightly negative.
- The IRR is close to the assumed discount rate.
- The discounted payback period is between 11 and 20 years.
- Energy cost savings alone are therefore not sufficient to offset the additional upfront investment in the shorter term.

Table 2: Financial Analysis Summary

Annual Energy Savings (kWh/m^2)	Net Present Value (NPV) ($/m^2)	Internal Rate of Return (IRR) %	Discounted Payback Period (Years)
60	-$13.93	5%	17

IMPLICATIONS FOR THE HOUSING INDUSTRY

This research demonstrated the performance of a highly energy-efficient multi-unit residential building designed and built in the southwest coastal region of British Columbia. The research showed that, in this particular project, significant reduction in space heating performance can be achieved with a modest incremental cost compared with code-compliant construction of similar quality.

The research also showed that there is an opportunity to further improve energy performance through occupant education. For instance, tools such as user-friendly, real-time monitoring feedback have been successful in other low-energy housing projects.

Continued monitoring and demonstration of other low-energy buildings in various climates across Canada will add to the small but growing database of actual building performance, improve the accuracy of modelling assumptions and help inform the decisions of the owners and developers of affordable housing projects regarding investments in higher-performing building projects.

FURTHER READING

Full report – *Low Energy Monitoring Research Report – North Park Passive House, Victoria, B.C* (https://eppdscrmssa01.blob.core.windows.net/cmhcprodcontainer/sf/project/archive/research_2/rr_low_energy_monitoring_north_park_aug20.pdf)

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ALTERNATIVE TEXT AND DATA FOR FIGURES

Figure 2: Sheathing Moisture Content for North and South Walls, on Floors 2 and 3.

Month	Moisture Content (%)			
	S2 - MC	S3 - MC	N2 - MC	N3 - MC
January	14.5	15.6	11.7	18.2
February	15.0	16.0	11.8	19.0
March	13.5	15.5	11.0	18.6
April	11.4	13.4	9.2	15.9
May	11.9	N/A	9.2	13.0
June	12.0	10.1	9.0	N/A
July	11.7	9.7	9.2	11.0
August	11.8	N/A	8.9	N/A
September	11.7	N/A	9.0	N/A
October	10.5	10.9	N/A	12.2
November	12.8	12.9	N/A	14.9
December	13.8	14.1	10.8	16.4

Figure 3: Actual and Modelled Monthly Energy Consumption

Month	kWh	
	Actual Energy Consumption	Modelled Energy Consumption
January	3342.2	2727.3
February	3129.6	1881.5
March	3059.5	1616.3
April	2788.6	1358.7
May	2553.7	1330.3
June	2396.4	1278.7
July	2332.8	1320.3
August	2333.9	1320.3
September	2424.4	1278.7
October	2725.1	1414.3
November	3067.9	1951.7
December	3416.8	2695.3

Figure 4: Cumulative Distribution Plot of Percent Hours Exceeding Limiting Temperatures

Temperature	% Time Exceeding		
	Suite A - Living Room	Suite A - Bedroom	Suite B - Bedroom
15	99.7%	100.0%	100.0%
17.5	95.3%	99.8%	99.9%
20	76.6%	88.7%	95.2%
22.5	36.5%	42.4%	62.0%
25	4.0%	5.4%	13.2%
27.5	0.0%	0.3%	1.0%
30	0.0%	0.0%	0.1%

Figure 5: Percent Hours Exceeding Limiting CO_2 Values

CO_2 Concentration (ppm)	% Time Exceeding		
	Suite A - Living Room	Suite A - Bedroom	Suite B - Bedroom
350	100.0%	100.0%	100.0%
400	100.0%	100.0%	100.0%
450	86.1%	48.5%	99.6%
500	65.9%	36.0%	94.0%
550	56.1%	25.4%	75.5%
600	49.4%	17.2%	56.2%
650	43.9%	11.0%	39.4%
700	38.3%	6.2%	23.6%
750	33.2%	2.8%	13.1%
800	27.5%	0.9%	6.5%
850	22.5%	0.4%	3.0%
900	17.8%	0.2%	1.4%
950	14.1%	0.1%	0.7%
1000	11.1%	0.1%	0.4%
1050	8.8%	0.1%	0.3%
1100	7.0%	0.0%	0.2%
1150	5.4%	0.0%	0.1%
1200	4.5%	0.0%	0.1%
1250	3.6%	0.0%	0.1%
1300	3.1%	0.0%	0.0%
1350	2.6%	0.0%	0.0%
1400	2.1%	0.0%	0.0%
1450	1.7%	0.0%	0.0%
1500	1.2%	0.0%	0.0%
1550	1.0%	0.0%	0.0%
1600	0.8%	0.0%	0.0%
1650	0.6%	0.0%	0.0%
1700	0.4%	0.0%	0.0%
1750	0.2%	0.0%	0.0%
1800	0.1%	0.0%	0.0%
1850	0.0%	0.0%	0.0%
1900	0.0%	0.0%	0.0%
1950	0.0%	0.0%	0.0%
2000	0.0%	0.0%	0.0%