SUMMARY REVIEW ASSESSMENT OF ENERGY PERFORMANCE CODES ASHRAE 90.1-2004, 90.1-2010 and NECB for British Columbia

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The British Columbia government is considering updating the BC Building Code (Code) to make the energy performance requirements more stringent and up-to-date. This may include updates based on the latest ANSI/ASHRAE/IESNA Standard 90.1 (ASHRAE 90.1) 2010 version. It may also include references to the Canadian "National Energy Code for Buildings" 2011 (NECB). At the time of this assessment, the NECB was in draft form and scheduled to be release later in the fall of 2011[1].

BC Hydro representatives were interested in the implications of adopting the latest 2010 version of the ASHRAE 90.1 Standard to further the Code advancement. In support of this effort, EnerSys Analytics Inc. performed a comparative review of ASHRAE 90.1-2010 versus 90.1-2004 to identify potential barriers in the market. BC Hydro then had us perform a similar review to assess how the NECB compared and contrasted to ASHRAE 90.1-2010 (Hepting and Jones, 2011).

As a second phase effort, BC Hydro contracted EnerSys Analytics Inc. to perform a limited quantitative review of ASHRAE 90.1-2010 and the NECB 2011 to better assess how these compared to the Code (ASHRAE 90.1-2004). This report presents the findings of that effort. The objective of this brief study was to provide an initial, overall market-wide estimate of the relative energy consumption savings between these standards/codes for British Columbia. Due to time and budget constraints, the effort built on previous archetypal modelling studies we completed for several public and professional agencies, including BC Hydro, the B.C. Government, Natural Resources Canada (NRCan) and the Canadian Green Building Council (CaGBC).

It should be noted that our assessment took the perspective of applying the *prescriptive* aspects of ASHRAE and the NECB. This is an important distinction, because a *performance* (Energy Cost Budget) modelling approach, as used by LEED and other initiatives, will result in different comparative indicators, We selected the prescriptive approach because it is by far the most applicable means for new construction projects to demonstrate Code compliance in the Province, and hence, would be more reflective of the changes among the energy standards/codes in British Columbia.

APPROACH SUMMARY

The code comparison analysis was based on the same general approach followed for preceding efforts for (1) LEED-BC[2] and (2) the BC Government[3] ("Continuum study") that compared the energy performance of past ASHRAE 90.1 standards with the MNECB (with ecoEnergy provisions applied). This involved using DOE2.1e archetype

[1] SCEEB working draft of the NECB was provided in confidence to EnerSys in June 2011 for its exclusive use for this effort.
[2] Hepting and Ehret, March 2002.
[3] Hepting, February 2008.

energy performance models and the founding methodology created for the LEED-BC and LEED-Canada[4] energy equivalency studies. Starting with these efforts, we accounted for key differences in the *prescriptive* provisions of ASHRAE 90.1-2010 and the NECB 2011. A preceding effort that involved performing a qualitative comparative review of (1) ASHRAE 90.1-2010 versus 90.1-2004 and (2) the NECB versus ASHRAE 90.1-2010 also served as a basis for this study. The updated summary briefs from both of these efforts appear in Appendices C and D, respectively.

The LEED-BC study on the *Verification of LEED-BC v1.0 Energy Credit 1 Point Awards for Building Energy Conservation in British Columbia*[5] contains details on the founding approach adapted for this effort. In summary, we made use of the following eight archetypal building types that account for the vast majority of the commercial building stock in British Columbia.

- Large offices
- Small offices
- Schools (K-12)
- Motels/hotels
- Extended care
- Strip malls
- Big-box retail
- Multi-unit residential (MURB)

In addition to representing an appropriate cross-section of commercial building types, we applied the analysis for the following representative regions, as required by the scope of work:

- Lower Mainland and Vancouver Island, using Vancouver weather data (ASHRAE climate zone 5c, NECB climate zone 4).
- Southern Interior, using Summerland weather data (ASHRAE climate zones 5a and 5b, NECB climate zone 5)
- Northern Interior, using Prince George weather data (ASHRAE climate zone 7, NECB climate zones 7A and 7B)

These weather regions provided for a relatively wide degree of representative weather variations across British Columbia. Additionally, the specific weather sites within the above regions represent the major population centres in British Columbia.

We modified the DOE2 archetype models we originally used for a LEED-BC study (Hepting and Ehret, 2002) to represent the prescriptive requirements of ASHRAE 90.1-2004. However, in verifying the characteristics of these legacy models, it was apparent that some significant aspects required updating to reflect today's market conditions and the respective code requirements. For instance, exterior lighting was not represented previously, and was added to the models for this study. Additionally, because the previous models followed a performance modelling approach, we needed to modify some HVAC systems in the models. Most significantly, performance modelling rules specified using packaged terminal heat pumps for MURBs heated by electric

[4] Hepting and Ehret, 2004.
[5] Hepting and Ehret, March 2002.

baseboards. Following a prescriptive approach, this was not appropriate, so we changed those systems to electric baseboards.

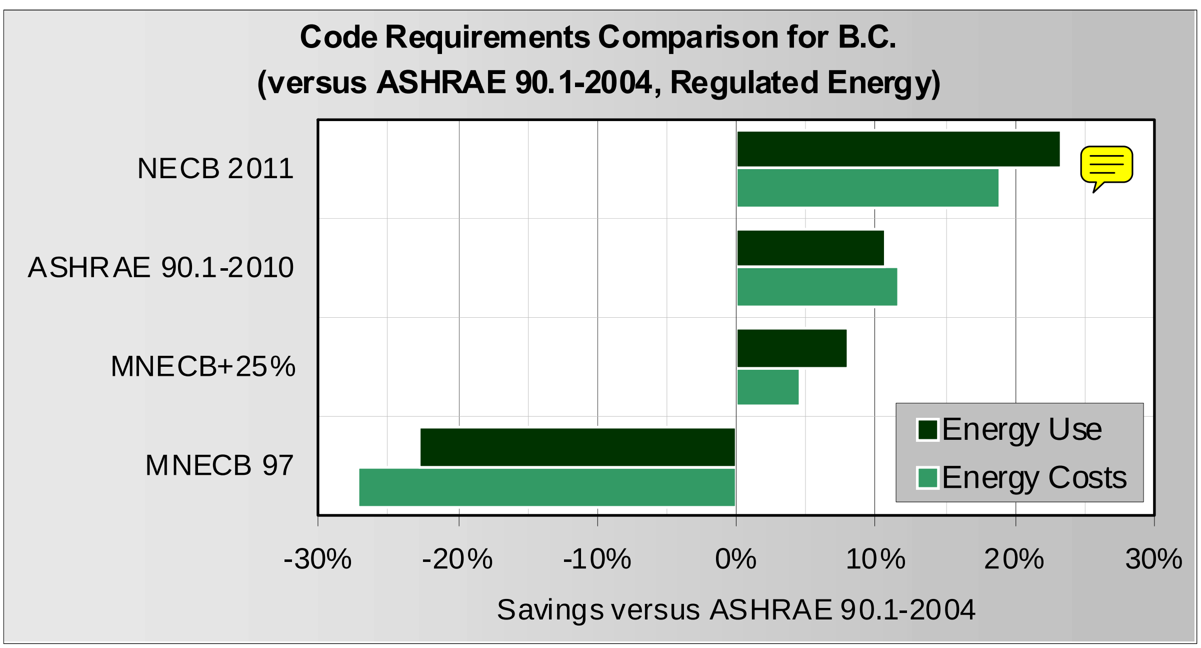
Building descriptions and key characteristics for each of the building archetypes appear in Appendix A.

RESULTS OVERVIEW

Savings Comparison to ASHRAE 90.1-2004

Building Code / Standard	Energy Use	Energy Cost
MNECB 1997	-22.7%	-27.2%
MNECB less 25% (MNECB+25%)	8.0%	4.6%
ASHRAE 90.1-2010	10.8%	11.6%
NECB 2011 (draft)	23.4%	18.9%

As shown in the adjacent table and following chart, the NECB provides for the lowest energy use levels. Our aggregate analysis of eight archetypal building types across three B.C. weather regions indicated the NECB's minimum requirements provided for saving of 14.1% in regulated energy consumption and 8.3% in energy costs over ASHRAE 90.1-2010. All of the relative savings stem from decreased natural gas use of over 26%; electricity use actually increased by about 2.0%. This makes sense as the most notable differences between the NECB and 90.1-2010 standards concern provisions that affect heating (e.g., insulation levels, heat recovery, furnace/boiler efficiencies). This also explains why energy cost savings are lower than the savings for energy use, as electricity is a higher cost energy source than natural gas.



In comparison to ASHRAE 90.1-2004, the NECB saves 23.4% and 18.9% on energy use and cost, respectively. ASHRAE 90.1-2010 comes out at 10.8% and 11.6% lower than 90.1-2004 on energy use and cost, respectively.

The above chart also shows how the MNECB and the MNECB with 25% savings (MNECB+25%) compare. Note that the MNECB+25% effectively corresponds to the minimum qualification requirements for the LEED-Canada NC 1.0 Energy & Atmosphere prerequisite 2 (i.e., equivalent to qualifying for NRCan's past ecoEnergy for Buildings program). The MNECB references were derived from comparisons based on applying the relative energy savings derived from past studies; hence, the comparison would not be completely consistent. Further, prescriptive and performance path provisions (including for ASHRAE's Appendix G Performance Rating Method) will provide for different comparative indicators.

Note that the comparative results were based on the estimated savings that include the end-uses covered by the respective standards/codes (i.e., "regulated"). This is an important distinction as the standards/codes do not cover many energy-related building functions, such as plug loads (e.g., computer, appliances) and process loads (e.g., elevators, cooking, low-temperature refrigeration). Further, the founding MNECB analysis did not include exterior lighting, which we added for this study on ASHRAE 90.1-2004, 90.1-2010 and the NECB 2011.

CONCLUSION

From our relatively cursory analysis, minimum compliance to the NECB 2011 should provide for lower energy use levels than ASHRAE 90.1-2010. This difference mainly resulted from provisions in the NECB that reduced space heating. Electricity used for space heating would also decrease, but was offset in many cases by increases in fan energy due to exhaust heat recovery provisions that differ from ASHRAE 90.1-2010.

It is important to note that our quantitative analysis covered the most prevalent building types and conditions. While this should capture the vast majority of the new commercial market, energy intensive facilities such as aquatic centres and ice arenas have provisions that differ significantly between ASHRAE and the NECB. For instance, ASHRAE has requirements concerning pool covers that the NECB does not, but the NECB dictates heat recovery on ice arena equipment that ASHRAE does not address. As another example, ASHRAE has requirements for heat recovery for fume and kitchen exhaust systems that the NECB does not regulate.

In regard to comparisons to ASHRAE 90.1-2004, both the NECB and 90.1-2010 provide for significant energy savings. However, our assessment demonstrated significantly less savings between the two ASHRAE Standards than did a recent, detailed study by the Pacific Northwest National Laboratory (PNNL)[6]. Time and budget unfortunately was not available to fully assess where potential discrepancies may lie (if even completely

[6] Thornton, BA et. al., May 2011.

possible). To help with a critical comparative review between the two studies, our summary model characteristics appear in Appendix B. Also, detailed results by building types, regions and energy source appear in Appendix A — extracted from an accompanying workbook provided to BC Hydro representatives.

We appreciate that our study is less detailed and at courser resolution than the PNNL study. However, from a qualitative standpoint, it is difficult to see where the changes from the 90.1-2004 to the 90.1-2010 Standard would provide for another ~18%–19% savings in British Columbia's heating-dominated climate. One possible explanation might relate to the relative outdoor air amounts. Our study maintained consistent levels for all models, whereas the PNNL study used lower outdoor air levels in the 90.1-2010 models than in the 90.1-2004 models (based on changes to applied ASHRAE 62.1 versions).

In contrast, our independent assessment indicated even higher savings than the National Research Council's assessment that the NECB 2011 "is 25% more energy efficient than the current Model National Energy Code of Canada for Buildings 1997 [(MNECB)]."[7] Based on past studies comparing the MNECB to past versions of ASHRAE 90.1, it may be as much as 38% more efficient.

[7] National Research Council (NRC), September 2011

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Appendix A:

Comparative Regulated Energy Performance Summary Tables

Appendix A

NECB 2011 versus ASHRAE 90.1-2010

Summary Comparison: Energy and Cost Results

Comparison of NECB 2011 versus ASHRAE 90.1-2010						
B.C. Region	Energy (kBtu/ft²)			Energy Cost ($/ft²)		
	ASHRAE 90.1-2010	NECB 2011	Diff. (Svgs)	ASHRAE 90.1-2010	NECB 2011	Diff. (Svgs)
B.C. Average	***59.7***	***51.3***	***14.1%***	***$0.97***	***$0.89***	***8.3%***
Lower Mainland	56.7	48.6	14.2%	$0.91	$0.83	8.4%
Southern Interior	61.5	51.6	16.1%	$1.02	$0.93	9.1%
Northern Interior	68.6	59.6	13.0%	$1.14	$1.05	8.3%
Small Office	39.9	34.9	12.4%	$0.74	$0.66	9.8%
Large Office	33.5	29.2	12.6%	$0.61	$0.56	8.3%
Schools	55.8	48.0	13.9%	$0.81	$0.75	6.7%
Extended Care	119.5	115.7	3.2%	$1.73	$1.71	0.9%
Hotel/Motel	71.6	71.8	-0.2%	$0.82	$0.83	-0.5%
Multi-unit Residential	55.6	47.9	13.9%	$1.00	$0.94	6.5%
Retail, Big Box	83.4	66.0	20.8%	$1.32	$1.20	9.2%
Retail, Strip Mall	100.1	75.7	24.4%	$1.71	$1.45	14.9%

Note: Utility costs derived from rates used for LEED-BC Study (2002) + 40% for electricity to account for the relative increase in rates since 2002; gas rates are nearly the same as in 2002.

Summary Comparison: Electrical Energy and Fossil Fuel Results

Comparison of NECB 2011 versus ASHRAE 90.1-2010						
B.C. Region	Electricity (kWh/ft²)			Fossil Fuel (kWhe/ft²)		
	ASHRAE 90.1-2010	NECB 2011	Diff. (Svgs)	ASHRAE 90.1-2010	NECB 2011	Diff. (Svgs)
B.C. Average	***7.5***	***7.6***	***-2.0%***	***10.0***	***7.4***	***26.2%***
Lower Mainland	7.2	7.3	-2.1%	9.5	6.9	26.6%
Southern Interior	7.8	7.9	-1.8%	10.2	7.2	29.8%
Northern Interior	8.1	8.2	-1.4%	12.0	9.3	22.7%
Small Office	6.4	6.0	6.5%	5.3	4.3	19.6%
Large Office	5.4	5.3	2.7%	4.4	3.3	25.0%
Schools	5.0	5.5	-10.0%	11.3	8.5	24.5%
Extended Care	14.7	15.3	-4.4%	20.4	18.6	8.6%
Hotel/Motel	7.3	7.5	-2.7%	13.7	13.6	1.1%
Multi-unit Residential	6.5	6.8	-4.4%	9.8	7.2	26.0%
Retail, Big Box	12.0	13.3	-10.8%	12.4	6.1	51.3%
Retail, Strip Mall	12.1	12.0	0.9%	17.2	10.2	41.0%

Appendix A

ASHRAE 90.1-2010 versus ASHRAE 90.1-2004

Summary Comparison: Energy and Cost Results

Comparison of ASHRAE 90.1-2010 versus ASHRAE 90.1-2004

B.C. Region	Energy (kBtu/ft²)			Energy Cost ($/ft²)		
	ASHRAE 90.1-2004	ASHRAE 90.1-2010	Diff.	ASHRAE 90.1-2004	ASHRAE 90.1-2010	Diff.
B.C. Average	*66.9*	*59.7*	*10.8%*	*$1.10*	*$0.97*	*11.6%*
Lower Mainland	62.2	56.7	8.8%	$1.01	$0.91	10.2%
Southern Interior	68.3	61.5	9.9%	$1.15	$1.02	10.8%
Northern Interior	83.3	68.6	17.7%	$1.37	$1.14	16.5%
Small Office	45.4	39.9	12.2%	$0.85	$0.74	13.6%
Large Office	36.5	33.5	8.2%	$0.67	$0.61	9.0%
Schools	64.7	55.8	13.7%	$0.94	$0.81	14.2%
Extended Care	128.4	119.5	6.9%	$1.86	$1.73	7.0%
Hotel/Motel	76.9	71.6	6.8%	$0.89	$0.82	7.6%
Multi-unit Residential	59.8	55.6	7.2%	$1.11	$1.00	9.5%
Retail, Big Box	94.3	83.4	11.6%	$1.50	$1.32	11.6%
Retail, Strip Mall	114.1	100.1	12.3%	$1.93	$1.71	11.6%

Note: Utility costs derived from rates used for LEED-BC Study (2002) + 40% for electricity to account for the relative increase in rates since 2002; gas rates are nearly the same as in 2002.

Summary Comparison: Electrical Energy and Fossil Fuel Results

Comparison of ASHRAE 90.1-2010 versus ASHRAE 90.1-2004 by Fuel Type

B.C. Region	Electricity (kWh/ft²)			Fossil Fuel (kWhe/ft²)		
	ASHRAE 90.1-2004	ASHRAE 90.1-2010	Diff.	ASHRAE 90.1-2004	ASHRAE 90.1-2010	Diff.
B.C. Average	*8.6*	*7.5*	*12.7%*	*11.0*	*10.0*	*9.2%*
Lower Mainland	8.2	7.2	12.3%	10.1	9.5	6.0%
Southern Interior	8.9	7.8	12.1%	11.1	10.2	8.2%
Northern Interior	9.4	8.1	14.7%	15.0	12.0	19.6%
Small Office	7.5	6.4	15.2%	5.8	5.3	8.4%
Large Office	6.0	5.4	9.9%	4.6	4.4	6.0%
Schools	5.9	5.0	14.4%	13.1	11.3	13.4%
Extended Care	15.8	14.7	7.1%	21.9	20.4	6.9%
Hotel/Motel	8.3	7.3	12.3%	14.2	13.7	3.6%
Multi-unit Residential	7.5	6.5	12.8%	10.1	9.8	3.0%
Retail, Big Box	13.6	12.0	11.5%	14.1	12.4	11.7%
Retail, Strip Mall	13.5	12.1	10.5%	19.9	17.2	13.5%

Appendix A

NECB 2011 versus ASHRAE 90.1-2004

Summary Comparison: Energy and Cost Results

Comparison of NECB 2011 versus ASHRAE 90.1-2004						
B.C. Region	Energy (kBtu/ft²)			Energy Cost ($/ft²)		
	ASHRAE 90.1-2004	NECB 2011	Diff.	ASHRAE 90.1-2004	NECB 2011	Diff.
B.C. Average	*66.9*	*51.3*	*23.4%*	*$1.10*	*$0.89*	*18.9%*
Lower Mainland	62.2	48.6	21.8%	$1.01	$0.83	17.7%
Southern Interior	68.3	51.6	24.4%	$1.15	$0.93	18.9%
Northern Interior	83.3	59.6	28.4%	$1.37	$1.05	23.5%
Small Office	45.4	34.9	23.2%	$0.85	$0.66	22.1%
Large Office	36.5	29.2	19.8%	$0.67	$0.56	16.5%
Schools	64.7	48.0	25.7%	$0.94	$0.75	19.9%
Extended Care	128.4	115.7	9.9%	$1.86	$1.71	7.9%
Hotel/Motel	76.9	71.8	6.7%	$0.89	$0.83	7.1%
Multi-unit Residential	59.8	47.9	20.0%	$1.11	$0.94	15.4%
Retail, Big Box	94.3	66.0	30.0%	$1.50	$1.20	19.9%
Retail, Strip Mall	114.1	75.7	33.7%	$1.93	$1.45	24.8%

Note: Utility costs derived from rates used for LEED-BC Study (2002) + 40% for electricity to account for the relative increase in rates since 2002; gas rates are nearly the same as in 2002.

