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New energy efficiency requirements for Part 3 buildings in British Columbia

Part 1: Overall impacts on energy savings, greenhouse gas emissions reductions, and incremental costs

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Commissioned by the Climate Action Secretariat[1]

Summary

As of December 20, 2013 (January 24, 2014 for Vancouver), new mid- and high-rise (Part 3) buildings in British Columbia have to comply with one of two new energy codes: ASHRAE 90.1-2010 or the 2011 National Energy Code for Buildings (NECB 2011).

This briefing note synthesizes the results from two modelling studies assessing the performance gains expected from these two standards in B.C. These are the key conclusions:

Energy savings

- Energy savings over the previous B.C. energy code (based on ASHRAE 90.1-2004) range from 10% to 30% for NECB 2011 and 9% to 33% for ASHRAE 90.1-2010, depending on building archetypes and climate zones.
- Generally, commercial archetypes (e.g. mid-rise commercial, big box retail) show greater savings than multi-unit residential buildings (MURBs), as lighting offers significant opportunities. As can be expected, increased insulation requirements lead to larger performance gains in northern and interior regions than in the south coast climatic region.
- Averaging across all archetypes and regions gives savings of 18% for NECB 2011 and 13% for ASHRAE 90.1-2010. If the standard with the most lenient requirements (and therefore most likely the lowest incremental cost) is used in each case, the averaged energy savings across all archetypes is reduced to 11%. If on the other hand, the most energy efficient of the two standards is selected for each case, savings averaged across all archetypes increases to approximately 30% (See Table 1).
- Given the added complexity of having two compliance options, uncertain compliance rates, and the existing performance gap between 'as designed' and actual energy use, it is difficult to predict what will be the effective energy performance gains from the new code. A 10% to 15% range seems likely.

[1] The author would like to thank Anthony Ho (FortisBC), Curt Hepting (EnerSys Analytics), and Susan Hayes (Focal Engineering) for performing a technical review of this briefing note.

Table 1: Energy savings from ASHRAE 90.1-2010 and NECB 2011 compared to ASHRAE 90.1-2004

Standard selected as compliance option	Resulting energy savings*
ASHRAE 90.1-2010	13%
NECB 2011	18%
The lowest cost option	11%
The most energy efficient option	30%

*Averaged over the multi-unit residential, mid-rise office, and big box store archetypes in Stantec 2012 and Hepting 2011

Greenhouse gas emissions reductions

- Greenhouse gas emissions (GHG) reductions over current building practices, as estimated by Stantec, average 16% overall regions and archetypes, ranging from 6% for mid-rise residential to up to 30% for mid-rise commercial (mostly due to an increase in use of heat recovery in this archetype).
- Over all, the new standards tend to reduce natural gas use through better insulation and heating-system performance, but can sometimes increase electricity use due to stricter ventilation requirements and the use of heat pumps.

Incremental cost and simple payback

- The average incremental cost of the improved energy efficiency measures, as estimated by Stantec, is below 1% of total construction cost, with an average simple payback of less than nine years.
- Incremental costs range from less than 0.5% of construction cost for mid-rise residential and mid-rise commercial, and averaged 2.2% for big box retail. The higher cost for big box retail is mainly due to the cost of the heat recovery ventilation system, and that of additional roof insulation, which is significant given the large roof area.
- Simple payback for these incremental costs range from less than a year to six years for mid-rise residential and mid-rise commercial, and from three to 26 years for big box retail.

Introduction

As of December 20, 2013 (January 24, 2014 for Vancouver), new Part 3 buildings[2] in B.C. have to comply with either ASHRAE 90.1-2010 or the 2011 National Energy Code for Buildings (NECB 2011), with minor adjustments specific to B.C.[3] The energy savings expected from these new standards vary by region and building type.

[2] Part 3, 'complex buildings': buildings that are taller than 3 storeys, larger than 600m^2, or that are used as post-disaster buildings, for assembly, for care, for correction, or for high-risk industrial use. All other buildings are considered 'simple' buildings, and follow the requirement outlined in Part 9 of the Building code. See Table 8 for more details.

[3] Building and Safety Standards Branch, *New Energy Requirements - Information Bulletin* (2013). http://www.housing.gov.bc.ca/pub/bulletins/B13-05 New Energy Requirements.pdf; and City of Vancouver, *By-law no. 9419: A By-law to regulate the construction of buildings and related matters and to adopt the British Columbia Building Code.* http://app.vancouver.ca/bylaw_net/Report.aspx?bylawid=9419. Note that some B.C.-specific revisions have been made to harmonize ventilation requirements between these two standards.

