USING OPTIMISATION SOFTWARE IN SUPPORT OF BUILDING CODE DEVELOPMENT

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EXTENDED ABSTRACT

The BC government has introduced a Step Code that will help the BC Building Code (BCBC) transition from current energy requirements to near net-zero energy requirements by 2032. The idea is to show a clear path to all stakeholders as to how the BCBC will transition in the next 15 years. The Step Code will also provide municipalities with a mechanism to require or incent energy requirements that are more stringent than the current BCBC. An extensive modelling exercise was carried out to analyze the design and cost implications of achieving the various steps outlined in the Step Code (Integral Group, et al., 2017).

Given the quantity of possible energy conservation measures (ECMs) and combinations thereof, as well as the significant number of climate zones in BC, the use of an optimization software tool to analyze the impacts of the Step Code was determined to be important. At the same time, using HOT2000 and the EnerGuide Rating System (ERS) as part of the analysis was also deemed important as this is the energy modelling tool that will predominantly be used in the energy modelling to verify compliance with the energy Step Code. The Housing Technology Assessment Platform (HTAP), developed by Natural Resources Canada (NRCan) in 2010, is a tool that does optimization using HOT2000 as the energy modelling tool, meeting both requirements.

HTAP has been used internally at NRCan to support a number of initiatives. Its results have been presented to a number of builders across the country as part of the Local Energy Efficiency Partnerships (LEEP) workshops. Having developed a similar optimization tool for his doctoral thesis (Charron, 2007), NRCan approached a consultant, Remi Charron, to utilize HTAP to support the Step Code metrics research project.

The advantage of using HTAP instead of HOT2000 as a standalone tool is that it adds the capability to utilize:

- Batch processing and optimization capabilities that automate the task of evaluating different combinations of ECMs, housing archetypes and locations; and
- High performance computing resources that shorten the time required to evaluate hundreds-of-thousands of different home designs.

HTAP automates configuring, dispatching, and collecting the results from HOT2000 energy simulation runs using an objective function that factors in capital and operating costs. Based on the value of the objective function for a set of ECMs evaluated, HTAP automatically selects more design variants with the

aim to improve the objective function. HTAP can optimize for a range of criteria, including upgrade costs, utility bills, energy use, and home ownership affordability. Traditionally done manually by energy advisors, this HTAP process greatly increased the variety of Step Code-related design options that could be explored.

MODELLING DETAILS

Six different house archetypes were evaluated in HTAP:

- 10-unit low-rise multi-unit residential building (MURB), 165 m^2/unit, (1,780ft^2/unit), 3 storey over underground parkade
- 6-unit row house, 159 m^2/unit, (1,720ft^2/unit), 3 storey over underground parkade
- Quadplex, 128 m^2/unit, (1,382ft^2/unit), 3 storey over underground parkade
- Large house, 511 m^2 (5,500 ft^2), 2 storey with basement
- Medium house, 237 m^2 (2,550 ft^2), 2 storey with basement
- Small house, 102 m^2 (1,100 ft^2), single storey on heated crawlspace

Each archetype was modelled in 6 different climate zones :

- Climate Zone 4: Vancouver – 2,825 HDD
- Climate Zone 5: Summerland – 3,350 HDD
- Climate Zone 6: Cranbrook – 4,400 HDD
- Climate Zone 7a: Fort St John – 5,750 HDD
- Climate Zone 7b: Fort Nelson – 6,710 HDD
- Climate Zone 8: Uranium City, SK – 7,500 HDD

Note that Uranium City in Saskatchewan was selected to represent climate zone 8 as there were no representative British Columbia locations within the HOT2000 climate database.

Table 1 shows which ECMs were evaluated for the different archetypes and climates.

Table 1: Energy Conservation Measures Evaluated in HTAP for Step Code Metrics Study