Summary Comparison: Electrical Energy and Fossil Fuel Results

Comparison of NECB 2011 versus ASHRAE 90.1-2004 by Fuel Type						
B.C. Region	Electricity (kWh/ft²)			Fossil Fuel (kWhe/ft²)		
	ASHRAE 90.1-2004	NECB 2011	Diff.	ASHRAE 90.1-2004	NECB 2011	Diff.
B.C. Average	*8.6*	*7.6*	*11.0%*	*11.0*	*7.4*	*33.0%*
Lower Mainland	8.2	7.3	10.5%	10.1	6.9	31.0%
Southern Interior	8.9	7.9	10.5%	11.1	7.2	35.5%
Northern Interior	9.4	8.2	13.4%	15.0	9.3	37.8%
Small Office	7.5	6.0	20.7%	5.8	4.3	26.3%
Large Office	6.0	5.3	12.4%	4.6	3.3	29.5%
Schools	5.9	5.5	5.9%	13.1	8.5	34.7%
Extended Care	15.8	15.3	3.0%	21.9	18.6	14.9%
Hotel/Motel	8.3	7.5	10.0%	14.2	13.6	4.7%
Multi-unit Residential	7.5	6.8	9.0%	10.1	7.2	28.2%
Retail, Big Box	13.6	13.3	1.9%	14.1	6.1	57.0%
Retail, Strip Mall	13.5	12.0	11.3%	19.9	10.2	49.0%

Appendix B:

Archetype Model
Code-Compliant Building Characteristics

Small Office: Key Building Characteristics

The small office archetype from NRCan represents a square 43,000 ft² (4,000 m²), 3-storey building with a wall-to-roof area ratio of 1.2. The zoning includes 5 uniformly loaded zones per floor, with a 1,300 ft² perimeter zone on each of the four major orientations and a core zone which accounts for 64% of the floor space.

The following listing provides the key building characteristics which differ between the ASHRAE 90.1-2004, ASHRAE 90.1-2010 and the NECB 2011 code-compliant models. In many cases information for certain characteristics are the same between the models, but we provide information since it is unique to the building type and/or of significance to the energy performance.

NOTE: The original archetypes were formulated for the purposes of determining the equivalency between the MNECB 97's and ASHRAE 90.1-1999's performance path approaches, modified for use with LEED EAp2 and EAc1. This is not quite the same as a comparison on the prescriptive application of the Codes. Thus, certain characteristics are indicative of what ASHRAE 90.1 would dictate for its ECB case, which is not necessarily fully representative for the market -- particularly for the HVAC system(s). For offices, fan coil systems would have a signficant market share, but at least they are partially represented with the ECB's system type with fan-powered boxes.

Item	ASHRAE 90.1-2004					ASHRAE 90.1-2010					NECB 2011	Discussion/Issues
EXTERIOR SURFACES												
Wall Overall R-Value	Mass	Metal	Steel	Other	R_o	Mass	Metal	Steel	Other	R_o	No variation by construction	Allocation of construction types is based on professional judgement and for consistency with past, founding studies. It is not statistically proven nor supported by market research. A "mass" type construction would likely include concrete components and brick vaneer assemblies. Steel stud (without concrete or brick) and curtainwall systems would be considered as "steel" (framed). Other includes wood stud construction.
South Coast	Climate Zone 5					Climate Zone 5					Climate Zone 4	
	50%	0%	50%	0%	10.0	50%	0%	50%	0%	13.4	18.0	
	8.13	8.85	11.9	11.2		11.1	14.5	15.6	15.6			
Southern Interior	Climate Zone 5					Climate Zone 5					Climate Zone 5	
	50%	0%	30%	20%	9.9	50%	0%	30%	20%	13.4	20.6	
	8.13	8.85	11.9	11.2		11.1	14.5	15.6	15.6			
Northern Interior	Climate Zone 5					Climate Zone 7					Zone 7A (60%) & 7B (40%)	
	50%	0%	30%	20%	12.5	50%	0%	30%	20%	15.7	7A / 7B; 27.0	
	11.1	17.5	15.6	11.2		14.1	17.5	15.6	19.6		27.0 / 27.0	
Roof Overall R-Value	Insulation Entirely above Deck					Insulation Entirely above Deck					No variation by construction	For this building type, all roof types as flat roofs with continuous insulation. This is based on professional experience in the commercial sector and is not statistically proven nor supported by market research.
South Coast	15.9					20.8					25.0	
Southern Interior	15.9					20.8					31.0	
Northern Interior	15.9					20.8					7A: 35.0, 7B: 35.0; 35.0	

Small Office: Key Building Characteristics

Exposed Floor R-Value	Mass	Mass	No variation by construction	Allocation of construction types is based solely on professional experience in the commercial sector and is not statistically proven nor supported by market research. Note that floor losses are relatively insignificant and hence, focus is on most common occurences. Note that an "Other" classification includes wood-framed floor systems.
South Coast	100% / 0% / 0% 11.5 / 19.2 / 30.3 11.5	100% / 0% / 0% 13.5 / 26.3 / 30.3 13.5	**25.0**	
Southern Interior	60% / 0% / 40% 11.5 / 19.2 / 30.3 19.0	60% / 0% / 40% 13.5 / 26.3 / 30.3 20.2	**31.0**	
Northern Interior	60% / 0% / 40% 11.5 / 26.3 / 30.3 19.0	60% / 0% / 40% 15.6 / 26.3 / 30.3 21.5	7A / 7B 35.0 / 35.0 **35.0**	
GLAZING				
Glazing Percent	40%	40%	40%	From BC Hydro survey information on older existing offices, the average percent window area is about 21%. However, since newer buildings have much higher percentages of glazing, estimated new construction percent at the 90.1-2010, NECB (and MNECB) prescriptive maximum level based on professional judgement.
Window U-value	Operable / Fixed / U_o	Non-metal / c.w./store / Metal door / Other metal / U_o	No variation by window type	Operable windows are increasing, but are still relatively low overall. For ASHRAE 90.1-2010, "c.w./store" refers to curtainwall/storefront. Other window types would include wood, vinyl and fiberglass framed units. Factors are based on professional judgement and is not statistically proven nor supported by market research. Input is corrected for DOE2's adjustment for air films to produce the specified overall U-value.
South Coast	10% / 90% 0.67 / 0.57 0.58	0% / 50% / 5% / 45% 0.35 / 0.45 / 0.80 / 0.55 0.51	**0.42**	
Southern Interior	10% / 90% 0.67 / 0.57 0.58	0% / 40% / 5% / 55% 0.35 / 0.45 / 0.80 / 0.55 0.52	**0.39**	
Northern Interior	10% / 90% 0.67 / 0.57 0.58	0% / 40% / 5% / 55% 0.35 / 0.40 / 0.80 / 0.45 0.45	7A / 7B 0.39 / 0.39 **0.39**	
Window Shading Coefficient				ASHRAE no longer provides a differentiation for North-facing windows from all other windows. NECB has no requirements on the SC, so we have set it same as for ASHRAE 90.1-2010 to neutralize the effect; also, the NECB U-value infers low-e which ASHRAE's SC levels correspond to.
South Coast	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)	No requirements (set same as for 90.1-2010)	
Southern Interior	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)		
Northern Interior	0.57 (all orientations) / 0.74 (North)	0.52 (all orientations)		
SPACE				
Schedules	MNECB Schedule A	MNECB Schedule A	MNECB Schedule A	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines

Small Office: Key Building Characteristics

Interior Lighting	0.97 W/ft² (1.0 W/ft², less 3% PAF)	**0.72 W/ft² (1.0 W/ft², less 10%, less 18% PAF)**	**0.72 W/ft² (1.0 W/ft², less 10%, less 18% PAF)**	By Building Area, offices have a 10.0% reduction in interior lighting power allowance. 9.4.1.2 stipulates occupancy sensors for most spaces in an office building: meeting, break, storage, enclosed offices, washrooms. Corridors, stairs excluded (40% of space in a small office). PAF: 0.6*0.3 = 18%.
Exterior Lighting	0.9 kW (grounds and security/entry lighting)	**0.81 kW (grounds and security/entry lighting). 0.9 kW less 10%.**	**0.81 kW (grounds and security/entry lighting). 0.9 kW less 10%.**	Using 90.1-2004 lighting as the baseline compliant with Standard, 2010 allows more overall exterior lighting for Zone 4 and less for Zone 3. The size of building and the mix of parking (lower allowance) and building grounds and security/entry lighting (higher allowance) areas would determine the difference. Small offices, mainly entrances, sinage, walkways ~ 10% lower. NECB is the same as 2010. Assume parking area outdoors, no occupancy sensors required
Equipment density	0.70 W/ft²	0.70 W/ft²	0.70 W/ft²	
HVAC SYSTEM TYPE (Most applicable ASHRAE ECB System Types retained, as prescriptive compliance applies for this study)				
Air Handling	a) VAV reheat (System 4) b) Distributed heat pump (System 6) c) VAV with parallel fan-powered boxes (System 3)	a) VAV reheat (System 4) b) Distributed heat pump (System 6) c) VAV with parallel fan-powered boxes (System 3)	Apply same as for ASHRAE, due to nature of code comparison study	System IDs indicated for ASHRAE refer to system types identified in Table 11.4.3A, as referenced in founding LEED and code comparison studies. They are appropriate here as they are representative of common air systems and capture a reasonable cross-section of heating sources used in new designs and retrofits. *As prescriptive compliance is the focus here, adherance to performance rating protocols is not applicable.* System 4 (packaged VAV) is referenced for small offices instead of System 2 since most smaller projects use air-cooled chillers or DX cooling.
	Note: PRM (Appendix G) for LEED rating purposes applies HVAC types that can be significantly different, depending on floor area, building type (Residential, Nonresidential) and heating source (fossil/purchased heat and electric/other).		Note: Part 8 "Energy Performance" method applies HVAC types that vary depending on building or space type, heating source and in some cases, number of floors.	

Small Office: Key Building Characteristics

Heating Source	a) Gas for System 4 (L02g??rB) b) Gas for System 6 (L02g??2B) c) Electric for System 3 (L02e??rB)	a) Gas for System 4 (L02g??rA10) b) Gas for System 6 (L02g??2A10) c) Electric for System 3 (L02e??rA10)	Apply same as for ASHRAE, due to nature of code comparison study a) L02g??rN11 b) L02g??2N11 c) L02e??rN11	Apply most prominent heating sources in market to capture major influences between energy providers/sources (e.g., electricity, natural gas). IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	Air	Air	Air	Note that method of cooling is not as important as the relative differences in the cooling efficiencies.
FAN SYSTEM				
Supply Air Temperature Control	Minimum based on warmest zone for mixed air systems	Minimum based on warmest zone for mixed air systems	Minimum based on warmest zone for mixed air systems	Minimum supply air temperature control applies to multiple zone systems with simultaneous heating and cooling. (Note: ECB would dictate constant control for PIU system, which was modified here.)
Fan Power	**For VAV, reduce by 20% below MNECB defaults of 1.25 W/cfm; MNECB defaults of 1.3"/40% fan efficiency for MAU and 0.5"/25% for distributed HPs**	Same as 90.1-2004 except increase MAU to 2.3" for heat recovery if applicable (still under fan power limit)	Keep at corresponding ASHRAE levels, with heat recovery cases increased by 1" overall due to heat recovery (still under fan power limit).	Most designs have no difficulty staying under the allowed fan power limits. Hence, the founding study's MNECB default total static pressures and fan efficiencies are retained even though most designs are better than the MNECB defaults. (It is interesting to note that ASHRAE Appendix G significantly lowers the baseline fan power from what is dictated in the body of the Standard.)
Outside Air	0.13 cfm/ft² (1 system at 5600 cfm)	0.13 cfm/ft² (1 system at 5600 cfm)	Same as for ASHRAE cases	ASHRAE 90.1-2010 added provisions in 6.5.3.3 that required VAV systems with DDC "include means to automatically reduce outdoor intake flow below design rates" per ASHRAE 62.1 Appendix A (dynamic reset) -- but note that it doesn't directly require it is implemented. While this theoretically could have a noticeable impact on energy use, the market does not have a firm understanding of the ASHRAE 62.1 multiple zone, mixed air provisions. Also, exceptions apply when transfer fans, fan-powered boxes and heat recovery applies. Hence, given these considerations and exceptions, the design O/A levels are kept consistent for all cases, but effectively credited with DCV potential applied for VAV cases.

Small Office: Key Building Characteristics

Fan Curve (VAV only)	VSD	VSD	VSD, for consistency with ASHRAE (although "top level" MNECB fan curve applies as well)	The NECB references the same fan curves as applied to the MNECB for ecoEnergy, but is effectively consistent with ASHRAE for systems over 25 kW (~33 hp). ASHRAE is more stringent for systems over 10 hp, with the requirement of MNECB's "top level" fan curve or VSDs.
Heat Reclaim				Design O/A percentage for VAV estimated at 11% O/A based on 1.2 cfm/ft² "design supply airflow rate" (ASHRAE 90.1-2010 applicability of heat recovery doesn't apply below 30%). NECB 2011 dictates heat recovery at the following system exhaust rates: Vancouver at 8900 cfm, Kelowna at 6600 cfm, Prince George at 4700 cfm.
South Coast	N/A	**MAU: 50% effectiveness** VAV: N/A	N/A	
Southern Interior	N/A	**MAU: 50% effectiveness** VAV: N/A	N/A	
Northern Interior	N/A	**MAU: 50% effectiveness** VAV: N/A	50% effectiveness	
HVAC				
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	
Economizer	Temperature for VAV; N/A for distributed HP	Temperature for VAV; N/A for distributed HP	Temperature for VAV; N/A for distributed HP	NECB indicates dry bulb or enthalpy may be used; dry bulb is more common and just about as effective in Canada.
Demand Controlled Ventilation	N/A	**DCV applied to 15% of O/A using occupancy sensors (emulated with O/A decreased by 2%)**	N/A	Requirements of 90.1-2010 (6.4.3.9) would apply to meeting rooms over 500 ft², estimated to account for about 15% of the total O/A. Method of DCV not dictated; hence, assume use of occupancy sensor as it is required for lighting anyway and is relatively common. Approximate based on 30% PAF x ½ potential for OS control x 15% of O/A.
HEATING				
Central Heating Efficiency	Two 80% efficient boilers, plus 1.5% - 2.0% pts. for reset:	Same as for ASHRAE 90.1-2004	Two 82.5% efficient boilers, plus 1.5% - 2.0% pts. for reset:	For consistency, apply same provisions for hot water reset as applied for CBIP/ecoEnergy and founding studies. This includes providing for hot water reset even though variable flow is also applied to to reduce pumping energy (exception per ASHRAE 6.5.4.3.b.). For NECB, estimate mid-size boiler requirements are most applicable.
South Coast	81.5%		**84.0%**	
Southern Interior	81.5%		**84.0%**	
Northern Interior	82.0%		**84.5%**	

Small Office: Key Building Characteristics

Hot Water Flow	Variable flow down to 50% flow, riding curve	Variable flow down to 50% flow, riding curve	Consistent with ASHRAE	Variable flow pumping applied as most designs provide for "control valves designed to modulate or step open and close as a function of load" [from ASHRAE and NECB]. Note that MNECB had the same requirement, yet the Performance Path applied constant speed pumps. Default CBIP models set at 50' head.
Heat Pumps	4.2 COP for distributed heat pumps	4.2 COP for distributed heat pumps	4.2 COP for distributed heat pumps	Draft NECB 2011 references CAN/CSA document that is not readily available; however, efficiency levels consistent with previous versions of ASHRAE 90.1, per OEE bulletin (http://oee.nrcan.gc.ca/regulations/product/internal-water-loop-heat-pumps.cfm).
COOLING				
Central Cooling Efficiency	Unitary air-cooled AC at 3.1 COP (average across most applicable size of units)	**Unitary air-cooled AC at 3.3 COP (average across most applicable size of units)**	**Unitary air-cooled AC at 3.3 COP (average across most applicable size of units)**	From founding study, packaged rooftop DX cooling was referenced here for the equivalency analysis, so as to capture offices with such equipment (versus larger ones with chillers). Consistently reference same equipment for 90.1-2010 and NECB, as best as possible.
Heat Pumps	12 EER for distributed HP system	12 EER for distributed HP system	12 EER for distributed HP system	Standards list different efficiency levels based on size of heat pump, but the HP size would vary depending on the situation. Hence, highest rated category was applied to be conservative with MNECB comparison (which applied to 2 of 3 categories anyway). Remained consistent with founding studies for ASHRAE 90.1-2010 and NECB 2011 here. Draft NECB 2011 references CAN/CSA document that is not readily available; however, efficiency levels consistent with previous versions of ASHRAE 90.1, per OEE bulletin (see above for Heat Pumps).
DOMESTIC HOT WATER (DHW)				
Heating Efficiency	80%	80%	80%	Losses set at 3% in CBIP archetype models.
Avg. Load (Btu/sf/day)	2.77	2.77	2.77	NECB dictates measures for limiting water use at fixtures, but measures are standard practice and hence, equivalently applied with ASHRAE since it is silent on such stipulations.

Small Office: Key Building Characteristics

Large Office: Key Building Characteristics

The large office archetype from NRCan represents a square 259,200 ft² (24,100 m²), 18-storey building with a wall-to-roof area ratio of 7.4. The zoning includes 5 uniformly loaded zones per floor, with a 1,300 ft² perimeter zone on each of the four major orientations and a core zone which accounts for 64% of the floor space. The core and perimeter zones are served by two separate HVAC systems.

The following listing provides the key building characteristics which differ between the ASHRAE 90.1-2004, ASHRAE 90.1-2010 and the NECB 2011 code-compliant models. In many cases information for certain characteristics are the same between the models, but we provide information since it is unique to the building type and/or of significance to the energy performance.

NOTE: The original archetypes were formulated for the purposes of determining the equivalency between the MNECB 97's and ASHRAE 90.1-1999's performance path approaches, modified for use with LEED EAp2 and EAc1. This is not quite the same as a comparison on the prescriptive application of the Codes. Thus, certain characteristics are indicative of what ASHRAE 90.1 would dictate for its ECB case, which is not necessarily fully representative for the market -- particularly for the HVAC system(s). For offices, fan coil systems would have a signficant market share, but at least they are partially represented with the ECB's system type with fan-powered boxes.