Three detailed modelling studies have been completed to analyze the gain in performance that could be expected from these two standards: Stantec[4] and Hepting[5] compare the new standard to the previous energy code (ASHRAE 90.1-2004), while Caneta[6] compares the two standards to each other (Table 2). This briefing note focuses on the first two studies.[7]

Table 2: Scope of the three modelling studies reviewed

Study	Stantec (2012)	Hepting (2011)	Caneta (2012)
Building archetypes covered	Mid-rise residential with retail units (ground level) Mid-rise commercial office Big box retail store	Large offices Small offices Schools (K-12) Motels/hotels Extended care Strip malls Big box retail Multi-unit residential (MURB)	High rise office High rise MURB Low-rise office Low-rise MURB Education Retail with anchor store Retail without anchor store (strip mall) Warehouse
Regions covered	South coast (e.g. Vancouver) Interior (e.g. Kamloops) North (e.g. Prince George)	Lower mainland (e.g. Vancouver) Southern interior (e.g. Summerland) Northern interior (e.g. Prince George)	13 major cities across Canada, including Vancouver
Building energy performance compared to base case	ASHRAE 90.1-2004	ASHRAE 90.1-2004	No base case
Results	Energy savings Energy cost savings GHG reductions Incremental building costs Simple payback	Energy savings Energy cost savings	Energy savings

NOTE: Results from the Caneta study are discussed in the companion briefing note *New energy efficiency requirements for Part 3 buildings in B.C.: Key differences between ASHRAE 90.1-2010 and NECB 2011.*

[4] Stantec Consulting, *B.C. Energy Code Comparison (Final Report)*, prepared for B.C. Ministry of Energy and Mines (2012). http://housing.gov.bc.ca/building/green/energy/Stantec - Part 3 Energy - FINAL-rpt01_bc_energy_code_comparison__update_201201022.pdf

[5] Curt Hepting, *Summary Review Assessment of Energy Performance Codes ASHRAE 90.1-2004, 90.1-2010 and NECB for British Columbia* (2011). http://www.enersys.ca/reports/ASHRAE%20vs%20NECB%20Summary-FINAL.pdf

[6] Caneta Research, *ASHRAE 90.1 2010 and NECB 2011 Cross Canada Comparison* (2012). http://housing.gov.bc.ca/building/green/energy/Caneta_ASHRAE90 1-2010 - NECB 2011 Report_FINAL_20120216 pdf.pdf

[7] See the companion briefing note *New energy efficiency requirements for Part 3 buildings in B.C.: Key differences between ASHRAE 90.1-2010 and NECB 2011NECB 2011* for a review of Caneta results.

Methodology

Modelling studies can only represent certain aspects of a building's expected energy use. The energy performance resulting from the adoption of an energy code varies depending on design factors such as building use and occupation, climate zone, building form, mechanical system, and heating fuel. These parameters are included in energy models. Ultimately, the energy performance also depends on the degree to which buildings comply with code, as well as whether compliant buildings actually reach their modelled performance level. The studies reviewed here do not address compliance and performance gap issues; they focus solely on designed performance, as estimated by an energy modelling software (DOE 2.1E, for all studies).

For each building type, assumptions are made regarding both the current building practice (for the base case) as well as how the prescriptive requirements of the new code would most likely be applied to achieve compliance with the new code.[8] Design options for both the base case and the modelled case vary regionally, based on climatic zone and on the heating fuel typically used in the area.

The three studies used different archetypes, which complicates their comparison. Table 5 outlines the difference in design parameters for the three archetypes which overlapped most closely between the three studies (big box store, mid-rise residential, mid-rise commercial). Despite the differences in assumptions, areas of agreement as well as a few differences can be noted. These are discussed below, after a summary of the results of each study.

Study results: Stantec

Stantec modelled the energy, emissions, and financial performance associated with the prescriptive requirements of ASHRAE 90.1-2010 and NECB 2011, comparing the new standards to the previous provincial standard, ASHRAE 90.1-2004.[9] Stantec's study considers three building archetypes in three climate regions of B.C. Each standard offers cost and performance advantages over the other for certain types of buildings.

Averaging the results over the three regions, the three archetypes, and the two possible compliance paths, Stantec estimated the average energy savings to be about 15% beyond current practices. Breaking down the results between the three building types we get average energy savings over current practices of 9.5% for mid-rise residential, 12.2% for big box retail, and 23.5% for mid-rise commercial (Table 3). Emissions reductions resulting from these performance gains showed an overall average reduction of ~16%. Figure 1 illustrates how the energy savings vary across the three regions.

[8] Note that common building practices sometimes exceed the minimum requirements set by code; both studies constructed their base case scenario to reflect, as much as possible, current building practices, rather than the minimum requirement set by ASHRAE 90.1-2004.

[9] Results were validated using BC Hydro Commercial Building Survey 2009, the BC Hydro Conservation Potential Review (2007), and NRCan data.

Table 3: Stantec study results: savings over ASHRAE 90.1-2004, averaged over the three climate zones and two compliance options

Archetype	Energy saving	GHG reductions	Energy cost saving	Incremental capital cost (% of construction cost)	Simple payback (years)
Mid-rise residential	9.5%	6.8%	11.8%	0.3%	4.9
Mid-rise commercial	23.5%	25.4%	21.5%	0.5%	3.6
Big box retail	12.2%	14.5%	10.2%	2.2%	18.2
AVERAGE	**15%**	**16%**	**15%**	**1.0%**	**8.9**