Component	Options	# of choices
Airtightness ACH	3.5 ACH, 2.5 ACH, 1.5 ACH, 1.0 ACH, 0.6 ACH	5
Wall R-Value	R16, R18, R22, R24, R30, R40, R50, R60	8
Under-slab R-Value	R11, R15, R20, R40	4
Foundation Wall R-Value	R11, R17, R20, R25	4
Exposed Floor R-Value	R27, R29, R35, R40	4
Ceiling/Roof R-Value	R40, R50, R60, R70, R80, R100	6
Window Option & U-Value	Double (1.8), double (1.6), double (1.4), high gain triple (1.2), low gain triple (1.2), triple (1.0), high performance triple (0.8)	7
Domestic Hot Water (DHW) System	Electric & gas tank, 2 x gas tankless, heat pump (electric)	5
Drain Water Heat Recovery	None, 30%, 42%, 55% (recovery efficiencies)	4
Space Heating	Gas 92% & 95% AFUE, gas combo, Cold Climate ASHP (electric), Baseboard (electric)	5
Ventilation Heat Recovery	None, 60%, 70%, 75% & 84% SRE	5
Total Number of Possible Combinations	**53,760,000**	

For each archetype and climate, HTAP evaluated between 10,000 and 20,000 individual combinations of ECMs in HOT2000. In order to expedite the process, cloud computing through Amazon Web Service was used.

RESULTS

Representative results of data obtained from the HTAP analysis for the medium house are presented in the Figures, with Figure 1 showing Peak Thermal Load (PTL), Figure 2 showing the Thermal Energy Demand Intensity (TEDI), and Figure 3 showing the Mechanical Energy Use Intensity (MEUI).

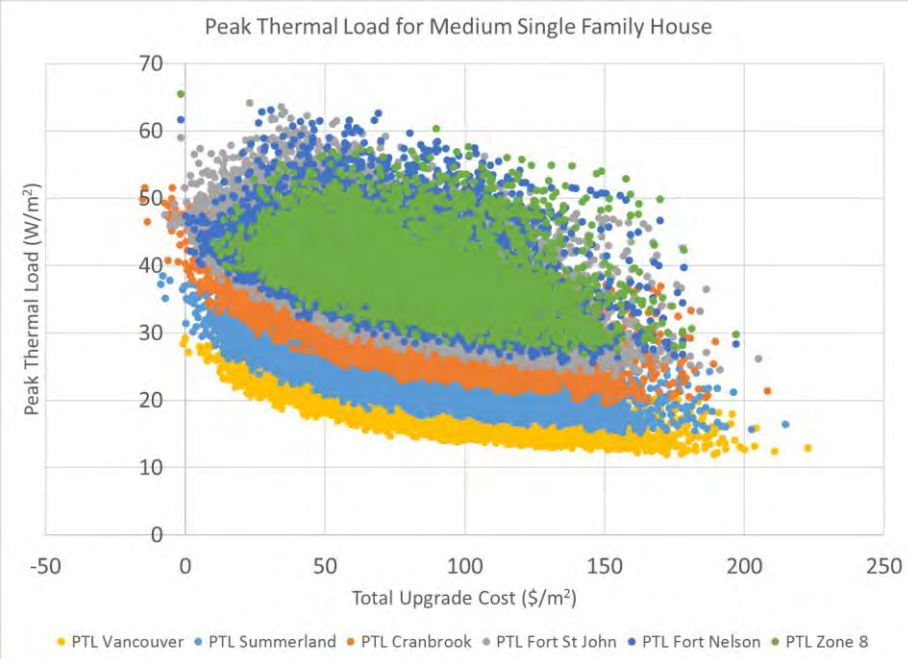

Figure 1: HTAP results for the medium house showing peak thermal loads of the thousands of ECM combinations modelled