Item	ASHRAE 90.1-2004					ASHRAE 90.1-2010					NECB 2011	Discussion/Issues
EXTERIOR SURFACES												
Wall Overall R-Value	Mass	Metal	Steel	Other	R_o	Mass	Metal	Steel	Other	R_o	No variation by construction	Allocation of construction types is based on professional judgement and for consistency with past, founding studies. It is not statistically proven nor supported by market research. A "mass" type construction would likely include concrete components and brick vaneer assemblies. Steel stud (without concrete or brick) and curtainwall systems would be considered as "steel" (framed). Other includes wood stud construction.
South Coast	Climate Zone 5					Climate Zone 5					Climate Zone 4	
	25%	0%	75%	0%	11.0	25%	0%	75%	0%	14.5	18.0	
	8.13	8.85	11.9	11.2		11.1	14.5	15.6	15.6			
Southern Interior	Climate Zone 5					Climate Zone 5					Climate Zone 5	
	25%	0%	75%	0%	11.0	25%	0%	75%	0%	14.5	20.6	
	8.13	8.85	11.9	11.2		11.1	14.5	15.6	15.6			
Northern Interior	Climate Zone 5					Climate Zone 7					Zone 7A (60%) & 7B (40%)	
	25%	0%	75%	0%	14.5	25%	0%	75%	0%	15.2	7A: 27.0, 7B: 27.0 — 27.0	
	11.1	17.5	15.6	11.2		14.1	17.5	15.6	19.6			
Roof Overall R-Value	Insulation Entirely above Deck					Insulation Entirely above Deck					No variation by construction	For this building type, all roof types as flat roofs with continuous insulation. This is based on professional experience in the commercial sector and is not statistically proven nor supported by market research.
South Coast	15.9					20.8					25.0	
Southern Interior	15.9					20.8					31.0	
Northern Interior	15.9					20.8					7A: 35.0, 7B: 35.0 — 35.0	

Large Office: Key Building Characteristics

Exposed Floor R-Value	Mass				Mass					No variation by construction			Allocation of construction types is based solely on professional experience in the commercial sector and is not statistically proven nor supported by market research. Note that floor losses are relatively insignificant and hence, focus is on most common occurences. Note that an "Other" classification includes wood-framed floor systems.
South Coast	100%	0%	0%	11.5	100%	0%	0%		13.5	25.0			
	11.5	19.2	30.3		13.5	26.3	30.3						
Southern Interior	100%	0%	0%	11.5	100%	0%	0%		13.5	31.0			
	11.5	19.2	30.3		13.5	26.3	30.3						
Northern Interior	100%	0%	0%	11.5	100%	0%	0%		15.6	7A	7B	35.0	
	11.5	26.3	30.3		15.6	26.3	30.3			35.0	35.0		
GLAZING													
Glazing Percent	50% (prescriptive maximum)				40% (prescriptive maximum)					40% (prescriptive maximum)			Newer buildings have much higher percentages of glazing than older stock. The prescriptive maximum is nearly always exceeded (triggering the application of trade-off or performance path, which references prescriptive maximum levels).
Window U-value	Operable	Fixed		U_o	Non-metal	c.w./store	Metal door	Other metal	U_o	No variation by window type			Operable windows are increasing, but are still relatively low overall. For ASHRAE 90.1-2010, "c.w./store" refers to curtainwall/storefront. Other window types would include wood, vinyl and fiberglass framed units. Factors are based on professional judgement and is not statistically proven nor supported by market research. Input is corrected for DOE2's adjustment for air films to produce the specified overall U-value.
South Coast	5%	95%		0.46	0%	70%	0%	30%	0.48	0.42			
	0.47	0.46			0.35	0.45	0.80	0.55					
Southern Interior	5%	95%		0.46	0%	60%	0%	40%	0.49	0.39			
	0.47	0.46			0.35	0.45	0.80	0.55					
Northern Interior	5%	95%		0.46	0%	50%	0%	50%	0.43	7A	7B	0.39	
	0.47	0.46			0.35	0.40	0.80	0.45		0.39	0.39		
Window Shading Coefficient													ASHRAE no longer provides a differentiation for North-facing windows from all other windows. NECB has no requirements on the SC, so we have set it same as for ASHRAE 90.1-2010 to neutralize the effect; also, the NECB U-value infers low-e which ASHRAE's SC levels correspond to.
South Coast	0.30 (all orientations) / 0.41 (North)				0.46 (all orientations)					No requirements (set same as for 90.1-2010)			
Southern Interior	0.30 (all orientations) / 0.41 (North)				0.46 (all orientations)								
Northern Interior	0.41 (all orientations) / 0.74 (North)				0.52 (all orientations)								
SPACE													
Schedules	MNECB Schedule A				MNECB Schedule A					MNECB Schedule A			Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines

Large Office: Key Building Characteristics

Interior Lighting	0.97 W/ft² (1.0 W/ft², less 3% PAF)	**0.72 W/ft² (1.0 W/ft², less 10%, less 18% PAF)**	**0.72 W/ft² (1.0 W/ft², less 10%, less 18% PAF)**	By Building Area, offices have a 10.0% reduction in interior lighting power allowance. 9.4.1.2 stipulates occupancy sensors for most spaces in an office building: meeting, break, storage, enclosed offices, washrooms. Corridors, stairs excluded (40% of space in a large office). PAF: 0.6*0.3 = 18%.
Exterior Lighting	5.2 kW (mainly regulated parkade lighting)	**2.9 kW (mainly regulated parkade lighting). 5.2 kW less 25%, less PAFof 25%**	3.9 kW (mainly regulated parkade lighting) 5.2 kW less 25%	Using 90.1-2004 lighting as the baseline compliant with Standard, 2010 allows more overall exterior lighting for Zone 4 and less for Zone 3. The size of building and the mix of parking (lower allowance) and building grounds and security/entry lighting (higher allowance) areas would determine the difference. For mainly parking, a decrease of ~25%. Parking areas require occupancy sensors for 90.1-2010 but not for the NECB. For parking garages 9.4.1.3 stipulates that occupancy sensors shall reduce the lighting by 30% in parkade lighting zones. Assume Parking is 85% of the exterior lighting, the PAF = 0.3*85% = 25%.
Equipment density	0.70 W/ft²	0.70 W/ft²	0.70 W/ft²	
HVAC SYSTEM TYPE (Most applicable ASHRAE ECB System Types retained, as prescriptive compliance applies for this study)				
Air Handling	a) VAV reheat (System 2) b) Distributed heat pump (System 6) c) VAV with parallel fan-powered boxes (System 1)	a) VAV reheat (System 2) b) Distributed heat pump (System 6) c) VAV with parallel fan-powered boxes (System 1)	Apply same as for ASHRAE, due to nature of code comparison study	System IDs indicated for ASHRAE refer to system types identified in Table 11.4.3A, as referenced in founding LEED and code comparison studies. They are appropriate here as they are representative of common air systems and capture a reasonable cross-section of heating sources used in new designs and retrofits. *As prescriptive compliance is the focus here, adherance to performance rating protocols is not applicable.*

Large Office: Key Building Characteristics

	Note: PRM (Appendix G) for LEED rating purposes applies HVAC types that can be significantly different, depending on floor area, building type (Residential, Nonresidential) and heating source (fossil/purchased heat and electric/other).		Note: Part 8 "Energy Performance" method applies HVAC types that vary depending on building or space type, heating source and in some cases, number of floors.	
Heating Source	a) Gas for System 2 (L01g??rB) b) Gas for System 6 (L01g??2B) c) Electric for System 1 (L01e??rB)	a) Gas for System 2 (L01g??rA10) b) Gas for System 6 (L01g??2A10) c) Electric for System 1 (L01e??rA10)	Apply same as for ASHRAE, due to nature of code comparison study a) L01g??rN11 b) L01g??2N11 c) L01e??rN11	Apply most prominent heating sources in market to capture major influences between energy providers/sources (e.g., electricity, natural gas). IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	Water	Water	Water	Note that method of cooling is not as important as the relative differences in the cooling efficiencies.
FAN SYSTEM				
Supply Air Temperature Control	Minimum based on warmest zone for mixed air systems	Minimum based on warmest zone for mixed air systems	Minimum based on warmest zone for mixed air systems	Minimum supply air temperature control applies to multiple zone systems with simultaneous heating and cooling. (Note: ECB would dictate constant control for PIU system, which was modified here.)
Fan Power	**For VAV, reduce by 20% below MNECB defaults of 1.25 W/cfm; MNECB defaults of 1.3"/40% fan efficiency for MAU and 0.5"/25% for distributed HPs**	Same as 90.1-2004 except increase MAU to 2.3" for heat recovery if applicable (still under fan power limit)	Keep at corresponding ASHRAE levels, with all cases increased by 1" overall due to heat recovery (still under fan power limit).	Most designs have no difficulty staying under the allowed fan power limits. Hence, the founding study's MNECB default total static pressures and fan efficiencies are retained even though most designs are better than the MNECB defaults. (It is interesting to note that ASHRAE Appendix G significantly lowers the baseline fan power from what is dictated in the body of the Standard.)

Large Office: Key Building Characteristics

Outside Air	0.13 cfm/ft² (2 systems at 21600 cfm and 12100 cfm, respectively)	0.13 cfm/ft² (2 systems at 21600 cfm and 12100 cfm, respectively)	Same as for ASHRAE cases	ASHRAE 90.1-2010 added provisions in 6.5.3.3 that required VAV systems with DDC "include means to automatically reduce outdoor intake flow below design rates" per ASHRAE 62.1 Appendix A (dynamic reset) -- but note that it doesn't directly require it is implemented. While this theoretically could have a noticeable impact on energy use, the market does not have a firm understanding of the ASHRAE 62.1 multiple zone, mixed air provisions. Also, exceptions apply when transfer fans, fan-powered boxes and heat recovery applies. Hence, given these considerations and exceptions, the design O/A levels are kept consistent for all cases, but effectively credited with DCV potential applied for VAV cases.
Fan Curve (VAV only)	VSD	VSD	VSD, for consistency with ASHRAE (although "top level" MNECB fan curve applies as well)	The NECB references the same fan curves as applied to the MNECB for ecoEnergy, but is effectively consistent with ASHRAE for systems over 25 kW (~33 hp). ASHRAE is more stringent for systems over 10 hp, with the requirement of MNECB's "top level" fan curve or VSDs.
Heat Reclaim				Design O/A percentage for VAV estimated at 11% O/A based on 1.2 cfm/ft² "design supply airflow rate" (ASHRAE 90.1-2010 applicability of heat recovery doesn't apply below 30%). NECB 2011 dictates heat recovery at the following system exhaust rates: Vancouver at 8900 cfm, Kelowna at 6600 cfm, Prince George at 4700 cfm.
South Coast	N/A	**MAU: 50% effectiveness** VAV: N/A	50% effectiveness	
Southern Interior	N/A	**MAU: 50% effectiveness** VAV: N/A	50% effectiveness	
Northern Interior	N/A	**MAU: 50% effectiveness** VAV: N/A	50% effectiveness	
HVAC				
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	
Economizer	Temperature for VAV; N/A for distributed HP	Temperature for VAV; N/A for distributed HP	Temperature for VAV; N/A for distributed HP	NECB indicates dry bulb or enthalpy may be used; dry bulb is more common and just about as effective in Canada

Large Office: Key Building Characteristics

Demand Controlled Ventilation	N/A	**DCV applied to 15% of O/A using occupancy sensors (emulated applying a 2% O/A decrease)**	N/A	Requirements of 90.1-2010 (6.4.3.9) would apply to meeting rooms over 500 ft², estimated to account for about 15% of the total O/A. Method of DCV not dictated; hence, assume use of occupancy sensor as it is required for lighting anyway and is relatively common. Approximate based on 30% PAF x ½ potential for OS control x 15% of O/A.
HEATING				
Central Heating Efficiency	Two 80% efficient boilers, plus 1.5% - 2.0% pts. for reset:	Same as for ASHRAE 90.1-2004	Two 82.5% efficient boilers, plus 1.5% - 2.0% pts. for reset:	Some new designs may use furnaces instead of boilers, but there exists no significant difference in heating efficiency between the Codes or between the heating equipment. Hence, we stayed with the CBIP Reference model default. Further, this should be more conservative because of the improved part-load performance of the ASHRAE Reference with the use of two boilers and hot water reset.
South Coast	81.5%		**84.0%**	
Southern Interior	81.5%		**84.0%**	
Northern Interior	82.0%		**84.5%**	
Hot Water Flow	Variable flow down to 50% flow, riding curve	Variable flow down to 50% flow, riding curve	Consistent with ASHRAE	Variable flow pumping applied as most designs provide for "control valves designed to modulate or step open and close as a function of load" [from ASHRAE and NECB]. Note that MNECB had the same requirement, yet the Performance Path applied constant speed pumps. Default CBIP models set at 50' head.
Heat Pumps	4.2 COP for distributed heat pumps	4.2 COP for distributed heat pumps	4.2 COP for distributed heat pumps	Draft NECB 2011 references CAN/CSA document that is not readily available; however, efficiency levels consistent with previous versions of ASHRAE 90.1, per OEE bulletin (http://oee.nrcan.gc.ca/regulations/product/internal-water-loop-heat-pumps.cfm).
COOLING				
Central Cooling Efficiency	2 screw or centrifugal chillers depending on region; effectively increase COP by 8% - 21% for reset	2 screw or centrifugal chillers depending on region; effectively increase COP by 8% - 21% for reset	Same as for ASHRAE cases	Equivalent efficiency improvement for reset derived from applicable DOE2.1e runs. **Refer to founding LEED-BC Equivalency report for more discussion on the identification of cooling equipment for the prototype models.** For ASHRAE 90.1-2010, Path A kW/ton referenced from Table 6.8.1C. For NECB, Draft document references CAN/CSA document that is not readily
South Coast	2 screw chillers at COP of	**2 screw chillers at COP**	**2 screw chillers at COP of**	

Large Office: Key Building Characteristics

Souh Coast	4.9 + 0.4 = 5.3	of 5.2 + 0.4 = 5.6	5.2 + 0.4 = 5.6	references CAN/CSA document that is not readily available; however, OEE references infer that efficiency levels are consistent with ASHRAE 90.1.
Southern Interior	2 centrifugal chillers at COP of 6.1 + 1.3 = 7.4	2 centrifugal chillers at COP of 6.1 + 1.3 = 7.4	2 centrifugal chillers at COP of 6.1 + 1.3 = 7.4	
Northern Interior	2 screw chillers at COP of 4.9 + 0.3 = 5.2	2 screw chillers at COP of 5.2 + 0.3 = 5.2	2 screw chillers at COP of 5.2 + 0.3 = 5.2	
Heat Pumps	12 EER for distributed HP system	12 EER for distributed HP system	12 EER for distributed HP system	Standards list different efficiency levels based on size of heat pump, but the HP size would vary depending on the situation. Hence, highest rated category was applied to be conservative with MNECB comparison (which applied to 2 of 3 categories anyway). Remained consistent with founding studies for ASHRAE 90.1-2010 and NECB 2011 here. Draft NECB 2011 references CAN/CSA document that is not readily available; however, efficiency levels consistent with previous versions of ASHRAE 90.1, per OEE bulletin (see above for Heat Pumps).
Chilled Water Temperature	12°F rise; 44°F supply	12°F rise; 44°F supply	12°F rise; 44°F supply	Maintain consistent conditions, although they may vary for Performance (Modelling) Path.
Chilled Water Flow	Variable flow down to 50% flow, riding curve	Variable flow down to 50% flow, VSD	Consistent with ASHRAE	ASHRAE 90.1-2010 doesn't explicitly reference VSDs, but with the decrease to variable flow for 5HP systems (vs 50HP before), apply VSDs as they are common in practice. Default CBIP models set at 50' head.
Cooling Tower	Two cell cooling tower with 85°F - 95°F temperature rise, and a two speed fan at >=38.2 gpm/hp. Pumping power same as original archetypes (DOE2 TWR-EIR = 0.0133)	Two cell cooling tower with 85°F - 95°F temperature rise, and a two speed fan at >=38.2 gpm/hp. Pumping power same as original archetypes (DOE2 TWR-EIR = 0.0133)	Two cell cooling tower with 85°F - 95°F temperature rise, and a two speed fan at >=38.2 gpm/hp. Pumping power same as original archetypes (DOE2 TWR-EIR = 0.0133)	Maintain consistent conditions, although they may vary for Performance (Modelling) Path.
DOMESTIC HOT WATER (DHW)				
Heating Efficiency	80%	80%	80%	Losses set at 3% in CBIP prototype models.

Large Office: Key Building Characteristics

Avg. Load (Btu/sf/day)	2.77	2.77	2.77	NECB dictates measures for limiting water use at fixtures, but measures are standard practice and hence, equivalently applied with ASHRAE since it is silent on such stipulations.

School: Key Building Characteristics

The school archetype from NRCan represents a 168,000 ft² (15,600 m²), single storey building. The building has a wall-to-roof area ratio of 0.52. The functional zones include classrooms, a gym, an auditorium, corridors, library, administrative offices, a lounge, and a small greenhouse. Note that modifications to NRCan templates were made to provide for many more unoccupied days than is allocated by default MNECB schedules. Note that updates to inappropriate schedules were implemented; hence, *comparison of direct energy use results to past studies would be skewed, particularly for absolute values (although relative percentage differences would be less impacted)*.

The following listing provides the key building characteristics which differ between the ASHRAE 90.1-2004, ASHRAE 90.1-2010 and the NECB 2011 code-compliant models. In many cases information for certain characteristics are the same between the models, but we provide information since it is unique to the building type and/or of significance to the energy performance.

NOTE: The original archetypes were formulated for the purposes of determining the equivalency between the MNECB 97's and ASHRAE 90.1-1999's performance path approaches, modified for use with LEED EAp2 and EAc1. This is not quite the same as a comparison on the prescriptive application of the Codes. Thus, certain characteristics are indicative of what ASHRAE 90.1 would dictate for its ECB case, which is not necessarily fully representative for the market -- particularly for the HVAC system(s).