Data source: Stantec

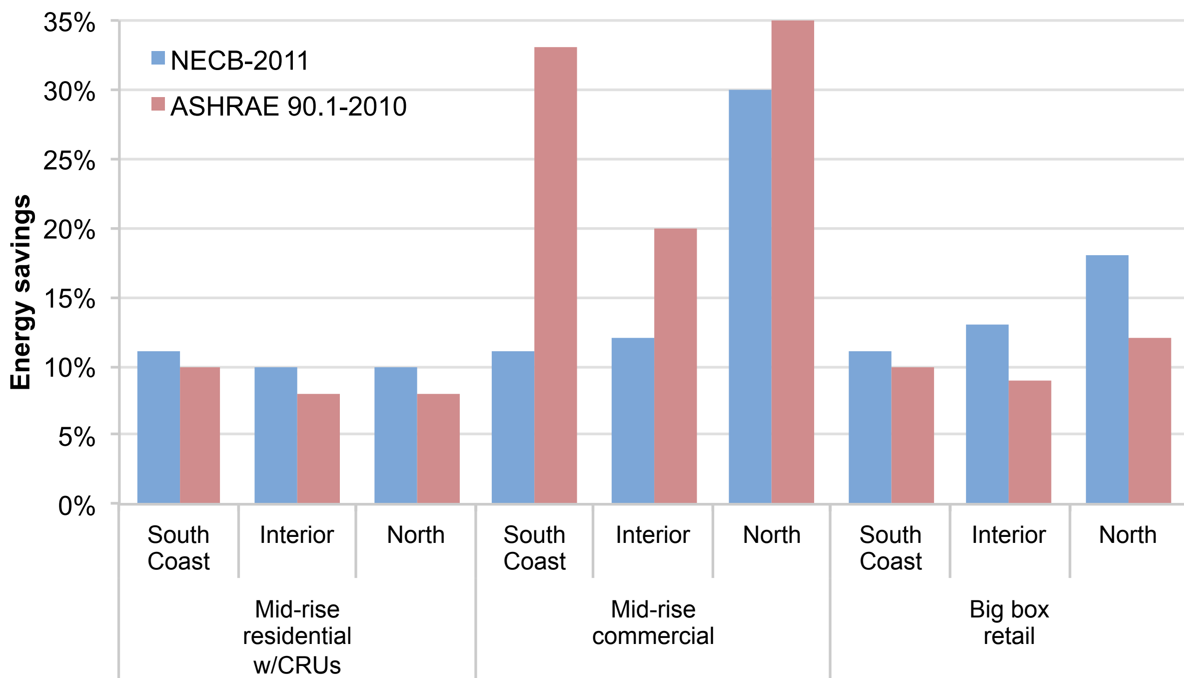


Figure 1: Energy savings over ASHRAE 90.1-2004 for three building archetypes in three regions of B.C.

Data source: Stantec

The cost premium for these energy gains is surprisingly modest in most cases. The average cost of the improved energy efficiency measures was below 1% of construction cost, averaging 0.3% for mid-rise residential, 0.5% for mid-rise commercial, and 2.2% for big box retail (Table 3). Over time, energy cost savings offset these capital cost increases. Simple payback for these incremental costs range from less than a year to six years for mid-rise residential and mid-rise commercial, and from three to 26 years for big box retail (Figure 2).

The higher incremental cost and longer payback periods for big box retail are due to the significant cost of improved roof insulation for a building with a high roof area and low wall-to-roof ratio. This is an additional reason — beyond transportation and land use issues — why mixed use buildings can be preferable to single-storey big box stores and strip malls from an energy use perspective. It is worth noting that despite the large range in payback periods, the energy saving measure packages for each archetype are expected to pay for themselves within the life of the building, and can therefore be considered cost effective on a life cycle basis.

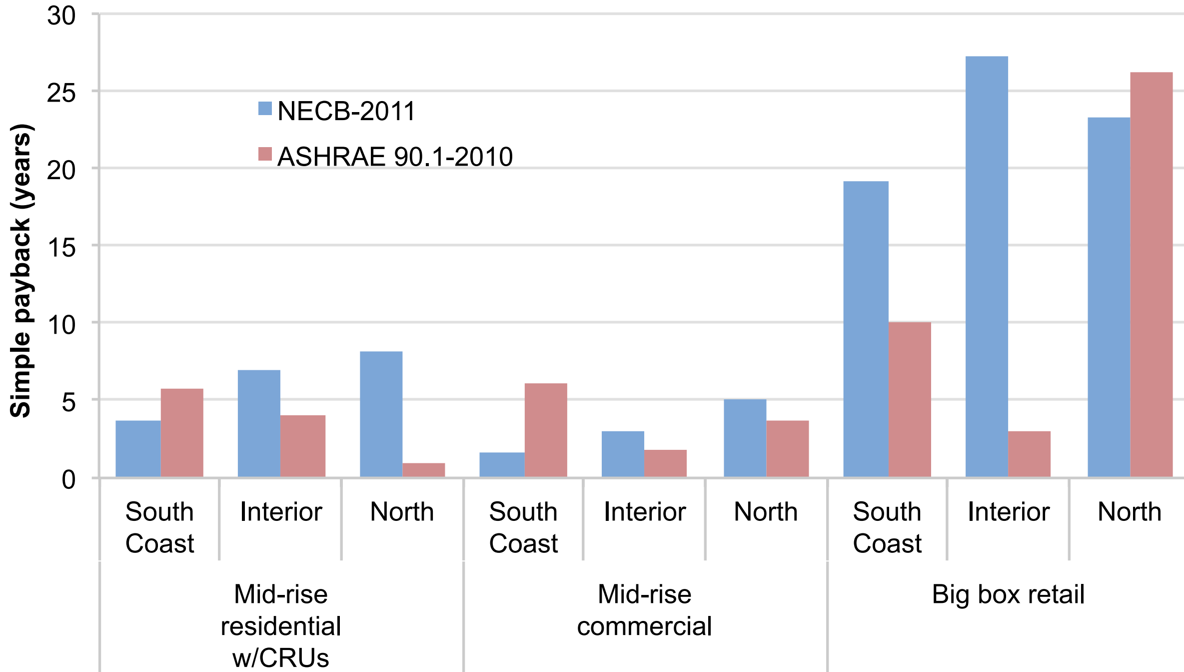


Figure 2: Simple payback to recover incremental capital cost expenditure through reduced energy costs