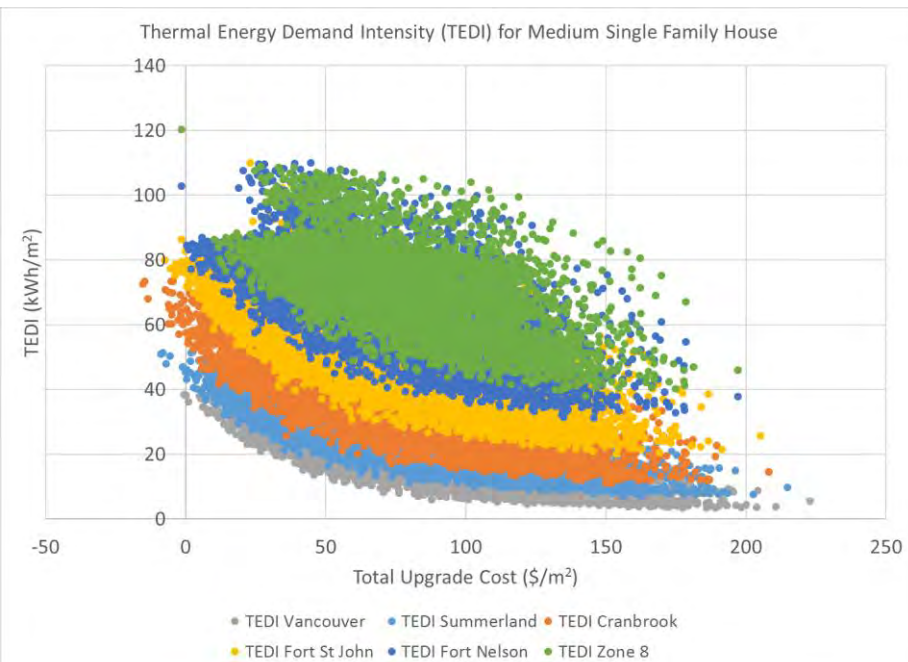

Figure 2: HTAP results for the medium house showing the thermal energy design intensity (TEDI) of the thousands of ECM combinations modelled

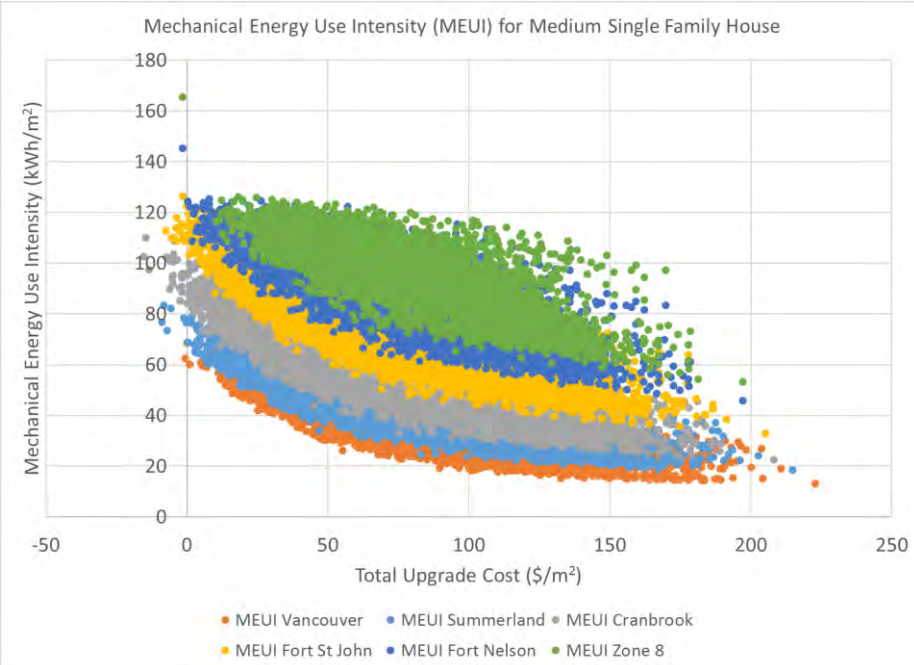

Figure 3: HTAP results for the medium house showing mechanical energy use intensity (MEUI) of the thousands of ECM combinations modelled

Unlike the other steps, Step 5 of the Step Code has the same targets irrespective of climate: MEUI 25 kWh/m^2, and either TEDI of 15 kWh/m^2 or PTL of 10 W/m^2. As can be seen in the figures, there is a significant difference between where the performance metrics trend towards as energy efficiency is increased depending on the climate. With the ECMs considered in this study, Step 5 was not obtained in the coldest three climate zones for the medium house as shown in the Figures. More analysis is required to determine if and how Step 5 could be adjusted to account for climate.

On the other end of the spectrum, the research showed that meeting the requirements of the lower steps involves only modest construction premiums. In most situations, builders can achieve lower steps for less than a 2% construction cost premium above that of a home built to the requirements of the BC Building Code.

With the millions of data points generated with HTAP for the Step Code metrics study, there is a significant amount of additional analysis that can still be carried out to extract useful information.

REFERENCES

Charron, 2007. Development of a Genetic Algorithm Optimisation Tool for the Early Stage Design of Low and Net-Zero Energy Solar Homes, Ph.D. Thesis, Concordia University

Integral Group, et al., 2017, Energy Step Code – Building Beyond the Standard – 2017 Metrics Research Full Report, research report published by BC Housing.