Item	ASHRAE 90.1-2004					ASHRAE 90.1-2010					NECB 2011	Discussion/Issues
EXTERIOR SURFACES												
Wall Overall R-Value	Mass	Metal	Steel	Other	R_o	Mass	Metal	Steel	Other	R_o	No variation by construction	Allocation of construction types is based on professional judgement and for consistency with past, founding studies. It is not statistically proven nor supported by market research. However, we have observed many new schools that are steel framed, tilt-up or concerte block (particularly in gyms), and wood famed ("other") for small elementary schools. Thus, it appears that an even mix of constructions is appropriate.
South Coast	Climate Zone 5					Climate Zone 5					Climate Zone 4	
	33%	0%	33%	33%	10.4	33%	0%	33%	33%	14.1	18.0	
	8.13	8.85	11.9	11.2		11.1	14.5	15.6	15.6			
Southern Interior	Climate Zone 5					Climate Zone 5					Climate Zone 5	
	33%	0%	33%	33%	10.4	33%	0%	33%	33%	14.1	20.6	
	8.13	8.85	11.9	11.2		11.1	14.5	15.6	15.6			
Northern Interior	Climate Zone 5					Climate Zone 7					Zone 7A (60%) & 7B (40%)	
	33%	0%	33%	33%	12.7	33%	0%	33%	33%	16.4	7A: 27.0; 7B: 27.0; 27.0	
	11.1	17.5	15.6	11.2		14.1	17.5	15.6	19.6			
Roof Overall R-Value	Insulation Entirely above Deck					Insulation Entirely above Deck					No variation by construction	For this building type, all roof types as flat roofs with continuous insulation. This is based on professional experience in the commercial sector and is not statistically proven nor supported by market research.
South Coast	15.9					20.8					25.0	
Southern Interior	15.9					20.8					31.0	
Northern	15.9					20.8					7A; 7B; 35.0	

School: Key Building Characteristics

Interior	15.9	20.8	35.0 / 35.0 / 35.0	
Slab-on-Grade Floor R-Value	Not required (n.r.)	South Coast and Southern Interior: n.r. **Northern Interior: R-15**	**R-7.5**	Exposed floors were provided for in NRCan archetypes only (no exposed floors).
GLAZING				
Glazing Percent	32%* (updated to be same as for new Codes)	32%	32%	From BC Hydro information on existing schools, the average percent window area was about 16%. However, nearly all new school designs we have seen have at typically more than doubled this -- significantly enough to warrant revising this from previous studies. **Consequently, the relative comparison to past quantitative studies will be slightly inconsistent and skewed.**
Window U-value	Operable / Fixed / U_o	Non-metal / c.w./store / Metal door / Other metal / U_o	No variation by window type	Operable windows are increasing, but are still relatively low overall (proportional to the increase in window area). For ASHRAE 90.1-2010, "c.w./store" refers to curtainwall/storefront. Factors are based on professional judgement and is not statistically proven nor supported by market research. Input is corrected for DOE2's adjustment for air films to produce the specified overall U-value.
South Coast	20% / 80% 0.67 / 0.57 U_o 0.59	0% / 30% / 5% / 65% 0.35 / 0.45 / 0.80 / 0.55 U_o 0.53	**0.42**	
Southern Interior	20% / 80% 0.67 / 0.57 U_o 0.59	0% / 30% / 5% / 65% 0.35 / 0.45 / 0.80 / 0.55 U_o 0.53	**0.39**	
Northern Interior	20% / 80% 0.67 / 0.57 U_o 0.59	0% / 20% / 5% / 75% 0.35 / 0.40 / 0.80 / 0.45 U_o 0.46	7A / 7B 0.39 / 0.39 **0.39**	
Window Shading Coefficient			No requirements (set same as for 90.1-2010)	ASHRAE no longer provides a differentiation for North-facing windows from all other windows. NECB has no requirements on the SC, so we have set it same as for ASHRAE 90.1-2010 to neutralize the effect; also, the NECB U-value infers low-e which ASHRAE's SC levels correspond to.
South Coast	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)		
Southern Interior	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)		
Northern Interior	0.57 (all orientations) / 0.74 (North)	0.52 (all orientations)		
SPACE				
Schedules	MNECB Schedule D	MNECB Schedule D	MNECB Schedule D	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines

School: Key Building Characteristics

Interior Lighting	1.13 W/ft^2 (1.2 W/ft^2, less 6% PAF)	**0.78 W/ft^2 (1.2 W/ft^2, less 17.5%, less 21% PAF)**	**0.78 W/ft^2 (1.2 W/ft^2, less 17.5%, less 21% PAF)**	The Building Area Method shows a 17.5% reduction in schools. 9.4.1.1 stipulates occupancy sensors for almost all spaces in a school (corridors, lobbies, etc excluded). Many school now include sensors in spaces not requiring sensors: washrooms, mechancial/electrical rooms, etc. Assume 70% of lighting in a typical school, hence, apply a 70% x 0.30 PAF = 21% reduction.
Exterior Lighting	3.4 kW (Parking, grounds and security lighting)	**2.9 kW (Parking, grounds and security lighting), 3.4 kW less 15%.**	**2.9 kW (Parking, grounds and security lighting), 3.4 kW less 15%.**	Using 90.1-2004 lighting as the baseline compliant with Standard, 2010 allows more overall exterior lighting for Zone 4 and less for Zone 3. The size of building and the mix of parking (lower allowance) and building grounds and security/entry lighting (higher allowance) areas would determine the difference. For schools, grounds and security 65% and parking 35%, hense a net decrease of 15%. Assume parking is above ground, no occupancy sensor control required.
Equipment density	0.50 W/ft^2	0.50 W/ft^2	0.50 W/ft^2	
HVAC SYSTEM TYPE (Most applicable ASHRAE ECB System Types retained, as prescriptive compliance applies for this study)				
Air Handling	a) VAV reheat (System 4), PSZ serving Gym (System 11) b) VAV with parallel fan-powered boxes (System 3), PSZ with heat pump serving Gym (System 9)	a) VAV reheat (System 4), PSZ serving Gym (System 11) b) VAV with parallel fan-powered boxes (System 3), PSZ with heat pump serving Gym (System 9)	Apply same as for ASHRAE, due to nature of code comparison study	System IDs indicated for ASHRAE refer to system types identified in Table 11.4.3A, as referenced in founding LEED and code comparison studies. They are retained here due to scope limitations, although VAV applied in new schools is becoming more common (with displacement ventilation). *As prescriptive compliance is the focus here, adherance to performance rating protocols is not applicable.* System 4 (packaged VAV) is referenced instead of System 2 since most smaller projects use air-cooled chillers or DX cooling. Note that ASHRAE's ECB system with fan-powered boxes still is not applicable for a school, but many designs do provide for terminal fan coils, with electric resistance and heat pump components.
	Note: PRM (Appendix G) for LEED rating purposes applies HVAC types that can be significantly different, depending on floor area, building type (Residential, Nonresidential) and heating source (fossil/purchased heat and electric/other).		Note: Part 8 "Energy Performance" method applies HVAC types that vary depending on building or space type, heating source and in some cases, number of floors.	

School: Key Building Characteristics

Heating Source	a) Gas for System 4 (S01g??rB) b) Electric for System 3, with air-source heat pump for Gym (S01e??rB)	a) Gas for System 4 (S01g??rA10) b) Electric for System 3, with air-source heat pump for Gym (S01e??rA10)	Apply same as for ASHRAE, due to nature of code comparison study a) S01g??rN11 b) S01e??rN11	Apply most prominent heating sources in market to capture major influences between energy providers/sources (e.g., electricity, natural gas). IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	Air	Air	Air	Note that method of cooling is not as important as the relative differences in the cooling efficiencies. It is typical to have DX cooling, where cooling is applied.
FAN SYSTEM				
Supply Air Temperature Control	Minimum based on warmest zone for mixed air systems	Minimum based on warmest zone for VAV systems	Minimum based on warmest zone for VAV systems	Minimum supply air temperature control applies to multiple zone systems with simultaneous heating and cooling.
Fan Power	**Static pressure set at MNECB default for DX/no cooling since it is closer to typical proposed designs: multiple zone systems at 3.0"/55% fan efficiency for supply and 0.6"/30% fan efficiency for return; Single zone systems same as MNECB defaults**	Same as 90.1-2004 except increase cases with heat recovery (1" for portion of flow HRV is applied to)	Same as ASHRAE 90.1-2004 except increase cases with heat recovery (1" for portion of flow HRV is applied to)	Most designs have no difficulty staying under the allowed fan power limits. Hence, the founding study's MNECB default total static pressures are retained with corresponding minimum fan efficiencies we typically see. (It is interesting to note that ASHRAE Appendix G significantly lowers the baseline fan power from what is dictated in the body of the Standard.)

School: Key Building Characteristics

Outside Air	0.35 cfm/ft²	0.35 cfm/ft²	Same as for ASHRAE cases	ASHRAE 90.1-2010 added provisions in 6.5.3.3 that required VAV systems with DDC "include means to automatically reduce outdoor intake flow below design rates" per ASHRAE 62.1 Appendix A (dynamic reset) -- but note that it doesn't directly require it is implemented. While this theoretically could have a noticeable impact on energy use, the market does not have a firm understanding of the ASHRAE 62.1 multiple zone, mixed air provisions. Also, exceptions apply when transfer fans, fan-powered boxes and heat recovery applies. Hence, given these considerations and exceptions, the design O/A levels are kept consistent for all cases but full DCV potential applied for VAV cases.
Fan Curve (VAV only)	MNECB "top-level" fan curve (Type c) as approximation for 15 hp restriction	**VSD (more common and slightly better fan curve to reflect difference in lower 10 hp restruction vs 90.1-2004**	MNECB "mid-level" fan curve (Type b) (consistent with previous MNECB study for average equipment below 25 kW)	The NECB references the same fan curves as applied to the MNECB for ecoEnergy, but is effectively consistent with ASHRAE for systems over 25 kW (~33 hp). ASHRAE is more stringent for systems over 10 hp, with the requirement of MNECB's "top level" fan curve or VSDs.
Heat Reclaim				Design O/A percentages estimated at 30-50% O/A for most systems. NECB 2011 dictates heat recovery at the following system exhaust rates: Vancouver at 8900 cfm (est. 40% of O/A), Kelowna at 6600 cfm (est. 85% of O/A), Prince George at 4700 cfm (est. 85% of O/A).
South Coast	N/A	N/A	**19% net effectiveness**	
Southern Interior	N/A	19% net effectiveness	**43% net effectiveness**	
Northern Interior	N/A	**45% net effectiveness**	43% net effectiveness	
HVAC				
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	
Economizer	Temperature for VAV and PSZ	Temperature for VAV and PSZ	Temperature for VAV and PSZ	
Demand Controlled Ventilation	Factors from Screening Tool applied for control of 20% of O/A	**90.1-2004 factors adjusted to account for 25% of O/A**	N/A	For ASHRAE 90.1-2010, 90.1-2004 applicability expanded from 20% of O/A (e.g., for Gyms, Large multipurpose) to include some small multipurpose assembly areas.

School: Key Building Characteristics

HEATING				
Central Heating Efficiency	Two 80% efficient boilers, plus 1.5% - 2.0% pts. for reset, as indicated below.	Same as for ASHRAE 90.1-2004	Two 82.5% efficient boilers, plus 1.5 - 2.0% pts. for reset (incl. below).	
South Coast	81.5%		**84.0%**	
Southern Interior	81.5%		**84.0%**	
Northern Interior	82.0%		**84.5%**	
Hot Water Flow	VSD	VSD	Consistent with ASHRAE	As is now common, VSDs applied to satisfy variable flow pumping reqirement from "control valves designed to modulate or step open and close as a function of load" [from ASHRAE and NECB]. Note that MNECB had the same requirement, yet the Performance Path applied constant speed pumps. Default CBIP models set at 50' head.
Heat Pumps	Air-source at 3.2 COP	**Air-source at 3.3 COP**	**Air-source at 3.3 COP (most optimistic estimate as draft NECB is not consistent with ASHRAE classifications)**	Heating efficiency is linked with the cooling efficiency and is as high as 1.1 times higher in heating mode than in cooling mode for air-source heat pumps and close to 1.2x for water-source.

School: Key Building Characteristics

COOLING: *Applied consistently throughout with Gym not cooled (as is typical)*				
Central Cooling Efficiency	Unitary air-cooled AC at 3.1 COP (average across most applicable size of units)	**Unitary air-cooled AC at 3.3 COP (average across most applicable size of units)**	**Unitary air-cooled AC at 3.3 COP (average across most applicable size of units)**	From founding study, packaged rooftop DX cooling was referenced here for the equivalency analysis, so as to capture offices with such equipment (versus larger ones with chillers). Consistently reference same equipment for 90.1-2010 and NECB, as best as possible.
Heat Pumps	Air-cooled - 10.1 EER (65 - 135 MBH)	**Air-cooled - 11.0 EER (65 - 135 MBH)**	Air-cooled Unitary A/C, All Phases - 9.7 EER (19 - 73 kW)	For ASHRAE 90.1 from founding LEED studies, the highest rating, which applies to potential units, was applied to be conservative in the comparison to the MNECB. For consistency, we applied the ratings for ASHRAE 90.1-2010 and the NECB that mostly closely aligned with the same categories.
DOMESTIC HOT WATER (DHW)				
Heating Efficiency	80%	80%	80%	Losses set at 3% in CBIP prototype models.
Avg. Load (Btu/sf/day)	7.3	7.3	7.3	NECB dictates measures for limiting water use at fixtures, but measures are standard practice and hence, equivalently applied with ASHRAE since it is silent on such stipulations.

MURB: Key Building Characteristics

The original MURB archetype from NRCan that was used in previous LEED and Continuum studies represented a 56,000 ft² (5,200 m²), five storey building. But the models were deficient in several regards compared with much more representative archetypes we have since developed (e.g., with typical corridor pressurization and parkade lighting). With much more representative models from other MURB studies (e.g., with corridor pressurization), we discarded the NRCan models and applied the characteristics to similarly configured "FAST" archetypes. The revised baseline models provide for the same floor area but with a more realistic wall-to-roof area ratio of ~2.0, with (64) 750 ft² apartments and 14.3% corridors and common area. The models are intended to be representative for multi-unit residential buildings of four storyes or more; MURBs of fewer storeys are not covered under the MNECB or ASHRAE 90.1.

The following listing provides the key building characteristics which differ between the ASHRAE 90.1-2004, ASHRAE 90.1-2010 and the NECB 2011 code-compliant models. In many cases information for certain characteristics are the same between the models, but we provide information since it is unique to the building type and/or of significance to the energy performance.

NOTE: The original archetypes were formulated for the purposes of determining the equivalency between the MNECB 97's and ASHRAE 90.1-1999's performance path approaches, modified for use with LEED EAp2 and EAc1, and not a comparison based on the prescriptive application of the Code. Thus, certain characteristics are indicative of what ASHRAE 90.1 would dictate for its ECB case, which is not fully representative for the market -- particularly for the HVAC system(s). *MURBs deviate the most from the HVAC systems applied, with heat pumps being applied in cases where electric resistance is employed.*

Item	ASHRAE 90.1-2004					ASHRAE 90.1-2010					NECB 2011	Discussion/Issues
EXTERIOR SURFACES												
Wall Overall R-Value	Mass	Metal	Steel	Other	R_o	Mass	Metal	Steel	Other	R_o	No variation by construction	Allocation of construction types is based on professional judgement and for consistency with past, founding studies. It is not statistically proven nor supported by market research. Note that the distribution by construction type is intended to capture a representative mix of wood construction typical of low-rise MURBs and concrete & steel construction typical of mid-/high-rise construction.
South Coast	Climate Zone 5					Climate Zone 5					Climate Zone 4	
	25%	0%	50%	25%	13.4	25%	0%	50%	25%	15.8	18.0	
	11.1	17.5	15.6	11.2		12.5	17.5	15.6	19.6			
Southern Interior	Climate Zone 5					Climate Zone 5					Climate Zone 5	
	30%	0%	40%	30%	12.9	30%	0%	40%	30%	15.9	20.6	
	11.1	17.5	15.6	11.2		12.5	17.5	15.6	19.6			
Northern Interior	Climate Zone 5					Climate Zone 7					Zone 7A (60%) & 7B (40%)	
	30%	0%	40%	30%	15.9	30%	0%	40%	30%	19.2	7A: 27.0, 7B: 27.0 → 27.0	
	12.5	17.5	15.6	19.6		12.5	17.5	23.8	19.6			
Roof Overall R-Value	Insulation Entirely above Deck					Insulation Entirely above Deck					No variation by construction	For this building type, most all roof types as flat roofs with continuous insulation. This is based on professional experience in the commercial sector and is not statistically proven nor supported by market research.
South Coast	15.9					20.8					25.0	

MURB: Key Building Characteristics

Southern Interior	15.9				20.8					**31.0**			
Northern Interior	15.9				20.8					7A	7B	**35.0**	
										35.0	35.0		
Exposed Floor R-Value	Mass				Mass					No variation by construction			Allocation of construction types is based on professional judgement in the commercial sector and is not statistically proven nor supported by market research. Note that floor losses are relatively insignificant and hence, focus is on most common occurences.
South Coast	60%	0%	40%	20.2	60%	0%	40%		21.5	**25.0**			
	13.5	26.3	30.3		15.6	26.3	30.3						
Southern Interior	60%	0%	40%	20.2	60%	0%	40%		21.5	**31.0**			
	13.5	26.3	30.3		15.6	26.3	30.3						
Northern Interior	60%	0%	40%	21.5	60%	0%	40%		23.9	7A	7B	**35.0**	
	15.6	26.3	30.3		19.6	31.3	30.3			35.0	35.0		
GLAZING													
Glazing Percent	50%				**40% (prescriptive maximum)**					**40% (prescriptive maximum)**			From several studies and our experience, the average percent window area for new low-rise and high-rise construction averages to roughly 50% (nearly about double of older building stock).
Window U-value	Operable		Fixed	U_o	Non-metal	store c.w./door	Metal	Other metal	U_o	No variation by window type			Low-rise MURBs tend to provide for vinyl windows and high-rise with a mix of curtainwall and window wall (other metal). As high-rise stock accounts for a disproportate share of window area, weighting is shifted toward metal framed categories. Also, proportionally more low-rise (wood-framed) MURBs appear to be built in the Southern and Northern regions than in the Lower Mainland / Vancouver Island region.
South Coast	30%		70%	0.46	30%	30%	10%	30%	0.49	**0.42**			
	0.47		0.46		0.35	0.45	0.80	0.55					
Southern Interior	30%		70%	0.46	40%	20%	10%	30%	0.48	**0.39**			
	0.47		0.46		0.35	0.45	0.80	0.55					
Northern Interior	30%		70%	0.46	50%	10%	10%	30%	0.43	7A	7B	**0.39**	
	0.47		0.46		0.35	0.40	0.80	0.45		0.39	0.39		
Window Shading Coefficient													ASHRAE no longer provides a differentiation for North-facing windows from all other windows. NECB has no requirements on the SC, so we have set it same as for ASHRAE 90.1-2010 to neutralize the effect; also, the NECB U-value infers low-e which ASHRAE's SC levels correspond to.
South Coast	0.30 (all orientations) / 0.56 (North)				0.46 (all orientations)					No requirements (set same as for 90.1-2010)			
Southern Interior	0.30 (all orientations) / 0.56 (North)				0.46 (all orientations)								
Northern Interior	0.41 (all orientations) / 0.74 (North)				No requirements, maintain at 0.41								
SPACE													

MURB: Key Building Characteristics

Schedules	Typical suite schedules; Corridor/stair lighting always on	Typical suite schedules; Corridor/stair lighting always on	Typical suite schedules; Corridor/stair lighting always on	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines, but refined to be even more representative based on load research studies
Interior Lighting	0.7 W/ft² (suites at 0.84 W/ft²)	**0.58 W/ft² (0.7 W/ft², less 14.3%, less 3% PAF) (suites unchanged)**	**0.58 W/ft² (0.7 W/ft², less 14.3%, less 3% PAF) (suites unchanged)**	The Building Area Method shows a 14.3% reduction in MURBS. 9.4.1.1 stipulates occupancy sensors for only a few spaces in MURBs (storage rooms, multi-purpose rooms). Assume 10% of lighting in a MURB, hence, apply a 10% x 0.30 PAF = 3% reduction for the building.
Exterior Lighting	10.0 kW (Parking, grounds and security lighting)	**6.1 kW (Parking, grounds and security lighting); 10 kW less 20%, less PAF 24%**	8.0 kW (Parking, grounds and security lighting); 10 kW less 20%	Using 90.1-2004 lighting as the baseline compliant with Standard, 2010 allows more overall exterior lighting for Zone 4 and less for Zone 3. The size of building and the mix of parking (lower allowance) and building grounds and security/entry lighting (higher allowance) areas would determine the difference. For MURBs, grounds and security 20% and parking 80%; hence, a net decrease of 20%. Parking areas require occupancy sensors for 90.1-2010 but not for the NECB. For parking garages, 9.4.1.3 stipulates that occupancy sensors shall reduce the lighting by 30% in parkade lighting zones. Assume Parking is 80%, the PAF = 0.3 x 80% = 24%.
Equipment density	0.5 W/ft²	0.5 W/ft²	0.5 W/ft²	Revised up based on load research indicators.
HVAC SYSTEM TYPE (Most applicable ASHRAE ECB System Types retained, as prescriptive compliance applies for this study)				
Air Handling	Gas-fired MAUs serving: a) Electric baseboards (cooling with PTACs for Southern Interior) b) WSHPs c) Hot water baseboards from gas-fired boiler (cooling with PTACs for Southern Interior)		Apply same as for ASHRAE, due to prescriptive nature of code comparison study	Founding LEED ECB models corresponded to the most common proposed cases which are served by: 1) distributed heat pumps or 2) baseboards or individual packaged units, if cooling is provided; both served by fossil-fired MAUs. Note that ASHRAE's ECB approach dictates the use of heat pumps where suites are heated with electric baseboards. This does not make sense and is a very significant discrepancy

MURB: Key Building Characteristics

	Note: ECB and PRM (Appendix G) for LEED rating purposes applies HVAC types that can be significantly different, depending on floor area, building type (Residential, Nonresidential) and heating source (fossil/purchased heat and electric/other). Hence, significantly different comparative results would apply.		Note: Part 8 "Energy Performance" method applies HVAC types that vary depending on building or space type, heating source and in some cases, number of floors.	when comparing the Standards on a prescriptive basis (which is the main reason for redoing the models).
Heating Source	Gas MAU: a) Electric baseboards (R01e??nB/3B) b) Heat pump (R01e??2B) c) Gas (hot water) (R01g??nB/3B)	Gas MAU: a) Electric baseboards (R01e??nA10/3A10) b) Heat pump (R01e??2A10) c) Gas (hot water) (R01g??nA10/3A10)	Apply consistent with ASHRAE... Gas MAU: a) Electric baseboards (R01e??nN11/3N11) b) Heat pump (R01e??2N11) c) Gas (hot water) (R01g??nN11/3N11)	Apply most prominent heating sources in market to capture major influences between energy providers/sources (e.g., electricity, natural gas). IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	DX, if applicable	DX, if applicable	DX, if applicable	Note that method of cooling is not as important as the relative differences in the cooling efficiencies. Note that original NRCan archetypes applied hydronic cooling for fan coil cases, which is very rare in actual market.
FAN SYSTEM				
Supply Air Temperature Control	Constant	Constant	Constant	Minimum supply air temperature control only applies to multiple zone systems.
Fan Power	**PTACs/HPs: 0.5"/25% supply, no return MAUs: 1.8"/50% supply, no return**	**PTACs/HPs: 0.5"/25% supply, no return MAUs: 1.8"/50% supply, no return**	PTACs/HPs: 0.5"/25% supply, no return MAUs: 1.8"/50% supply + 0.6 - 0.8" additional static due to heat recovery (based on 1" x application below)	Most designs have no difficulty staying under the allowed fan power limits. Hence, the founding study's MNECB default total static pressures and fan efficiencies are retained even though most designs are better than the MNECB defaults. (It is interesting to note that ASHRAE Appendix G significantly lowers the baseline fan power from what is dictated in the body of the Standard.)
Outside Air	0.1 cfm/ft²	0.1 cfm/ft²	Same as for ASHRAE cases	Assuming 1.5 bathrooms per suite, latest ASHRAE 62.1 dictates an average of 87.5 cfm/suite.