Data source: Stantec

GHG reductions over current building practices average 16% over all regions and archetypes, ranging from 6% for mid-rise residential to over 30% for mid-rise commercial (mostly due to increased use of heat recovery in this archetype) (Figure 3).

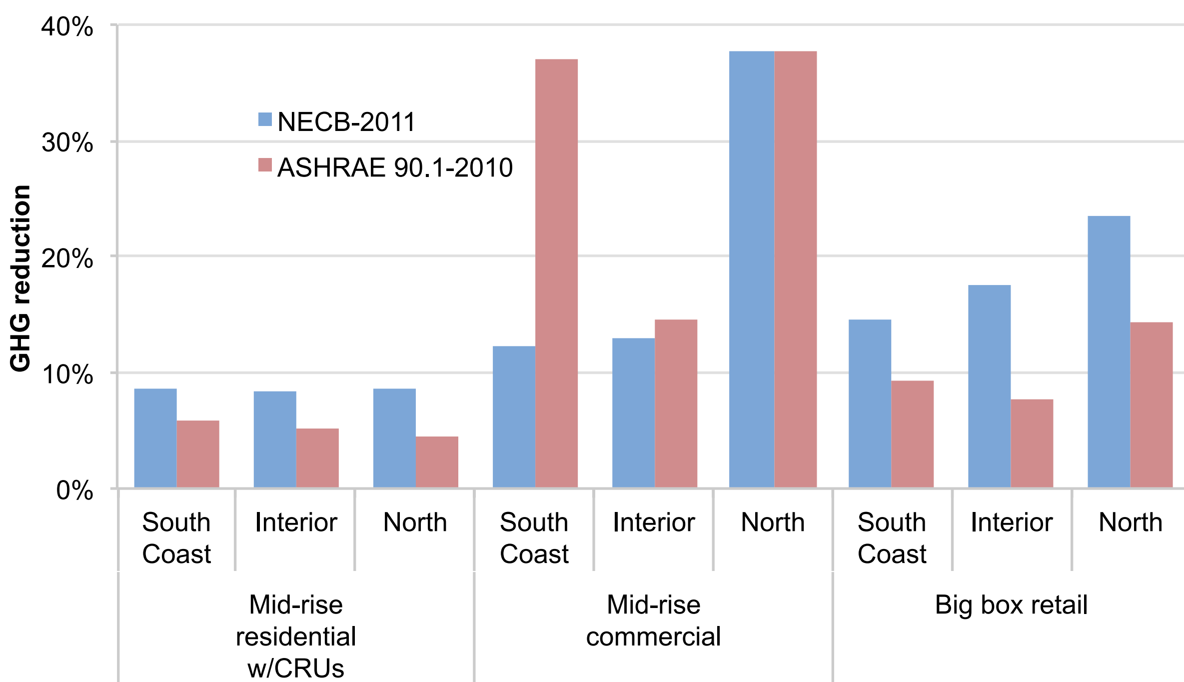


Figure 3: GHG reductions from energy savings

Data source: Stantec

Study results: Hepting

Prior to Stantec's 2012 study, Hepting had conducted another energy study analyzing eight building archetypes across three B.C. weather regions that modelled the energy savings expected from ASHRAE 90.1-2010 and NECB 2011 as compared to current building practices based on ASHRAE 90.1-2004.[10] The Hepting study did not quantify GHG reductions or construction costs implications of these standards.

Table 4 presents Hepting's results. Overall energy savings across the eight building archetypes are around 11% for ASHRAE 90.1-2010 and 23% for NECB.

Hepting also showed that compliance with NECB 2011 would lead to an average 26% reduction in natural gas use and a 2% increase in electricity compared to current practices. This difference mainly resulted from stricter provisions in the NECB that reduced space heating (e.g. higher insulation levels, heat recovery requirements, higher furnace/boiler efficiencies). Electricity used for space heating also decreased, but was offset in many cases by increases in fan energy due to exhaust heat recovery provisions that differ from ASHRAE 90.1-2004.[11]

Table 4: Hepting study results

	Energy savings over ASHRAE 90.1-2004		Difference (rounded)
	ASHRAE 90.1-2010	NECB 2011	
Region			
Lower mainland	9%	22%	13%
Southern interior	10%	24%	15%
Northern interior	18%	28%	11%
B.C. average	11%	23%	13%
Archetype			
Small office	12%	23%	11%
Large office	8%	20%	12%
Schools	14%	26%	12%
Extended care	7%	10%	3%
Hotel/motel	7%	7%	0%
Multi-unit residential	7%	20%	13%
Retail, big box	12%	30%	18%
Retail, strip mall	12%	34%	21%

Note: values have been rounded

[10] Note that the NECB models used by Hepting were based on a working draft of the standard, as the final was not released yet. We contacted Hepting to discuss the possibility that significant changes might have been made before the standard was finalized, but they reported having analyzed the final NECB in detail for a subsequent study, and did not notice significant changes from the draft they used for the 2011 study.