MURB: Key Building Characteristics

Heat Reclaim				Nearly all MURBs have a typical corridor pressurization configuration where 100% O/A is delivered to corridors and is conditioned to 60° or higher. Most of the building stock would meet this condition if it weren't for the exception that the largest exhaust source not exceed 75% of ventilation delivery (6.3.6.1.(h)). For NECB, *heat recovery requirements for MURBs vs "dwelling units" are not clear* ; assumed provisions of 5.2.10.4.(5) would be most applicable since suites do not have "self-contained mechanical ventilation".
South Coast	N/A	Same as 90.1-2004	**50% eff. applied to 60% of O/A (30% net)**	
Southern Interior	N/A	Same as 90.1-2004	**50% eff. applied to 70% of O/A (35% net)**	
Northern Interior	N/A	Same as 90.1-2004	**50% eff. applied to 80% of O/A (40% net)**	
HVAC				
Heating and Cooling Setpoints	Occupied: 68°/78°; Setback: 64°/78° Except hot water heating case (c) constant at 70° for heating	Occupied: 68°/78°; Setback: 64°/78° Except hot water heating case (c) constant at 70° for heating	Occupied: 68°/78°; Setback: 64°/78° Except hot water heating case (c) constant at 70° for heating	Setpoints changed from original NRCan archetypes as more recent studies show occupants maintain a lower average setpoint with individual metering and zone control, as is common with electrically heated suites. Thus, centrally metered hot water cases with higher heating setpoints.
Economizer	N/A	N/A	N/A	
Demand Controlled Ventilation	N/A	N/A	N/A	

MURB: Key Building Characteristics

HEATING				
Central Heating Efficiency	Gas furnace for MAU at 80% efficiency; If applicable, 80% efficient boiler, plus 1.5 - 2.0% pts. for reset:	Same as for ASHRAE 90.1-2004	Gas furnace for MAU at 81% efficiency; If applicable, 82.5% efficient boiler, plus 1.5 - 2.0% pts. for reset:	
South Coast	81.5%		**84.0%**	
Southern Interior	81.5%		**84.0%**	
Northern Interior	82.0%		**84.5%**	
Hot Water Flow	If applicable, variable flow down to 50% flow, riding curve	Variable flow down to 50% flow, riding curve	Consistent with ASHRAE	Variable flow pumping applied as most designs provide for "control valves designed to modulate or step open and close as a function of load" [from ASHRAE and NECB]. Note that MNECB had the same requirement, yet the Performance Path applied constant speed pumps. Default CBIP models set at 50' head.
Heat Pumps	Distributed heat pumps at 4.2 COP	Distributed heat pumps at 4.2 COP	Distributed heat pumps at 4.2 COP	Heating efficiency is linked with the cooling efficiency and close to 1.2x for water-source.
COOLING				
Terminal Heat Pumps & Air Conditioners	12.0 EER for distributed HP system 11.0 EER for PTACs	12 EER for distributed HP system **11.5 EER for PTACs (after 10/8/2012)**	12 EER for distributed HP system 11.0 EER for PTACs (same as 90.1-2010's req'ts prior to 10/8/2012)	For ASHRAE 90.1 from founding LEED studies, the highest rating that applies to applicable units, was applied to be conservative in the comparison to the MNECB. For consistency, we applied the ratings for ASHRAE 90.1-2010 and the NECB that mostly closely aligned with the same categories.
Cooling Tower	Two cell cooling tower with 85°F - 95°F temperature rise, apply two speed fan as most HP cases will be >=38.2 gpm/hp. Pumping power as per original archetype (DOE2 TWR-EIR =	Two cell cooling tower with 85°F - 95°F temperature rise, apply two speed fan as most HP cases will be >=38.2 gpm/hp. Pumping power as per original archetype (DOE2 TWR-EIR =	Two cell cooling tower with 85°F - 95°F temperature rise, apply two speed fan as most HP cases will be >=38.2 gpm/hp. Pumping power as per original archetype (DOE2 TWR-EIR = 0.0133)	Maintain consistent conditions, although they may vary for Performance (Modelling) Path.

MURB: Key Building Characteristics

DOMESTIC HOT WATER (DHW)				
Heating Efficiency	80%	80%	80%	No losses in CBIP prototype models, as is consistent with EE4. Assume typical tank heaters.
Avg. Load (Btu/sf/day)	24.1	24.1	24.1	NECB dictates measures for limiting water use at fixtures, but measures are standard practice and

Extended Care Facility: Key Building Characteristics

The extended care archetype from NRCan represents a 50,000 ft² (4,650 m²), two storey building. The building has a wall-to-roof area ratio of 1.0. The functional zones include patient rooms, corridors, administration offices, multi-purpose rooms, kitchen, and laundry.

The following listing provides the key building characteristics which differ between the ASHRAE 90.1-2004, ASHRAE 90.1-2010 and the NECB 2011 code-compliant models. In many cases information for certain characteristics are the same between the models, but we provide information since it is unique to the building type and/or of significance to the energy performance.

NOTE: The original archetypes were formulated for the purposes of determining the equivalency between the MNECB 97's and ASHRAE 90.1-1999's performance path approaches, modified for use with LEED EAp2 and EAc1, and not a comparison based on the prescriptive application of the Code. Thus, certain characteristics are indicative of what ASHRAE 90.1 would dictate for its ECB case, which is not necessarily fully representative for the market -- particularly for the HVAC system(s). For this building type, most extended care would not have PTACs and PTHPs serving rooms but employ larger central AHUs instead.

Item	ASHRAE 90.1-2004					ASHRAE 90.1-2010					NECB 2011	Discussion/Issues
EXTERIOR SURFACES												
Wall Overall R-Value	Mass	Metal	Steel	Other	R_o	Mass	Metal	Steel	Other	R_o	No variation by construction or function	Allocation of construction types is based on professional judgement and is not statistically proven nor supported by market research. We have observed several designs with steel studs, but also with brick vaneer, which would qualify as "mass" type instead of "steel" according to ASHRAE definitions on thermal capacitance.
South Coast	Climate Zone 5					Climate Zone 5					Climate Zone 4	
	40%	0%	40%	20%	11.9	40%	0%	40%	20%	14.6	18.0	
	9.91	14	14.1	11.2		11.9	16.3	15.6	18			
Southern Interior	Climate Zone 5					Climate Zone 5					Climate Zone 5	
	40%	0%	40%	20%	11.9	40%	0%	40%	20%	14.6	20.6	
	9.91	14	14.1	11.2		11.9	16.3	15.6	18			
Northern Interior	Climate Zone 5					Climate Zone 7					Zone 7A (60%) & 7B (40%)	
	40%	0%	40%	20%	14.3	40%	0%	40%	20%	17.4	7A: 27.0 7B: 27.0 27.0	
	11.9	17.5	15.6	16.3		13.1	17.5	20.5	19.6			
Roof Overall R-Value	Insulation above Deck					Insulation above Deck					No variation by construction	For this building type, indications were that roof types are divided between flat and attic type roofs, particularly in the colder climates. This is based on professional experience in the commercial sector, including surveys performed for NRCan in developing the extended care archetypes. Note that for ASHRAE, Nonresidential and Residential classifications reference the same prescriptive values.
South Coast	15.9					20.8					25.0	
Southern Interior	15.9					20.8					31.0	
Northern Interior	15.9					20.8					7A: 35.0 7B: 35.0 35.0	

Extended Care Facility: Key Building Characteristics

Slab-on-Grade Floor R-Value	South Coast and Southern Interior: n.r. Northern Int.: R-10 x 50%			South Coast / Southern Interior: R-10 x 50% **Northern Interior: R-15**					**R-7.5**				Slab-on-grade floor R-values for ASHRAE vary for Nonresidential and Residential functions; assume 50:50 division of space functions on ground floor.
GLAZING													
Glazing Percent	24%			24%					24%				Average specified in NRCan archetypes and appears reasonable based on our experience.
Window U-value	Oper-able	Fixed	U_o	Non-metal	c.w./ store	Metal door	Other metal	U_o	No variation by window type				Operable windows are more prevalent in extended care since many are not cooled, but is still relatively low overall due to large sections which are not operable. 90.1-2010 window types are estimated to be similar to low-rise MURBs, except likely with a bit more metal framed windows. Factors are based on professional judgement. Input is corrected for DOE2's adjustment for air films to produce the specified overall U-value.
South Coast	25% 0.67	75% 0.57	0.60	70% 0.35	0% 0.45	5% 0.80	25% 0.55	**0.42**	**0.42**				
Southern Interior	25% 0.67	75% 0.57	0.60	70% 0.35	0% 0.45	5% 0.80	25% 0.55	0.42	**0.39**				
Northern Interior	25% 0.67	75% 0.57	0.60	70% 0.35	0% 0.40	5% 0.80	25% 0.45	0.40	7A 0.39	7B 0.39	**0.39**		

Extended Care Facility: Key Building Characteristics

Window Shading Coefficient				ASHRAE no longer provides a differentiation for North-facing windows from all other windows. NECB has no requirements on the SC, so we have set it same as for ASHRAE 90.1-2010 to neutralize the effect; also, the NECB U-value infers low-e which ASHRAE's SC levels correspond to.
South Coast	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)	No requirements (set same as for 90.1-2010)	
Southern Interior	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)		
Northern Interior	0.57 (all orientations) / 0.74 (North)	0.52 for Nonresidential Not required for Res.		
SPACE				
Schedules	MNECB Schedules A, B, C, G & H	MNECB Schedules A, B, C, G & H	MNECB Schedules A, B, C, G & H	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines, based on major space functions.
Interior Lighting	0.90 W/ft² (0.95 W/ft², less 5% PAF)	**0.71 W/ft² (0.95 W/ft², less 20%, less 6% PAF)**	**0.71 W/ft² (0.95 W/ft², less 20%, less 6% PAF)**	The MNECB and ASHRAE Lighting loads are based on Space Function for a typical Extended Care home from the NRCan Health Care Study. The Space-by-Space method indicates a net decrease in lighting power allowance of approximately 20%. ASHRAE 9.4.1.2 stipulates occupancy sensors for most lounge/recreation, storage, offices, washrooms, meeting rooms and break/lunch rooms. Assume 20% of lighting for these spaces; hence, apply a 20% x 0.30 PAF = 6% reduction.
Exterior Lighting	4.0 kW (Parking, grounds and security lighting)	**3.2 kW (Parking, grounds and security lighting), 4.0 kW less 20%**	**3.2 kW (Parking, grounds and security lighting), 4.0 kW less 20%**	Using 90.1-2004 lighting as the baseline compliant with Standard, 2010 allows more overall exterior lighting for Zone 4 and less for Zone 3. The size of building and the mix of parking (lower allowance) and building grounds and security/entry lighting (higher allowance) areas would determine the difference. For MURBS, grounds and security 50% and parking 50%, hense a net decrease of 20%. Assume parking is above ground, no occupancy sensor control required.
Equipment density	0.2 W/ft²	0.2 W/ft²	0.2 W/ft²	
HVAC SYSTEM TYPE (Most applicable ASHRAE ECB System Types retained, as prescriptive compliance applies for this study)				

Extended Care Facility: Key Building Characteristics

Air Handling	a) Suites with PTACs (System 10), common with VAV reheat (System 4) b) Suites with PTHP (System 8), common with VAV and parallel fan-powered boxes (System 3)	a) Suites with PTACs (System 10), common with VAV reheat (System 4) b) Suites with PTHP (System 8), common with VAV and parallel fan-powered boxes (System 3)	Apply same as for ASHRAE, due to nature of code comparison study	Founding ECB baseline models correspond to the most common proposed cases. Two primary system types exist, serving 1) suites and 2) for the common spaces. PTACs refer to packaged terminal air conditioners and PTHPs refer to packaged terminal heat pumps. Single zone systems serving kitchen and laundry also are provided with packaged AC and HP units. System ID indicated for ASHRAE refers to system type identified in Table 11.4.3A.
	Note: PRM (Appendix G) for LEED rating purposes applies HVAC types that can be significantly different, depending on floor area, building type (Residential, Nonresidential) and heating source (fossil/purchased heat and electric/other).		Note: Part 8 "Energy Performance" method applies HVAC types that vary depending on building or space type, heating source and in some cases, number of floors.	
Heating Source	a) Gas for Systems 4 & 10 (H01g??rB) b) Electric for Systems 8 & 3 (H01e??rB)	a) Gas for Systems 4 & 10 (H01g??rA10) b) Electric for Systems 8 & 3 (H01e??rA10)	Apply same as for ASHRAE, due to nature of code comparison study a) H01g??rN11 b) H01e??rN11	Apply most prominent heating sources in market to capture major influences between energy providers/sources (e.g., electricity, natural gas). IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	No Chillers DX Only	No Chillers DX Only	No Chillers DX Only	Note that method of cooling is not as important as the relative differences in the cooling efficiencies. Only Okanagan region has mechanical cooling in suites.
FAN SYSTEM				
Supply Air Temperature Control	Minimum based on warmest zone for mixed air systems	Minimum based on warmest zone for VAV systems	Minimum based on warmest zone for VAV systems	Minimum supply air temperature control applies to multiple zone systems with simultaneous heating and cooling.
Fan Power	**Suites: 0.5"/25% supply, no return; Common: 3.0"/55% supply, 0.6"/30% return**	Suites: 0.5"/25% supply, no return; Common: 3.0"/45% supply, 0.6"/25% return + 0.5 - 1.0" additional static due to heat recovery (based on 1" x application below)	Suites: 0.5"/25% supply, no return; Common: 3.0"/45% supply, 0.6"/25% return + 0.5 - 1.0" additional static due to heat recovery (based on 1" x application below)	Most designs have no difficulty staying under the allowed fan power limits. Hence, the founding study's MNECB default total static pressures are retained with corresponding minimum fan efficiencies we typically see. (It is interesting to note that ASHRAE Appendix G significantly lowers the baseline fan power from what is dictated in the body of the Standard.)
Outside Air	0.32 cfm/ft²	0.32 cfm/ft²	0.32 cfm/ft²	

Extended Care Facility: Key Building Characteristics

Fan Curve (VAV only)	MNECB "top-level" fan curve (Type c) as approximation for 15 hp restriction	**VSD (more common and slightly better fan curve to reflect difference in lower 10 hp restruction vs 90.1-2004**	MNECB "mid-level" fan curve (Type b) (estimate for average equipment below 25 kW)	The NECB references the same fan curves as applied to the MNECB for ecoEnergy, but is effectively consistent with ASHRAE for systems over 25 kW (~33 hp). ASHRAE is more stringent for systems over 10 hp, with the requirement of MNECB's "top level" fan curve or VSDs.
Heat Reclaim		**Enthalpy Recovery**	Sensible Recovery	Most typical systems provide for 30-40% O/A, due to CSA requirements of 2 ACH O/A and 6 ACH S/A. Note that the founding study assumed MAUs might apply for a large portion of the O/A but that has been revised to more standard CSA conditions here. Kitchen system is not applicable for heat recovery. Note that NECB 2011 dictates heat recovery at the following system exhaust rates: Vancouver at 8900 cfm, Kelowna at 6600 cfm, Prince George at 4700 cfm. Also, archetype includes humidification, which means enthalpy versus sensible heat recovery has a more significant impact.
South Coast	N/A as O/A levels are below 70%	N/A since not required until O/A > 50%	**50% eff. applied to half of O/A (25% net)**	
Southern Interior		Half way between adj. regions (25% net)	**Half way between adj. regions (35% net)**	
Northern Interior		**50% effectiveness applied to all O/A**	50% effectiveness applied to all O/A	
HVAC				
Heating and Cooling Setpoints	Occupied: Common with 72°/77°, setback to 65°/85°; 74° minimum at all times in a quarter of suites	Occupied: Common with 72°/77°, setback to 65°/85°; 74° minimum at all times in a quarter of suites	Occupied: Common with 72°/77°, setback to 65°/85°; 74° minimum at all times in a quarter of suites	
Economizer	Temperature for VAV and PSZ	Temperature for VAV and PSZ	Temperature for VAV and PSZ	
Demand Controlled Ventilation	N/A	N/A	N/A	Requirements of 6.2.3.8 would not apply in most cases; dining and large multipurpose rooms are closest but CSA requirements would effectively negate DCV requirement.
HEATING				
Central Heating Efficiency	Two 80% efficient boilers, plus 1.5% - 2.0% pts. for reset:	Same as for ASHRAE 90.1-2004	Two 82.5% efficient boilers, plus 1.5% - 2.0% pts. for reset:	Some new designs may use furnaces instead of boilers, but there exists no significant difference in heating efficiency between the Codes or between the heating equipment. Hence, we stayed with the CBIP Reference model default. Further, this should be more conservative because of the improved part-load
South Coast	81.5%		**84.0%**	

Extended Care Facility: Key Building Characteristics

Southern Interior	81.5%	90.1-2004	**84.0%**	performance of the ASHRAE Reference with the use of two boilers and hot water reset.
Northern Interior	82.0%		**84.5%**	
Hot Water Flow	Variable flow down to 50% flow, riding curve	Variable flow down to 50% flow, riding curve	Consistent with ASHRAE	Variable flow pumping applied as most designs provide for "control valves designed to modulate or step open and close as a function of load" [from ASHRAE and NECB]. Note that MNECB had the same requirement, yet the Performance Path applied constant speed pumps. Default CBIP models set at 50' head.
Heat Pumps	PTHPs at 3.0 COP	**PTHPs at 3.3 COP (after 10/8/2012)**	PTHPs at 3.0 COP (same as 90.1-2010's req'ts prior to 10/8/2012)	Heating efficiency is linked with the cooling efficiency and is as high as 1.1 times higher in heating mode than in cooling mode for air-source heat pumps and close to 1.2x for water-source.