[11] Hepting's models used the same ventilation levels for ASHRAE and NECB estimates; this is in line with the current B.C. building code requirements, which call for ventilation rates to be set according to ASHRAE 62.1-2001 irrespective of which building standard is used. This is a B.C.-specific modification made to ASHRAE 90.1-2010, which normally refers to ASHRAE 62.1-2007 to set its different ventilation requirements (while NECB refers to ASHRAE 62.1-2001). It is worth noting that this modification will tend to increase energy use as 62.1-2001 mandates higher outside air levels (except for MURBs).

Cost implications

Of the three studies, only Stantec included a costing analysis of the new requirements. The cost premium for these energy gains is surprisingly modest in most cases, with the average cost of the improved energy efficiency measures below 1% of construction cost (Table 3). Over time, energy cost savings offset these capital cost increases. See Figure 2 for Stantec's results for simple payback time.

Stantec's incremental cost study also shows that the standard with the lowest incremental cost generally is also the one offering the lowest energy savings, which makes sense intuitively (i.e. additional energy saving measures will add to the cost). Following that argument, we can estimate the averaged energy savings if builders were to systematically select the cheapest of the two options for compliance. If for each archetype the standard with the lowest capital incremental cost was used for compliance, the averaged energy savings over all archetypes would be reduced to 11%, compared to 13% if ASHRAE 90.1-2010 was systematically used, and 18% for NECB 2011 (Table 5). If builders were incented to choose the most energy efficient standard, average savings across all the archetypes could increase up to 30%. That being said, other factors might be more significant in deciding what standard to use, such as alignment with LEED requirements (which are generally based on 90.1) and familiarity from previous experience. Anecdotal evidence indicates that most applications since the adoption of the new code are using 90.1 rather than NECB. [12]

[12] Antony Ho, Energy utilization manager, FortisBC, personal communication, April 2015.

Table 5: Comparison of the average incremental cost and energy savings of different standards

Study	Archetype	Incremental cost (% of total construction cost)		% energy savings over ASHRAE 90.1-2004		Difference in energy savings between most stringent/ higher cost and less stringent/ lower cost options
		NECB 2011	ASHRAE 90.1-2010	NECB 2011	ASHRAE 90.1-2010	
Stantec	Mid-rise residential	0.4%	0.2%	10.3%	8.7%	1.7%
	Mid-rise commercial	0.3%	0.6%	17.7%	29.3%	11.7%
	Big box retail	3.0%	1.5%	14.0%	10.3%	3.7%
	Average	1.2%	0.7%	14.0%	16.1%	5.7%
Hepting	Multi-unit residential	N/A		20%	7%	12.8%
	Small office			23%	12%	11.0%
	Retail, big box			30%	12%	18.4%
	Average			17.8%	10.3%	14.1%
Average energy savings, ASHRAE 90.1-2010						**13%**
Average energy savings, NECB 2011						**18%**
Average energy savings if selecting the standard with lowest cost[13]						**11%**
Average energy savings if selecting the most energy efficient standard						**30%**

Other study conclusions

Table 6 outlines the key conservation advantages of the two codes, compared to the savings estimates from each study. Figure 4 and Figure 5 compare the energy savings estimates. Some conclusions:

- Increased insulation requirements lead to larger performance gains in northern and interior regions than in the south coast climatic region.
- Generally, commercial archetypes (e.g. mid-rise commercial, big box retail) show greater savings than multi-unit residential buildings (MURBs), as lighting offer significant opportunities.
- NECB 2011 tends to yield higher energy savings than ASHRAE 90.1-2010, except for Stantec's mid-rise commercial archetype.[14]
- Averaging energy savings for all archetypes and regions in the two studies gives an overall estimated saving of 15%. It should be noted that both modeling studies used the prescriptive path to construct their archetypes. Proponents also have the option to use the trade-off or performance path, which can be more lenient.[15] Given the complexity added

[13] For Hepting's results, where cost information is not available, we assumed the option with the higher performance would also be more costly; this is intuitive and also corroborated by the Stantec results.

[14] The reason for this discrepancy is discussed in the companion briefing note *New energy efficiency requirements for Part 3 buildings in B.C.: Key differences between ASHRAE 90.1-2010 and NECB 2011.*

[15] Particularly for NECB-2011. Later work from Hepting has shown that, particularly for buildings with relatively low glazing areas and small HVAC systems, the relative savings expected from the performance or trade-off path

by allowing six different compliance paths (three for each standard), uncertain compliance rates, and the already existing performance gap between 'as designed' and actual energy use, it is difficult to predict what the effective energy performance gains from the new code will be. An overall improvement in the range of 10% to 15% seems likely, particularly for areas with the largest amount of Part 3 development in the province (south coast).