Extended Care Facility: Key Building Characteristics

COOLING				
Central Cooling Efficiency	Common with DX at 9.9 SEER (avg of A/C, air cooled <65 MBH).	Common with DX at 13.0 SEER (avg of A/C, air cooled <65 MBH).	**Common with DX at 14.5 SEER (avg of split and packaged A/C, <19 kW).**	Consistent with founding studies, referenced air conditioners that would be typical of small rooftop equipment.
Terminal Heat Pumps & Air Conditioners	a) 11.0 EER for PTACs b) 10.8 EER for PTHPs	**a) 11.5 EER for PTACs (after 10/8/2012)** **b) 11.7 EER for PTHPs (after 10/8/2012)**	a) 11.0 EER for PTACs b) 10.8 EER for PTHPs (same as 90.1-2010's req'ts prior to 10/8/2012)	For ASHRAE 90.1 from founding LEED studies, the highest rating that applies to applicable units, was applied to be conservative in the comparison to the MNECB. For consistency, we applied the ratings for ASHRAE 90.1-2010 and the NECB that mostly closely aligned with the same categories.
DOMESTIC HOT WATER (DHW)				
Heating Efficiency	80%	80%	**82.5%**	No losses in CBIP prototype models (included in schedule), as is consistent with EE4 (embodied in schedule). Assume DHW provided from boiler plant.
Avg. Load (Btu/sf/day)	28.3	28.3	28.3	NECB dictates measures for limiting water use at fixtures, but measures are standard practice and hence, equivalently applied with ASHRAE since it is silent on such stipulations.

Motel/Hotel: Key Building Characteristics

The original hotel archetype from NRCan represented a 123,500 ft² (11,500 m²), nine storey building but was found to be too deficient and non-representative of typical hotel/motel use. Hence, we utilized more robust template that we developed from BC Hydro load research studies on actual hotel and motel usage patterns and configurations. The general envelope characteristics of the NRCan archetype were maintained, with the same floor area, but wall-to-roof area ratio at a more average 1.2 wall-to-roof area ratio to blend in the many motels in the sector.

The following listing provides the key building characteristics which differ between the ASHRAE 90.1-2004, ASHRAE 90.1-2010 and the NECB 2011 code-compliant models. In many cases information for certain characteristics are the same between the models, but we provide information since it is unique to the building type and/or of significance to the energy performance.

NOTE: The original archetypes were formulated for the purposes of determining the equivalency between the MNECB 97's and ASHRAE 90.1-1999's performance path approaches, modified for use with LEED EAp2 and EAc1, and not a comparison based on the prescriptive application of the Code. Thus, certain characteristics are indicative of what ASHRAE 90.1 would dictate for its ECB case, which is not necessarily fully representative for the market -- particularly for the HVAC system(s). For this building type, the ECB-based HVAC systems are fairly representative of the actual market, but dictated some changes to reflect reality.

Item	ASHRAE 90.1-2004					ASHRAE 90.1-2010					NECB 2011			Discussion/Issues
EXTERIOR SURFACES														
Wall Overall R-Value	Mass	Metal	Steel	Other	R_o	Mass	Metal	Steel	Other	R_o	No variation by construction or function			Allocation of construction types is based on professional judgement and is not statistically proven nor supported by market research.
South Coast	Climate Zone 5					Climate Zone 5					Climate Zone 4			
	30%	0%	60%	10%	13.0	30%	0%	60%	10%	14.9	**18.0**			
	10.4	15.3	14.7	11.2		12.2	16.7	15.6	18.6					
Southern Interior	Climate Zone 5					Climate Zone 5					Climate Zone 5			
	45%	0%	45%	10%	12.4	45%	0%	45%	10%	14.4	**20.6**			
	10.4	15.3	14.7	11.2		12.2	16.7	15.6	18.6					
Northern Interior	Climate Zone 5					Climate Zone 7					Zone 7A (60%) & 7B (40%)			
	45%	0%	45%	10%	14.2	45%	0%	45%	10%	17.6	7A	7B	**27.0**	
	12.2	17.5	15.6	17.5		12.9	17.5	21.8	19.6		27.0	27.0		
Roof Overall R-Value	Insulation Entirely above Deck					Insulation Entirely above Deck					No variation by construction			For this building type, all roof types as flat roofs with continuous insulation. In some cases, steel joist with metal decking and built-up roofing and others are wood joists with plywood and build-up roofing. This is based on professional judgement.
South Coast	15.9					20.8					**25.0**			
Southern Interior	15.9					20.8					**31.0**			
Northern	15.9					20.8					7A	7B	**35.0**	

Motel/Hotel: Key Building Characteristics

Interior	15.9	20.8	35.0	35.0	35.0	
Slab-on-Grade Floor R-Value	Not required (n.r.)	South Coast and Southern Interior: n.r. **Northern Interior: R-15**	**R-7.5**			Exposed floors were provided for in NRCan archetypes only (no exposed floors).
GLAZING						
Glazing Percent	35%	35%	35%			From BC Hydro data on existing hotels/motels, the average percent window area was ~24% whereas the NRCan templates were set at 40%. Most larger new buildings have a high percent of glazing (i.e., over 60%), but smaller ones are still relatively low. We estimated between BC Hydro's survey information and NRCan's designated value.

Window U-value	Oper-able	Fixed	U_o	Non-metal	c.w./ store	Metal door	Other metal	U_o	No variation by window type			Comments
South Coast	25%	75%	0.60	0%	20%	5%	75%	0.54	**0.42**			Operable windows are common in low rise hotels/motels and some high rise hotels. Metal frame windows still dominate (due to durability). Factors are based on professional judgement. Input is corrected for DOE2's adjustment for air films to produce the specified overall U-value.
	0.67	0.57		0.35	0.45	0.80	0.55					
Southern Interior	25%	75%	0.60	0%	10%	5%	85%	0.55	**0.39**			
	0.67	0.57		0.35	0.45	0.80	0.55					
Northern Interior	25%	75%	0.60	0%	10%	5%	85%	0.46	7A	7B	**0.39**	
	0.67	0.57		0.35	0.40	0.80	0.45		0.39	0.39		

Motel/Hotel: Key Building Characteristics

Window Shading Coefficient				ASHRAE differentiates between North-facing windows separately from all other windows.
South Coast	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)	No requirements (set same as for 90.1-2010)	
Southern Interior	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)		
Northern Interior	0.57 (all orientations) / 0.74 (North)	0.52 for Nonresidential Not required for Res.		
SPACE				
Schedules	Schedules dervied from load research studies	Schedules dervied from load research studies	Schedules dervied from load research studies	
Interior Lighting	0.97 W/ft² (1.0 W/ft², less 3% PAF)	**0.86 W/ft² (1.0 W/ft², less 10%, less 4.5% PAF)**	**0.86 W/ft² (1.0 W/ft², less 10%, less 4.5% PAF)**	The Building Area Method shows no change in hotels and a 12% reduction in motels. Assume a mix of 50% hotels/motels - a 10% reduction. 9.4.1.1 stipulates occupancy sensors for some spaces in a hotel/motel (meeting rooms, storage rooms, offices, public washrooms). Assume 15% of lighting in a typical hotel/motel, hence, apply a 15% x 0.30 PAF = 4.5% reduction.
Exterior Lighting	10.0 kW (Parking, grounds and security lighting)	**7.1 kW (Parking, grounds and security lighting), 10.0 kW less 20%, less 11.25% PAF.**	8.0 kW (Parking, grounds and security lighting), 10.0 kW less 20%.	Using 90.1-2004 lighting as the baseline compliant with Standard, 2010 allows more overall exterior lighting for Zone 4 and less for Zone 3. The size of building and the mix of parking (lower allowance) and building grounds and security/entry lighting (higher allowance) areas would determine the difference. For Hotel/Motel assume a decrease of ~20%. Parking areas require occupancy sensors for 90.1-2010 but not for the NECB. For parking garages 9.4.1.3 stipulates that occupancy sensors shall reduce the lighting by 30% in parkade lighting zones. Assume Parking is above ground for motels and 75% of Hotel exterior lighting. The PAF = 0.3*75% = 22.5% for hotels. 50% hotels -> PAF = 11.25%.
Equipment density	0.35 W/ft²	0.35 W/ft²	0.35 W/ft²	Plug load increased from NRCan MNECB archetype default of 0.23 based on load research studies of actual facilities.
HVAC SYSTEM TYPE (Most applicable ASHRAE ECB System Types retained, as prescriptive compliance applies for this study)				

Motel/Hotel: Key Building Characteristics

Air Handling	a) FPFC with MAUs for suites, VAV for non-suites b) WSHP with MAUs c) PTHP serving suites, PSZ with heat pump and electric backup for non-suite area	a) FPFC with MAUs for suites, VAV for non-suites b) WSHP with MAUs c) PTHP serving suites, PSZ with heat pump and electric backup for non-suite area	Apply same as for ASHRAE, due to nature of code comparison study	Founding ECB baseline models corresponded to the most common proposed cases which are served by: 1) fan coils or distributed heat pumps, fed by a fossil-fired heating source, or 2) individual packaged units, which would be most prevalent in cases where electric heat is used. Note that cases where packaged units are served by a fossil-fired source are effectively represented with the fan coil case.
	Note: PRM (Appendix G) for LEED rating purposes applies HVAC types that can be significantly different, depending on floor area, building type (Residential, Nonresidential) and heating source (fossil/purchased heat and electric/other).		Note: Part 8 "Energy Performance" method applies HVAC types that vary depending on building or space type, heating source and in some cases, number of floors.	
Heating Source	a) Gas (CMTg??1B) b) Gas boiler & terminal heat pumps (CMTg??2B) c) Heat pumps with electric resistance (CMTa??5B)	a) Gas (CMTg??1A10) b) Gas boiler & terminal heat pumps (CMTg??2A10) c) Heat pumps with electric resistance (CMTa??5A10)	Apply same as for ASHRAE, due to nature of code comparison study a) CMTg??1N11 b) CMTg??2N11 c) CMTa??5N11	Apply most prominent heating sources in market to capture major influences between energy providers/sources (e.g., electricity, natural gas). IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	a) Hydronic (chiller) b) and c) DX	a) Hydronic (chiller) b) and c) DX	Apply same as for ASHRAE, due to nature of code comparison study	Note that method of cooling is not as important as the relative differences in the cooling efficiencies.
FAN SYSTEM				
Supply Air Temperature Control	Minimum based on warmest zone for VAV systems	Minimum based on warmest zone for VAV systems	Minimum based on warmest zone for VAV systems	Minimum supply air temperature control applies to multiple zone systems with simultaneous heating and cooling.

Motel/Hotel: Key Building Characteristics

Fan Power	Suites: 0.5"/30% supply, no return with MAU serving suites at 1.8"/50% supply and 0.5"/30% return/exhaust. Non-suites: Avg of 3.2" supply at 50% efficiency, 0.6" return at 35% efficiency (incl. allowance for heat recovery)	Same as ASHRAE 90.1-2004, plus the following for heat recovery: Southern Int: +0.2" Northern Int: +0.4"	**Same as ASHRAE 90.1-2004, with the following adjustments for heat recovery: South Coast: -0.36" Southern Int: -0.36" Northern Int: -0.36"**	Most designs have no difficulty staying under the allowed fan power limits. Hence, the founding study's MNECB default total static pressures with estimated allowances for heat recovery are effectively retained, but fan efficiencies are more reflective of what we typically see for new designs. (It is interesting to note that ASHRAE Appendix G significantly lowers the baseline fan power from what is dictated in the body of the Standard.)
Outside Air	0.15 cfm/ft²	0.15 cfm/ft²	0.15 cfm/ft²	
Fan Curve (VAV only)	MNECB "middle-level" fan curve (Type b) for banquet/restaurant; MNECB "low-level" curve (Type a) for other VAV systems	Same as 90.1-2004	Same as for ASHRAE cases	Fan sizes for applicable VAV systems in NRCan templates are under 10 HP, which would be typical for all but the largest hotels with significant convention/meeting space.
Heat Reclaim				From the founding study, the segment-wide heat reclaim average effectiveness was reduced by 60% as an approximation for the penetration of 100% O/A MAUs >5,000 cfm. As the thresholds are lowered for 90.1-2010, the penetration would increase, with an assumed 80% maximum potential applicability based on systems with >30% O/A and large enough flows. As NECB is based on system exhaust (not including Kitchen), this primarily applies to MAU serving rooms as other systems typically would be too small. Original NRCan archetype provides for a 5700 cfm MAU (~5100 est. exhaust), but actual market would see a wide range of sizes.
South Coast	50% effectiveness applied to 40% of outdoor air (20% net)	**Same as 90.1-2004, with nearly equivalent requirements**	Applied to MAUs >~9900 cfm; est. at 4% of O/A (2% net eff.)	
Southern Interior		**Roughly half of region more stringent; apply to 60% of O/A (30% net)**	Applied to MAUs >~7300 cfm; est. at 4% of O/A (2% net eff.)	
Northern Interior		**Apply to 80% of O/A (40% net effectiveness)**	Applied to MAUs >~5200 cfm; est. at 4% of O/A (2% net eff.)	
HVAC				
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	

Motel/Hotel: Key Building Characteristics

Economizer	Temperature, except for small suite units	Temperature, except for small suite units **Water-side economizer for Fan Coil**	Temperature, except for small suite units **Water-side economizer for Fan Coil**	Apply air-side over water-side economizer if applicable, which would not apply to small PTHPs serving suites. Note that water-side economizer would have applied to many cases under ASHRAE 90.1-2004 as well and likely was an oversight; but as cooling is such a minor end-use, the comparison is not significantly compromised.
Demand Controlled Ventilation	**Factors from Screening Tool applied for control of 10% of O/A**	**Same as for ASHRAE 90.1-2004**	N/A	Applicable to mainly larger conference rooms, estimated to account for roughly 10% of supply air. Approximate based on impacts indicated by Web Screening Tool
HEATING				
Central Heating Efficiency	Two 80% efficient boilers, plus 1.5% - 2.0% pts. for reset:	Same as for ASHRAE 90.1-2004	Two 82.5% efficient boilers, plus 1.5% - 2.0% pts. for reset:	
South Coast	81.5%		**84.0%**	
Southern Interior	81.5%		**84.0%**	
Northern Interior	82.0%		**84.5%**	
Hot Water Temperature	VSD	VSD	Consistent with ASHRAE	As is now common, VSDs applied to satisfy variable flow pumping reqirement from "control valves designed to modulate or step open and close as a function of load" [from ASHRAE and NECB]. Note that MNECB had the same requirement, yet the Performance Path applied constant speed pumps. Default CBIP models set at 50' head.
Heat Pumps	Distributed heat pumps at 4.2 COP; Rooftop heat pumps at 3.2 COP; PTHPs at 3.0 COP	Distributed heat pumps at 4.2 COP; R**ooftop heat pumps at 3.3 COP**; **PTHPs at 3.3 COP (after 10/8/2012)**	Distributed heat pumps at 4.2 COP; **Rooftop heat pumps at 3.3 COP**; PTHPs at 3.0 COP (same as 90.1-2010's req'ts prior to	Heating efficiency is linked with the cooling efficiency.

Motel/Hotel: Key Building Characteristics

COOLING				
Central Cooling Efficiency	a) One screw chiller with increasing efficiency for larger units (i.e., depending on region); effectively increase COP by 8% - 21% for reset c) Common areas with DX at 9.9 SEER (avg of A/C, air cooled <65 MBH).	a) One screw chiller with increasing efficiency for larger units (i.e., depending on region); effectively increase COP by 8% - 21% for reset c) Common areas at 13.0 SEER (avg of A/C, air cooled <65 MBH).	a) One screw chiller with increasing efficiency for larger units (i.e., depending on region); effectively increase COP by 8% - 21% for reset c) Common areas at 14.5 SEER (avg of split and packaged A/C, <19 kW).	Equivalent efficiency improvement for reset derived from applicable DOE2.1e runs. Refer to founding LEED-BC Equivalency report for more discussion on the identification of cooling equipment for the prototype models. For ASHRAE 90.1-2010, Path A kW/ton referenced from Table 6.8.1C. For NECB, Draft document references CAN/CSA document that is not readily available; however, OEE references infer that efficiency levels are consistent with ASHRAE 90.1. See following discussion on Terminal cooling equipment for specification of suite DX efficiencies.
South Coast	a) 1 screw chiller at COP of 4.5 + 0.4 = 4.9	a) 1 screw chiller at COP of 4.5 + 0.4 = 4.9	a) 1 screw chiller at COP of 4.5 + 0.4 = 4.9	
Southern Interior	a) 1 screw chiller at COP of 4.9 + 1.0 = 5.9	**a) 1 screw chiller at COP of 5.2 + 1.0 = 6.2**	**a) 1 screw chiller at COP of 5.2 + 1.0 = 6.2**	
Northern Interior	a) 1 screw chiller at COP of 4.5 + 0.3 = 4.8	a) 1 screw chiller at COP of 4.5 + 0.3 = 4.8	a) 1 screw chiller at COP of 4.5 + 0.3 = 4.8	
Terminal Heat Pumps & Air Conditioners	b) 12.0 EER for distributed HP system c) 10.1 EER for Rooftop units; 10.8 EER for PTHPs	b) 12 EER for distributed HP system c) **11.0 EER for Rooftop units; 11.7 EER for PTHPs (after 10/8/2012)**	b) 12 EER for distributed HP system c) 9.7 EER for Rooftop units; 10.8 EER fpr PTHPs (same as 90.1-2010's req'ts prior to 10/8/2012)	For ASHRAE 90.1 from founding LEED studies, the highest rating that applies to applicable units, was applied to be conservative in the comparison to the MNECB. For consistency, we applied the ratings for ASHRAE 90.1-2010 and the NECB that mostly closely aligned with the same categories.
Chilled Water Temperature	12°F rise; 44°F supply	12°F rise; 44°F supply	12°F rise; 44°F supply	Maintain consistent conditions, although they may vary for Performance (Modelling) Path.
Chilled Water Flow	Variable flow down to 50% flow, riding curve	Variable flow down to 50% flow, VSD	Consistent with ASHRAE 90.1-2010	ASHRAE 90.1-2010 doesn't explicitly reference VSDs, but with the decrease to variable flow for 5HP systems (vs 50HP before), apply VSDs as they are common in practice.

Motel/Hotel: Key Building Characteristics

Cooling Tower	Two cell cooling tower with 85°F - 95°F temperature rise, and a two speed fan at >=38.2 gpm/hp. Pumping power as per MNECB/CBIP (DOE2 TWR-EIR = 0.0133)	Two cell cooling tower with 85°F - 95°F temperature rise, and a two speed fan at >=38.2 gpm/hp. Pumping power as per MNECB/CBIP (DOE2 TWR-EIR = 0.0133)	Two cell cooling tower with 85°F - 95°F temperature rise, and a two speed fan at >=38.2 gpm/hp. Pumping power as per MNECB/CBIP (DOE2 TWR-EIR = 0.0133)	Maintain consistent conditions, although they may vary for Performance (Modelling) Path.
DOMESTIC HOT WATER (DHW)				
Heating Efficiency	80%	80%	**82.5%**	Losses separately represented. Assume DHW provided from boiler plant.
Avg. Load (Btu/sf/day)	55.02	55.02	55.02	NECB dictates measures for limiting water use at fixtures, but measures are standard practice and hence, equivalently applied with ASHRAE since it is silent on such stipulations.

Strip Mall: Key Building Characteristics

The strip mall archetype from NRCan represents a 15,600 ft² (1,500 m²), single storey building. The building has a wall-to-roof area ratio of 0.6. The functional zones include retail stores and adjacent storage areas.

The following listing provides the key building characteristics which differ between the ASHRAE 90.1-2004, ASHRAE 90.1-2010 and the NECB 2011 code-compliant models. In many cases information for certain characteristics are the same between the models, but we provide information since it is unique to the building type and/or of significance to the energy performance.

NOTE: The original archetypes were formulated for the purposes of determining the equivalency between the MNECB 97's and ASHRAE 90.1-1999's performance path approaches, modified for use with LEED EAp2 and EAc1, and not a comparison based on the prescriptive application of the Code. Thus, certain characteristics are indicative of what ASHRAE 90.1 would dictate for its ECB case, which is not necessarily fully representative for the market -- particularly for the HVAC system(s). For this building type, the ECB-based HVAC systems would be fairly representative of the actual market.

Item	ASHRAE 90.1-2004					ASHRAE 90.1-2010					NECB 2011			Discussion/Issues
EXTERIOR SURFACES														
Wall Overall R-Value	Mass	Metal	Steel	Other	R_o	Mass	Metal	Steel	Other	R_o	No variation by construction			Allocation of construction types is based solely on professional judgement.
South Coast	Climate Zone 5					Climate Zone 5					Climate Zone 4			
	50%	0%	30%	20%	9.9	50%	0%	30%	20%	13.4	18.0			
	8.13	8.85	11.9	11.2		11.1	14.5	15.6	15.6					
Southern Interior	Climate Zone 5					Climate Zone 5					Climate Zone 5			
	50%	0%	30%	20%	9.9	50%	0%	30%	20%	13.4	20.6			
	8.13	8.85	11.9	11.2		11.1	14.5	15.6	15.6					
Northern Interior	Climate Zone 5					Climate Zone 7					Zone 7A (60%) & 7B (40%)			
	50%	0%	30%	20%	12.5	50%	0%	30%	20%	15.7	7A	7B	27.0	
	11.1	17.5	15.6	11.2		14.1	17.5	15.6	19.6		27.0	27.0		
Roof Overall R-Value	Insulation Entirely above Deck					Insulation Entirely above Deck					No variation by construction			For this building type, all roof types as flat roofs with continuous insulation. In some cases, steel joist with metal decking and built-up roofing and others are wood joists with plywood and build-up roofing. This is based on professional judgement.
South Coast	15.9					20.8					25.0			
Southern Interior	15.9					20.8					31.0			
Northern Interior	15.9					20.8					7A	7B	35.0	
											35.0	35.0		

Strip Mall: Key Building Characteristics

Slab-on-Grade Floor R-Value	Not required (n.r.)	South Coast and Southern Interior: n.r. **Northern Interior: R-15**	**R-7.5**	Exposed floors were provided for in NRCan archetypes only (no exposed floors).
GLAZING				
Glazing Percent	15%	15%	15%	Average specified in NRCan archetypes was 10%, which was same as for big box retail. While the amount of overall glass appears reasonable, we increased the level slightly since strip malls tend to have a bit more glazing than big box retail.

<table>
<tr><td rowspan="1">Window U-value</td><td>Oper-able</td><td>Fixed</td><td>Uo</td><td>Non-metal</td><td>c.w./ store</td><td>Metal door</td><td>Other metal</td><td>Uo</td><td colspan="3">No variation by window type</td><td rowspan="7">Operable windows are becoming more prevalent in new construction, but we have observed little if any change in this aspect with the retail segment. Factors are based on professional experience in the commercial sector.
Input is corrected for DOE2's adjustment for air films to produce the specified overall U-value.</td></tr>
<tr><td rowspan="2">South Coast</td><td>10%</td><td>90%</td><td rowspan="2">0.58</td><td>0%</td><td>90%</td><td>10%</td><td>0%</td><td rowspan="2">0.49</td><td colspan="3" rowspan="2">0.42</td></tr>
<tr><td>0.67</td><td>0.57</td><td>0.35</td><td>0.45</td><td>0.80</td><td>0.55</td></tr>
<tr><td rowspan="2">Southern Interior</td><td>10%</td><td>90%</td><td rowspan="2">0.58</td><td>0%</td><td>90%</td><td>10%</td><td>0%</td><td rowspan="2">0.49</td><td colspan="3" rowspan="2">0.39</td></tr>
<tr><td>0.67</td><td>0.57</td><td>0.35</td><td>0.45</td><td>0.80</td><td>0.55</td></tr>
<tr><td rowspan="2">Northern Interior</td><td>10%</td><td>90%</td><td rowspan="2">0.58</td><td>0%</td><td>90%</td><td>10%</td><td>0%</td><td rowspan="2">0.44</td><td>7A</td><td>7B</td><td rowspan="2">0.39</td></tr>
<tr><td>0.67</td><td>0.57</td><td>0.35</td><td>0.40</td><td>0.80</td><td>0.45</td><td>0.39</td><td>0.39</td></tr>
</table>

Strip Mall: Key Building Characteristics

Window Shading Coefficient				ASHRAE no longer provides a differentiation for North-facing windows from all other windows. NECB has no requirements on the SC, so we have set it same as for ASHRAE 90.1-2010 to neutralize the effect; also, the NECB U-value infers low-e which ASHRAE's SC levels correspond to.
South Coast	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)	No requirements (set same as for 90.1-2010)	
Southern Interior	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)		
Northern Interior	0.57 (all orientations) / 0.74 (North)	0.52 (all orientations)		
SPACE				
Schedules	MNECB Schedule C	MNECB Schedule C	MNECB Schedule C	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines
Interior Lighting	1.98 W/ft²	**1.76 W/ft² (1.98 W/ft², less 6.7%, less 4.5% PAF)**	**1.76 W/ft² (1.98 W/ft², less 6.7%, less 4.5% PAF)**	The Building Area Method shows a 6.7% reduction in retail. 9.4.1.1 stipulates occupancy sensors for some spaces in a strip mall (storage, break rooms, washrooms). Assume 15% of lighting in a stripmall, hence, apply a 15% x 0.30 PAF = 4.5% reduction.
Exterior Lighting	3.5 kW (Parking, grounds and security lighting)	**3.3 kW (Parking, grounds and security lighting),3.5 kW less 5%.**	**3.3 kW (Parking, grounds and security lighting),3.5 kW less 5%.**	Using 90.1-2004 lighting as the baseline compliant with Standard (for strip mall - adjusted from 10 kW to 3.5 - parking is above ground lit by street lights), 2010 allows more overall exterior lighting for Zone 4 and less for Zone 3. The size of building and the mix of parking (lower allowance) and building grounds and security/entry lighting (higher allowance) areas would determine the difference. Facade, entrance, and security lighting change little for a Strip Mall ~ 5% reduction. NECB is the same as 2010. Assume parking area outdoors, no occupancy sensors required.
Equipment Density	0.21 W/ft²	0.21 W/ft²	0.21 W/ft²	
HVAC SYSTEM TYPE (Most applicable ASHRAE ECB System Types retained, as prescriptive compliance applies for this study)				
Air Handling	PSZ, with heat pump for electrically heated case	PSZ, with heat pump for electrically heated case	Apply same as for ASHRAE, due to nature of code comparison study	Most facilities served with individual packaged single zone units.

Strip Mall: Key Building Characteristics

	Note: PRM (Appendix G) for LEED rating purposes applies HVAC types that can be significantly different, depending on floor area, building type (Residential, Nonresidential) and heating source (fossil/purchased heat and electric/other).		Note: Part 8 "Energy Performance" method applies HVAC types that vary depending on building or space type, heating source and in some cases, number of floors.	
Heating Source	a) Gas using System 11 (B02g??1B) b) Electric, with heat pump, using System 9 (B02e??1B)	a) Gas using System 11 (B02g??1A10) b) Electric, with heat pump, using System 9 (B02e??1A10)	Apply same as for ASHRAE, due to nature of code comparison study a) B02g??1N11 b) B02e??1N11	Apply most prominent heating sources in market to capture major influences between energy providers/sources (e.g., electricity, natural gas). IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	No Chillers DX Only	No Chillers DX Only	No Chillers DX Only	Note that method of cooling is not as important as the relative differences in the cooling efficiencies.
FAN SYSTEM				
Supply Air Temperature Control	Constant	Constant	Constant	Minimum supply air temperature control only applies to VAV systems.
Fan Power	DX cooling for single zone systems: 1.3"/40% supply, no return	DX cooling for single zone systems: 1.3"/40% supply, no return	Keep at ASHRAE levels since potential differences are relatively minor overall	Most designs have no difficulty staying under the allowed fan power limits. Hence, the founding study's MNECB default total static pressures and fan efficiencies are retained even though most designs are better than the MNECB defaults. (It is interesting to note that ASHRAE Appendix G significantly lowers the baseline fan power from what is dictated in the body of the Standard.)
Outside Air	0.17 cfm/ft²	0.17 cfm/ft²	Same as for ASHRAE cases	NRCan archetype levels may appear low, but most of the O/A is associated with the Retail space and aligns with ASHRAE 62.1 (at nearly 0.3 cfm/sf).
Heat Reclaim				Design O/A percentage at below 30% O/A, as "design supply airflow rate" is nearly always over 1.0 cfm/ft². System exhaust flows hardly ever would exceed NECB 2011 thresholds: Vancouver at 8900 cfm infers exhaust from 33,000 ft²; Kelowna at 6600 cfm infers exhaust from 24,000 ft²; Prince George at 4700 cfm
South Coast	N/A	N/A	N/A	
Southern Interior	N/A	N/A	N/A	

Strip Mall: Key Building Characteristics

Northern Interior	N/A	N/A	N/A	infers exhaust from 17,000 ft².
HVAC				
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	
Economizer	None	**Temperature applied to half of Retail systems**	**Applied same as ASHARE 90.1-2010**	ASHRAE 90.1-2010 lowered requirement for economizer control to 4.5T; NECB 2011 requires at 5.7T, which for the purposes of this study is not significant enough a difference to warrant differentiating from 90.1-2010. Note that ASHRAE 90.1-2004 would have had some penetration, but much lower given higher thresholds.
Demand Controlled Ventilation	N/A	N/A	N/A	Based on ASHRAE 62.1-2010, default occupancy densities would not dictate DCV (although very close at threshold 40 people/1000 ft² for "Mall Common Areas").
HEATING				
Central Heating Efficiency	80% efficient furnaces	Same as for ASHRAE 90.1-2004	**92.5% AFUE furnaces (input at 90% full-load as part-load curve adjusts seasonally)**	Most stores would have furnaces (if gas heated) for metering/billing purposes. Condensing units apply to NECB for small applications; note that part-load curve in models adjust for condensing curve.
Heat Pumps	Air-source at 3.2 COP (65 - 135 MBH)	**Air-source at 3.3 COP (65 - 135 MBH)**	**Air-source at 3.3 (NOTE: Listing not clear, but assumed same as 90.1-2010)**	For the NECB, the rating for heat pumps in the equivalent 65 - 135 MBH range is confusingly listed. It is listed associated with a category of heat pumps in a "73 - 222.7 kW" range, yet indicates in another column a range that agrees with 90.1-2010.
COOLING				
Central Cooling Efficiency	Air-cooled AC at 10.1 EER (65 - 135 MBH)	**Air-cooled AC at 11 EER (65 - 135 MBH)**	Air-cooled AC at 9.7 EER (All Phases 19 - 73 kW)	Consistently reference same equipment for 90.1-2010 and NECB, as best as possible. *Note that the NECB listing for the cooling efficiency for the applicable category is one of the few entries that is significantly lower than for ASHRAE.*
Heat Pumps	Air-source (only) - same as above, since heating section electric	Air-source (only) - same as above, since heating section electric	Air-source (only) - same as above	
DOMESTIC HOT WATER (DHW)				

Strip Mall: Key Building Characteristics

Heating Efficiency	80%	80%	80%	No losses in CBIP prototype models, as is consistent with EE4.
Avg. Load (Btu/sf/day)	9.64	9.64	9.64	NECB dictates measures for limiting water use at fixtures, but measures are standard practice and

Big Box Retail: Key Building Characteristics

The big box retail archetype from NRCan represents a 45,000 ft² (4,180 m²), single storey building. The building has a wall-to-roof area ratio of 1.0. For this latest study, we made some adjustments to the 90.1-2004 baseline (e.g., reflected a more realistic supply air flow); hence, comparison of absolute results to past studies would be problematic.

The following listing provides the key building characteristics which differ between the ASHRAE 90.1-2004, ASHRAE 90.1-2010 and the NECB 2011 code-compliant models. In many cases information for certain characteristics are the same between the models, but we provide information since it is unique to the building type and/or of significance to the energy performance.

NOTE: The original archetypes were formulated for the purposes of determining the equivalency between the MNECB 97's and ASHRAE 90.1-1999's performance path approaches, modified for use with LEED EAp2 and EAc1, and not a comparison based on the prescriptive application of the Code. Thus, certain characteristics are indicative of what ASHRAE 90.1 would dictate for its ECB case, which is not necessarily fully representative for the market -- particularly for the HVAC system(s). For this building type, the ECB-based HVAC systems would be fairly representative of the actual market.

Item	ASHRAE 90.1-2004					ASHRAE 90.1-2010					NECB 2011	Discussion/Issues
EXTERIOR SURFACES												
Wall Overall R-Value	Mass	Metal	Steel	Other	R_o	Mass	Metal	Steel	Other	R_o	No variation by construction	Allocation of construction types is based solely on professional judgement.
South Coast	Climate Zone 5					Climate Zone 5					Climate Zone 4	
	70%	0%	25%	5%	9.2	70%	0%	25%	5%	12.5	**18.0**	
	8.13	8.85	11.9	11.2		11.1	14.5	15.6	15.6			
Southern Interior	Climate Zone 5					Climate Zone 5					Climate Zone 5	
	70%	0%	25%	5%	9.2	70%	0%	25%	5%	12.5	**20.6**	
	8.13	8.85	11.9	11.2		11.1	14.5	15.6	15.6			
Northern Interior	Climate Zone 5					Climate Zone 7					Zone 7A (60%) & 7B (40%)	
	70%	0%	25%	5%	12.2	70%	0%	25%	5%	14.7	7A / 7B: **27.0**	
	11.1	17.5	15.6	11.2		14.1	17.5	15.6	19.6		27.0 / 27.0	
Roof Overall R-Value	Insulation Entirely above Deck					Insulation Entirely above Deck					No variation by construction	For this building type, all roof types as flat roofs with continuous insulation. In some cases, steel joist with metal decking and built-up roofing and others are wood joists with plywood and build-up roofing. This is based on professional judgement.
South Coast	15.9					20.8					**25.0**	
Southern Interior	15.9					20.8					**31.0**	
Northern Interior	15.9					20.8					7A / 7B: 35.0 / 35.0; **35.0**	

Big Box Retail: Key Building Characteristics

Slab-on-Grade Floor R-Value	Not required (n.r.)	South Coast and Southern Interior: n.r. **Northern Interior: R-15**	**R-7.5**	Exposed floors were provided for in NRCan archetypes only (no exposed floors).
GLAZING				
Glazing Percent	10%	10%	10%	Average specified in NRCan archetypes and appears reasonable based on our experience.
Window U-value	Oper-able / Fixed / U_o	Non-metal / store c.w./ door / Metal / Other metal / U_o	No variation by window type	Operable windows are becoming more prevalent in new construction, but we have observed little if any change in this aspect with the retail segment. Factors are based on professional experience in the commercial sector. Input is corrected for DOE2's adjustment for air films to produce the specified overall U-value.
South Coast	10%: 0.67 / 90%: 0.57 / 0.58	0%: 0.35 / 85%: 0.45 / 10%: 0.80 / 5%: 0.55 / 0.49	**0.42**	
Southern Interior	10%: 0.67 / 90%: 0.57 / 0.58	0%: 0.35 / 85%: 0.45 / 10%: 0.80 / 5%: 0.55 / 0.49	**0.39**	
Northern Interior	10%: 0.67 / 90%: 0.57 / 0.58	0%: 0.35 / 85%: 0.40 / 10%: 0.80 / 5%: 0.45 / 0.44	7A: 0.39 / 7B: 0.39 / **0.39**	
Window Shading Coefficient				ASHRAE no longer provides a differentiation for North-facing windows from all other windows. NECB has no requirements on the SC, so we have set it same as for ASHRAE 90.1-2010 to neutralize the effect; also, the NECB U-value infers low-e which ASHRAE's SC levels correspond to.
South Coast	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)	No requirements (set same as for 90.1-2010)	
Southern Interior	0.45 (all orientations) / 0.57 (North)	0.46 (all orientations)		
Northern Interior	0.57 (all orientations) / 0.74 (North)	0.52 (all orientations)		
SPACE				
Schedules	MNECB Schedule C	MNECB Schedule C	MNECB Schedule C	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines
Interior Lighting	2.0 W/ft²	**1.76 W/ft² (2.0 W/ft², less 6.7%, less 4.5% PAF)**	**1.76 W/ft² (2.0 W/ft², less 6.7%, less 4.5% PAF)**	The Building Area Method shows a 6.7% reduction in retail. 9.4.1.1 stipulates occupancy sensors for some spaces in a big box retail store (storage, break rooms, washrooms). Assume 15% of lighting in a stripmall, hence, apply a 15% x 0.30 PAF = 4.5% reduction.

Big Box Retail: Key Building Characteristics

Exterior Lighting	17.5 kW (Outdoor parkade lighting)	**14 kW (Parking, grounds and security lighting), 17.5 kW less 20%.**	**14 kW (Parking, grounds and security lighting), 17.5 kW less 20%.**	Using 90.1-2004 lighting as the baseline compliant with Standard (adjusted for typical Canadian Tire with onsite parking), 2010 allows more overall exterior lighting for Zone 4 and less for Zone 3. The size of building and the mix of parking (lower allowance) and building grounds and security/entry lighting (higher allowance) areas would determine the difference. Big Box retail would be 90% parking - 20% reduction. NECB is the same as 2010. Assume parking area outdoors, no occupancy sensors required.
Equipment density	0.23 W/ft²	0.23 W/ft²	0.23 W/ft²	
HVAC SYSTEM TYPE (Most applicable ASHRAE ECB System Types retained, as prescriptive compliance applies for this study)				
Air Handling	PSZ, with heat pump for electrically heated case	PSZ, with heat pump for electrically heated case	Apply same as for ASHRAE, due to nature of code comparison study	
	Note: PRM (Appendix G) for LEED rating purposes applies HVAC types that can be significantly different, depending on floor area, building type (Residential, Nonresidential) and heating source (fossil/purchased heat and electric/other).		Note: Part 8 "Energy Performance" method applies HVAC types that vary depending on building or space type, heating source and in some cases, number of floors.	
Heating Source	a) Gas using System 11 (B01g??1B) b) Electric, with heat pump, using System 9 (B01e??1B)	a) Gas using System 11 (B01g??1A10) b) Electric, with heat pump, using System 9 (B01e??1A10)	Apply same as for ASHRAE, due to nature of code comparison study a) B01g??1N11 b) B01e??1N11	Apply most prominent heating sources in market to capture major influences between energy providers/sources (e.g., electricity, natural gas). IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	No Chillers DX Only	No Chillers DX Only	No Chillers DX Only	Note that method of cooling is not as important as the relative differences in the cooling efficiencies.
FAN SYSTEM				
Supply Air Temperature Control	Constant	Constant	Constant	Minimum supply air temperature control only applies to VAV systems.