Table 6: Energy savings and conservation measures from Stantec and Hepting studies

Archetype / study	Region	Energy savings over ASHRAE 90.1-2004		Differ-ence	Differentiating energy conservation measures	
		NECB 2011	ASHRAE 90.1-2010		NECB 2011	ASHRAE 90.1-2010
Mid-rise residential (Stantec)	South Coast	11%	10%	1%	Higher insulation requirements Furnace AFUE ≥ 92.4% (vs 80%) **NO heat recovery**	Heat pump for retail area with higher COP (3.2 vs 2.8) **NO heat recovery**
	Interior	10%	8%	2%	Same as above + Heat pump for retail area with higher COP (2.8 vs 2)	
	North	10%	8%	2%	Same as above	
Multi-unit residential (Hepting)	B.C. average	20%	7%	13%	Higher insulation requirements 84% AFUE furnace (vs 82%) **Heat recovery** (all climate zones)[16]	Contrary to Stantec, no plug load difference were assumed between the two models (for all archetypes) **Heat recovery only for North**
Mid-rise commercial (Stantec)	South Coast	11%	33%	-22%	Higher insulation requirements Modulating boiler, 83% efficiency (vs non-modulating, 80%) Make up air unit AFUE ≥ 92.4% (vs 80%)	Heat recovery Plug load control in office spaces
	Interior	12%	20%	-8%	Same as above	Same as above, BUT heat recovery NOT required in this case
	North	30%	35%	-5%	Same as above except MUA 81% efficient (vs 80%) + Heat recovery	Same as above except + Heat recovery
Small office (Hepting)	B.C. average	23%	12%	11%	Higher insulation requirements 92.5% AFUE furnace (vs 80%)	

could be 5% to 10% lower than the savings under the prescriptive path. Hepting, Curt. "Summary Review Assessment of Energy Performance Codes ASHRAE 90.1-2004, 90.1-2010 and NECB for British Columbia," 2011. http://www.enersys.ca/reports/ASHRAE vs NECB Summary-FINAL.pdf, annotation on p1

[16] Heat recovery is required by NECB assuming the air system is centralized (with over 150 kW exhaust heat content), which is common in MURBs. If MURBs go with in-suite units that are not served by a central make up air unit (which might have been Stantec's assumption), heat recovery is not required.

Big box retail (Stantec)	South Coast	11%	10%	1%	Higher insulation requirements Heat recovery for retail core only	Plug load control in office spaces Heat recovery for retail core only
	Interior	13%	9%	4%	Same as above + heat recovery for all zones	Plug load control in office spaces NO heat recovery
	North	18%	12%	6%	Same as above	Plug load control in office spaces Heat recovery for all zones
Big box retail (Hepting)	B.C. average	30%	12%	18%	Higher insulation requirements Heat recovery	

Note: cell shading indicates a standard that outperforms the other by more than 10% (dark green) or between 5% and 10% (medium green). Percentages have been rounded.

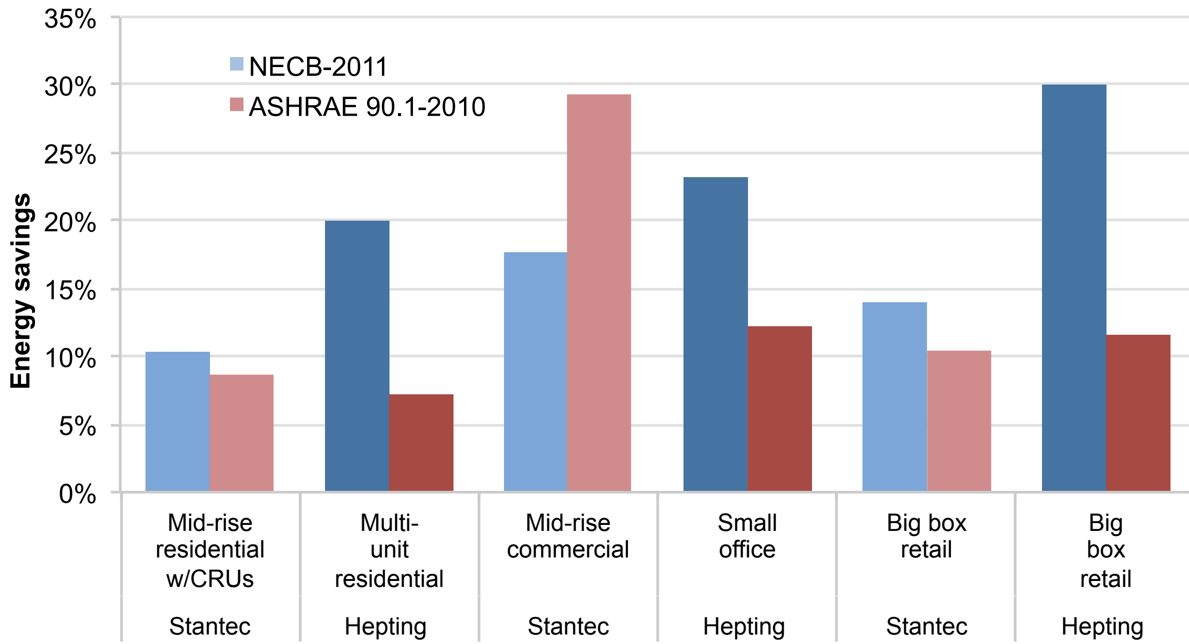
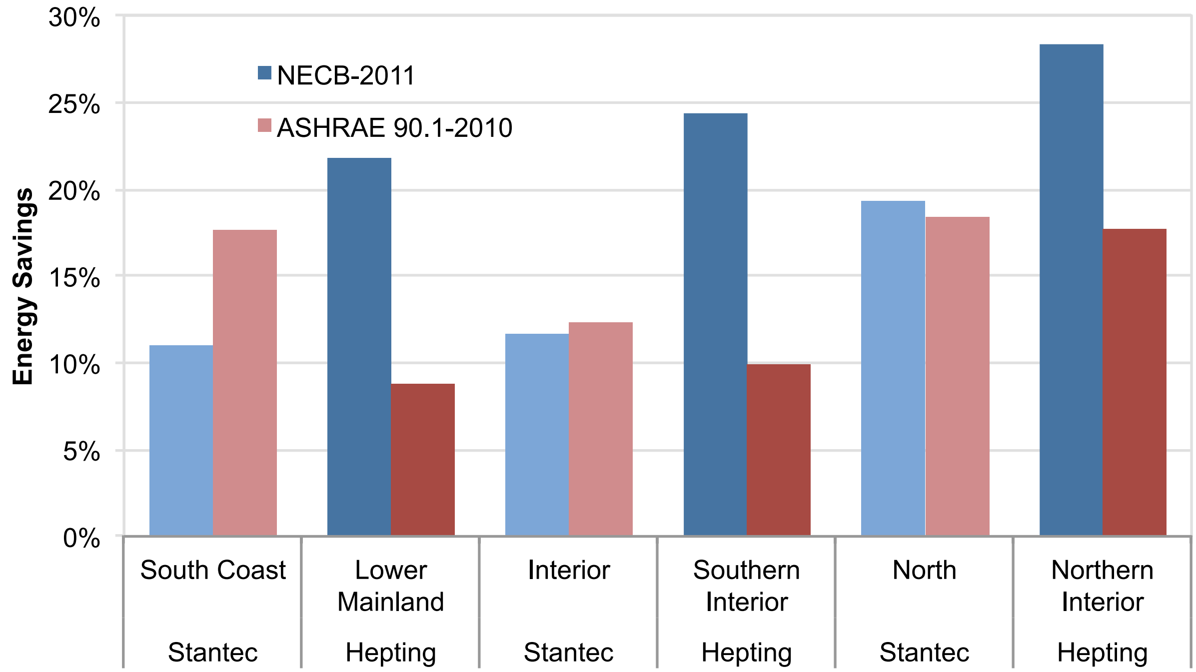


Figure 4: Energy savings over ASHRAE 90.1-2004 for three building archetypes averaged across three regions of B.C.

Data source: Stantec and Hepting



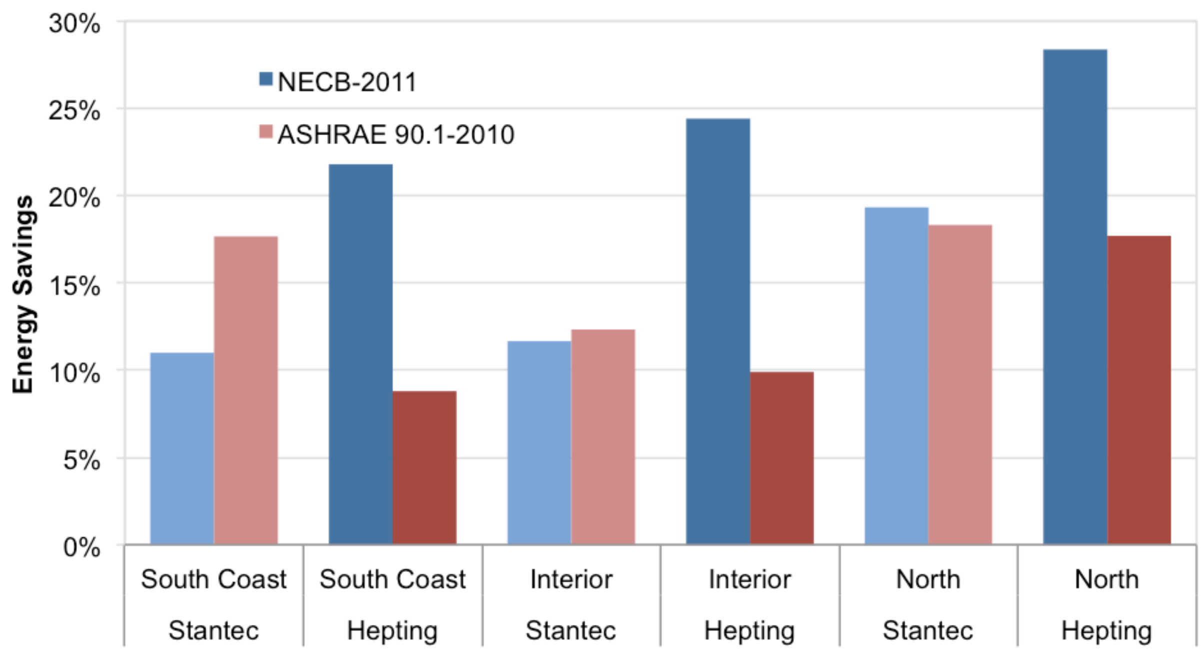


Figure 5: Energy savings over ASHRAE 90.1-2004 for three regions of B.C. averaged across the building archetypes

Data source: Stantec and Hepting

Appendix 1: Definition of Part 3 and Part 9 buildings

Table 7: Building code scopes: definition of Part 3 (complex) and Part 9 (simple) buildings[17]

Part 3: Complex Buildings	Part 9: Simple Buildings
1. Post disaster buildings (i.e. buildings that are essential to the provision of services in the event of a disaster: hospitals, power stations, water treatment plants, emergency response center, etc.) 2. Buildings that are used for: • assembly • care, or detention • high-hazard industrial 3. Buildings that are: • greater than 3 stories or larger than 600m^2	Buildings that are • ≤ 3 stories • ≤600 m^2 in building area with these occupancy types: • residential • business and personal services • mercantile • medium- and low-hazard industrial
These buildings must comply with requirements outlined in Part 3 (Fire Protection), 4 (Structural Design), 5 (Envelope), and 6 (HVAC) of the building code.* Registered professional architect and/or engineer required to ensure compliance with code.	These buildings must comply with requirements outlined in Part 9 (Housing and Small Buildings) of the building code.* General contractor can sign off on compliance. P.Eng required in specific cases.

* Along with Part 7 (Plumbing), 8 (Safety) and 10 (Energy and Water Efficiency), which apply to all buildings.

[17] B.C. Building code, 2012, Division A, Section 1.3, article 1.3.3.2 and 1.3.3.3

Appendix 2: Comparison of assumptions between the three modelling studies

Table 8: Comparison of archetype definitions and energy performance analysis studies by Stantec, Hepting and Caneta

	Stantec (2012)[18]	Hepting (2011)[19]	Caneta (2012)[20]
Mid-size residential			
Closest equivalent archetype in study	Mid-rise residential with commercial retail units (CRUs)	MURB	Low-rise residential
Size	5-storey, 50,000 ft²	5-storey, 56,000 ft²	3-storey, 42,000 ft²
wall to roof area ratio	unknown	2	1.1
Number of units	40 apartments, with retail on first floor	64 apartments	45 apartments
Glazing ratio	32%	40%	max 29% per area
Cooling	Interior B.C. only: package terminal air conditioners (PTACs)	Interior B.C. only: PTACs and DX cooling unit for make up air and common areas	PTACs and direct expansion (DX) cooling unit for make up air and common areas
Heating	Electrical baseboard in units Indirect gas-fired outdoor air unit for make up air and common areas Split system heat pump with electrical reheat for retail area	Three suite heating cases: (1) electric baseboard, (2) heat pump, (3) gas hydronic (each assigned a market allocation derived from previous LEED equivalency studies)[21] Gas furnace for make-up air and common areas	Hydronic baseboards in units Gas boiler for hydronics and hot water coil for make-up air and common areas
Small office			
Closest equivalent archetype in study	Mid-rise commercial (offices)	Small office	Low-rise office
Size	5-storey, 50,000 sq.ft	3-storey, 43,000 ft²	2-storey, 32,000 ft²
wall to roof area ratio	unknown	1.2	1.85

[18] Stantec, 34–59.

[19] Hepting, B1–B55.

[20] Caneta, 4.

[21] The fact that Hepting accounted for a range of in-suite heating approaches while Stantec considered only a baseboard heating case could explain some of the discrepancy between the two studies, as electric resistance, heat pumps and gas heating would provide for different relative savings. Hepting, personal communication, April 2015.

Glazing ratio	32%	40%	maximum 33% glazing (per area, variable)
Heating and cooling	Distributed heat pumps for offices with centrifugal closed circuit fluid cooler and gas-fired boiler for central plant	Three cases: (1) VAV reheat, all gas heat; (2) distributed heat pump with gas boiler; (3) VAV with parallel fan power boxes and electric terminal heating; all air cooled (DX)	Packaged variable air volume (PVAV), with natural gas furnace and DX cooling coils
Big box retail			
Closest equivalent archetype in study	Big box retail	Big box retail	Retail with anchor store
Size	1-storey, 100,000 ft^2	1-storey, 45,000 ft^2	1-storey, 190,123 ft^2
Wall to roof area ratio	unknown	1.0	0.42
Glazing ratio	23% vertical, + 5% skylights	10%	18.2%
Heating and cooling	Packaged constant volume roof top units (natural gas furnace and DX cooling)	Packaged constant volume roof top units with DX cooling, with two heating cases: (1) gas fired, (2) electrical heat pump	Packaged constant volume roof top units (natural gas furnace and DX cooling)
Climate zones	"South coast": Vancouver weather data, ASHRAE climate zone 5c, NECB climate zone 4 "Interior": Kamloops weather data, ASHRAE climate zone 5, NECB climate zone 5 "North": Prince George weather data, ASHRAE climate zone 7, NECB climate zone 7	"Lower Mainland": Vancouver weather data, ASHRAE climate zone 5c, NECB climate zone 4 "Southern Interior": Summerland weather data, ASHRAE climate zones 5a and 5b, NECB climate zone 5 "Northern Interior": Prince George weather data, ASHRAE climate zone 7, NECB climate zones 7A and 7B	Vancouver weather data, ASHRAE climate zone 5c, NECB climate zone 4