Big Box Retail: Key Building Characteristics

Fan Power	**DX cooling for single zone systems: 1.3"/40% supply, no return**	**DX cooling for single zone systems: 1.3"/40% supply, no return**	Increase ASHRAE 90.1-2010 levels by 1.0" for 90% of air flow (0.9" eff) due to heat recovery (still under 0.755 W/cfm limit)	Most designs have no difficulty staying under the allowed fan power limits. Hence, the founding study's MNECB default total static pressures and fan efficiencies are retained even though most designs are better than the MNECB defaults. (It is interesting to note that ASHRAE Appendix G significantly lowers the baseline fan power from what is dictated in the body of the Standard.)
Outside Air	0.2 cfm/ft²	0.2 cfm/ft²	Same as for ASHRAE	Most designs would provide for under 30% O/A.
Heat Reclaim			**50% effectiveness applied to 80% of O/A (40% net), assuming only typical retail space meets thesholds (regardless of archetype size).**	Design O/A percentage at below 30% O/A, as "design supply airflow rate" is nearly always over 1.0 cfm/ft². System exhaust flows often would exceed NECB 2011 thresholds, particularly with larger, new stores that are typical: Vancouver at 8900 cfm infers exhaust from 33,000 ft²; Kelowna at 6600 cfm infers exhaust from 24,000 ft²; Prince George at 4700 cfm infers exhaust from 17,000 ft².
South Coast	N/A	N/A		
Southern Interior	N/A	N/A		
Northern Interior	N/A	N/A		
HVAC				
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	
Economizer	Temperature	Temperature	Temperature	Not required for units below 4.5T for ASHRAE 90.1-2010 and 5.7T for NECB 2011, but likely applies in most cases for larger retail with larger systems.
Demand Controlled Ventilation	N/A (Removed previous factors as density not high enough)	N/A	N/A	NOT applicable to most systems based on ASHRAE 62.1-2010 default densities for retail spaces. Hence, *application to previous studies was inappropriate.*

Big Box Retail: Key Building Characteristics

HEATING				
Central Heating Efficiency	80% efficient furnaces	Same as for ASHRAE 90.1-2004	81% efficient furnaces	Some designs may use boilers instead of furnaces, but stayed with NRCan archetype models as rooftop gas-fired equipment is very common.
Heat Pumps	Air-source at 3.2 COP (Air cooled, average for 65 - 135 MBH and >135 MBH)	**Air-source at 3.3 COP (Air cooled, average for 65 - 135 MBH and >135 MBH)**	**Air-source at 3.3 COP (Air cooled, average)**	For the NECB, the ratings for heat pumps in the equivalent 65 - 135 MBH and >135 MBH ranges is confusingly listed. They are associated with a category of heat pumps in a "73 - 222.7 kW" range, yet indicates in another column a range that agrees with 90.1-2010.
COOLING				
Central Cooling Efficiency	Air cooled AC at 9.9 EER average for 65 - 240 MBH categories	**Air cooled AC at 11 EER average for 65 - 240 MBH categories**	Air cooled AC at 9.7 EER for 19 - 73 kW category	Consistently reference same equipment for 90.1-2010 and NECB, as best as possible. *Note that the NECB listing for the cooling efficiency for the applicable category is one of the few entries that is significantly lower than for ASHRAE.*
Heat Pumps	Air-source only - same as listed above	Air-source only - same as listed above	Air-source only - same as listed above	
DOMESTIC HOT WATER (DHW)				
Heating Efficiency	80%	80%	80%	No losses in CBIP prototype models, as is consistent with EE4.
Avg. Load (Btu/sf/day)	3.34	3.34	3.34	NECB dictates measures for limiting water use at fixtures, but measures are standard practice and

Appendix C:

Summary Review of ASHRAE 90.1-2010 for B.C. Comparison to 90.1-2004 and Identification of Potential Market Barriers

SUMMARY REVIEW OF ASHRAE 90.1-2010 FOR B.C.
Comparison to 90.1-2004 and Identification of Potential Market Barriers

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The British Columbia government is considering an update to the BC Building Code (Code) so that the energy performance requirements are more stringent and up-to-date. This may include updates based on the latest ANSI/ASHRAE/IESNA Standard 90.1 (ASHRAE 90.1) 2010 version. BC Hydro representatives are interested in the implications of adopting the latest 2010 version of the ASHRAE 90.1 to further the Code advancement. In support of this effort, EnerSys Analytics Inc. performed a comparative review of ASHRAE 90.1-2010 versus 90.1-2004 to identify potential barriers in the market. Market barriers for this brief exercise were defined as notable changes to the ASHRAE 90.1-2010 Standard that a significant portion of the market likely does not follow by (e.g., 10% or more would not be in compliance based on today's design practices).

ASHRAE 90.1-2010 UPDATES TO 90.1-2004

The following lists notable changes in ASHRAE 90.1-2010 from the 2004 version, based on the 90.1-2004 addenda, the 90.1-2007 addenda and summary review of the prescriptive sections of the 2010 Standard. Areas of particular concern where market barriers likely exist appear in red.

Note that we did not conduct a complete line-by-line comparison of the 2004 and 2010 versions as the scope and schedule did not allow for such detail. However, we completely reviewed the ASHRAE 90.1-2004 and 2007 addenda, as these revisions were absorbed into the 2007 version. Further, we also conducted a cursory review of the 2010 version, paying particular attention to key sections and stipulations that likely would have notable implications in the B.C. market.

Note that this brief represents contains slight revisions to a previous 7-July-2011 version whereby a closer review of the Standard warranted some further clarification.

Envelope

Nearly all of the following changes from the 2004 Standard were introduced with the 2007 version. Further provisions added with 2010 are accordingly indicated in parenthesis; otherwise, the revisions were a result of the 2007 version.

- *Vestibules:* Are required under a differing set of conditions; most notably, the 2004 exception for buildings less than four storeys above grade no longer applies and has been replaced with an exception for only very small buildings (i.e., less than 1000 ft^2). Note that a significant portion of the market was not in compliance with the mandatory vestibule stipulation for ASHRAE 90.1-2004, but even more proportionally are within the Vancouver City boundaries. Finally, the 2010 version extended the requirements to climate zone 4, which may barely apply to a few locations in B.C.

For the following points related to the building envelope tables, Attachment A provides a snapshot of two of the most pertinent tables that apply to British Columbia

- *Roof R-value:* Continuous insulation (c.i.) increased from R-15 to R-20 for a majority of applicable roof types in the market; attic type roofs for non-residential increased from R-30 to R-38 for Coastal and Southern Interior regions (C&SI, corresponding to Table 5.5-5); most roofs over semi-heated spaces will require more insulation as well. For 2010, only “metal building” roof R-values changed, with an increase of about R-3 and R-2 for conditioned and semi-heated spaces, respectively, for C&SI regions; R-5 and R-4 for conditioned and semi-heated spaces, respectively, for BC’s colder climates.
- *Wall R-value:* Insulation requirements increased for a majority of wall constructions in the market (the "Metal Building" category remained completely unchanged for 2007 with only one notable change for 2010). Most notable are:
  - ✓ An increase from R-3.8 to R-7.5 c.i. for non-residential steel-framed walls in the C&SI region. Note that the residential requirement of R-7.5 c.i. remained unchanged in the C&SI region, but hardly anyone in the residential market adheres to this requirement now.
  - ✓ The addition of R-3.8 and R-7.5 c.i. to non-residential wood-framed walls in the C&SI and Northern Interior (NI) regions, respectively (note that continuous insulation was not stipulated in 90.1-2004).
  - ✓ The addition of R-7.5 c.i. to residential wood-framed walls in the C&SI region (note that continuous insulation was not stipulated in 90.1-2004).
  - ✓ An increase of R-3.8 c.i. for non-residential mass walls.
  - ✓ An increase of R-1.9 c.i. for residential mass walls. (Much of the market doesn't comply with the 2004 Standard, much less the more stringent 2007 Standard.)
  - ✓ Mass walls next to semi-heated spaces (e.g., storage) now require insulation where none was required for 90.1-2004.
  - ✓ (2010) Metal building walls next to heated spaces for the C&SI region now require an additional layer of continuous insulation (R-5.6), equivalently providing for an extra R_o-5.6.
- *Below-Grade Walls:* R-7.5 c.i. required in the C&SI region, where no insulation was required before.
- *Exposed Floor R-value:* Insulation requirements increased for all mass floors by 2.1 and 4.2 c.i. in the C&SI and NI regions, respectively.
- *Slab-on-Grade Floors:* Insulation requirements increased for majority of conditions in the market. Most notable are:

- ✓ R-10 perimeter insulation stipulated for residential cases without heating in the slab for the C&SI region, whereas no insulation was required previously.
- ✓ R-15 perimeter insulation stipulated for non-residential cases without heating in the slab for the NI region, whereas no insulation was required previously.
- ✓ For the C&SI region, R-15 extending 24 inches below grade instead of R-10 extending 36 inches below grade for cases with heating in the slab.
- ✓ Effective doubling of the insulation required in the NI region for cases with heating in the slab.

- *Window U-value:* Specification for minimum requirements restructured based on one of four glazing types, instead of by window percentage. In nearly all cases, the requirements have become more stringent:
  - ✓ Maximum window percentage of 40% instead of 50% before envelope trade-off method (or Energy Cost Budget method) must be used. This effectively increases the stringency for buildings with 40 – 50% glazing (which is a significant portion of the MURB and office market). 2004
  - ✓ Nonmetal framed glazing (e.g., vinyl, wood, fiberglass) at U-0.35, which requires highly effective low-e for double pane windows with at least a one-half inch air space. In some cases with larger framing, as with operable windows, argon and/or insulated spacers would be required. Note that the equivalent of standard fixed double pane windows with thermally broken aluminum frames was required by 90.1-2004 for window percentages up to 40%.
  - ✓ For windows with metal framing (excluding fixed curtain wall and storefront), the same type of window as above, but in a thermally broken aluminum frame, is effectively required in the NI region (U-0.45 fixed).
  - ✓ Curiously, a punched (fixed) window with metal framing remains nearly unchanged (U-0.55 versus 0.57 for 2004).
  - ✓ Curtain wall and storefront windows in the C&SI region effectively have the same requirements as indicated above for nonmetal windows (but in a curtain wall/storefront frame).
  - ✓ Curtain wall and storefront windows in the NI region are more stringent than for the C&SI region mentioned directly above, typically requiring argon gas and/or insulating spacers and/or better frames than are typically used.
  - ✓ Windows for semi-heated spaces have effectively decreased from a single pane requirement to a double pane requirement in the NI region.
  - ✓ The solar heat gain coefficient (SHGC) has been reduced for most cases in the C&SI region. While the present requirement still provides for visibly clear options (i.e., not tinted or reflective), I suggest relaxing this stipulation and treating it the same as the MNECB since allowing solar gains into the building is sometimes desirable and beneficial.

- ✓ The SHGC has been reduced in the NI region for the non-residential category, while the requirement has been eliminated (i.e., "NR," or not required) for residential.

- *Air leakage (2010)*: Mandatory provisions have been re-written to be more explicit. In particular, requirements providing for a continuous air barrier would add to the design, installation and inspection costs for new projects if appropriately followed.
- *Fenestration and door air leakage (2010):* Requirements for design, testing and labelling is significantly more rigorous; as labelling has not been widely adopted in Canada, this could be a significant barrier to compliance.

Mechanical

The following changes were introduced with the 2010 version, unless otherwise noted (typically designated in paranthesis with "2007").

- *Air conditioning:* The cooling efficiency of most cooling equipment improved; the following highlights some of the changes to commonly used cooling equipment:
  - ✓ Unitary air conditioners increased between 4% - 14%, with units below 20 tons experiencing the relatively better improvements.
  - ✓ Single packaged vertical air conditioners and heat pumps increased cooling efficiency ratings for smallest sized units (i.e., < 5.4 tons) by 5%; 3-phase AC efficiencies increased for smallest units by 4% (2004).
  - ✓ Most package terminal air conditioners (PTACs) and heat pumps (PTHPs) will see an increase in the rated cooling efficiency of over 10% starting in October of 2012.
  - ✓ Heat pumps for sizes over 5.4 tons increased from 4% - 14%, with the largest sizes (over 20 tons) seeing the smallest improvements.
  - ✓ Air-cooled chiller integrated part-load (IPLV) efficiency increased over 20%.
  - ✓ Water-cooled chillers IPLV efficiency changes ranged from about no difference for some centrifugal categories to over 20% for the largest reciprocating equipment (although, more typical reciprocating size categories provided for about 8 – 12% decrease in the equivalent IPLV); formulas for determining minimum efficiencies for non-standard conditions are introduced as well.
- *Centrifugal fan cooling tower limitations:* Large open-circuit cooling towers with a total capacity of over 1100 gpm (69.4 l/s) must meet the same efficiency requirements that apply to similar axial fan cooling towers.
- *Air-source heat pumps, heating efficiency:* Single packaged heat pumps (HPs) increased heating efficiency ratings for smallest sized units (i.e., < 5.4 tons) by 11% and 3-phase HP heating efficiencies increased for smallest units by 4%

(2004). Further increases to larger heat pumps were introduced with the 2010 version were relatively small with low temperature ratings increasing by 2.5% or less. Finally, most package terminal heat pumps (PTHPs) will see an increase in the rated cooling efficiency of about 16% starting in October of 2012.

- *Water-to-water heat pumps:* For the first time, ASHRAE 90.1 added efficiency requirements for this product class of heat pumps. Also, hydronic heat pumps and water-cooled unitary air conditioners connected to a pump system exceeding 5 hp must be outfitted with variable flow capability (e.g., two-position valves) meeting the stipulations of 6.5.4.4.2. We still see hydronic heat pumps without this capability being specified.
- *Variable Refrigerant Flow (VRF) Equipment:* For the first time, ASHRAE 90.1 added efficiency requirements for VRF air conditioners and heat pumps.
- *Exhaust heat recovery*: Previous requirements for when energy recovery from exhaust air were redefined based on design supply fan airflow rate, climate zone and the percent of outdoor air (O/A). Note that most of the same exceptions still apply. A new table indicates when heat recovery is required has been added. As a few applicable examples:
  - ✓ Coastal climates would require heat recovery starting at 50% O/A for relatively large systems of 26000 cfm or greater, dropping to 12000 cfm systems at 60% O/A.
  - ✓ For coastal climates, the previous provision of heat recovery applying for systems over 70% O/A and 5000 cfm still applies, but systems with 80% O/A or higher require heat recovery once they reach 4000 cfm.
  - ✓ More significantly, colder climates in B.C. require heat recovery starting at 30% O/A with lower associated air flow levels. For instance, Prince George requires heat recovery for systems starting at 2500 cfm and once the percent of O/A reaches 50%, heat recovery is required regardless of the system air flow.
  - ✓ "Moist" climates in B.C. now require heat recovery starting at 30% O/A with lower associated air flow levels. Kelowna, Vernon, Castlegar and Whistler, for instance, would require heat recovery for systems 5500 cfm or higher with 30% - 40% O/A, ramping down to apply to all systems with 80% or more O/A.
  - ✓ Interestingly, heat recovery conditions for "dry" climates in B.C. (i.e., Zone 5**C**) remain unchanged. This applies to Kamloops, Osoyoos and Lillooet, for instance.
- *Laboratory exhaust systems:* Changes applied to the how the conditions for reducing operational exhaust are determined, but the most significant change is lowering of when these conditions apply from 15000 cfm to 5000 cfm systems.
- *Kitchen exhaust systems:* Use of available "free" transfer air is required when available from adjacent spaces. Further, facilities with over 5,000 cfm total kitchen hood exhaust are limited on the amount of allowed airflow, and are required to provide for (a) at least half of the replacement air for exhaust made

up by transferred air, (b) demand ventilation control applied to at least 75% of the exhaust air, or (c) energy recovery of at least 40% effectiveness applied to at least half of the total exhaust flow. The latter stipulations would apply to systems that affect larger restaurants and commercial kitchens.

- *Fan system power limitation (2007):* The allowable nameplate motor power for systems with less than 20,000 supply cfm has been lowered for constant volume and variable volume systems; our experience is that most fan systems are compliant, particularly given allowable adjustments and exceptions.
- *Single zone VAV system power limitation:* Air systems delivering variable air flow to single zones shall comply with the same fan power limitations as for constant volume systems (they used to have the same higher allowances as for multiple zone VAV systems).
- *Fan static pressure limits for energy recovery:* 0.5” (125 Pa) has been added to the fan pressure limitation adjustment.
- *Fan static pressure limits for fume hoods:* Additional static pressure allowances have been added for fume hoods, including special considerations for laboratory and vivarium systems in high-rise buildings.
- *Demand controlled ventilation (2007):* Applies under conditions with a lower occupancy density; for instance, meeting rooms over 500 ft² would require DCV if the air handling unit serving it has (a) economizer control, (b) modulating dampers, or (c) more than 3000 cfm of outside air. However, several exceptions and provision would limit it’s required application (e.g., based on ASHRAE 62.1 default occupant densities, retail would not require DCV). Note that the method of DCV (e.g., CO_2 or occupancy sensor) is not dictated.
- however, because of numerous conditions and exceptions, this likely would have little net impact. Note that this provision under the 2007 or past versions of ASHRAE 90.1 is often not complied with ~~(e.g., retail)~~.
- *Controls associated with reheating or re-cooling:* Revisions were applied that provide for more consistent and reasonable airflow limits which should still result in energy savings, but align indicators for Standard 62.1 and 55 and the realities of some of the previous provisions (e.g., 0.4 cfm/ft² flow requirement).
- *Economizer requirements increased:* The threshold limit on the size of the air handling unit when economizer control is required was decreased from 11.3 tons to between 4.5 to 5.4 tons. Also, exceptions to the requirements for integrated economizer control were removed.
- *Data centre controls and efficiency requirements:* The 2007 Standard relaxed dead band and humidification requirements. The 2010 Standard significantly modified efficiency requirements for HVAC systems dedicated to computer rooms and data centers, with provisions concerning minimum equipment cooling efficiencies, and economizer and humidification control. This included deleting some previous allowances associated with water-side economizer design

capacity and dehumidification exception using coincident cooling and heating (reheat).

- *Optimum Start Control (2007)*: Both standards mandate optimum start algorithms for HVAC systems with total supply air flow rate exceeding 10,000 cfm, but we noted this here because it is not followed in a significant number of cases and was not highlighted in past AHRAE 90.1 studies.
- *Multiple-zone VAV system ventilation optimization:* Controls shall be added to allow for dynamic reset of outdoor air based on changes in the system ventilation efficiency, as defined by ASHRAE 62.1. Exceptions apply for zonal transfer fans, dual-duct dual-fan systems and fan-powered boxes, in addition to systems requiring exhaust heat recovery and in cases where exhaust exceeds 70% of total outdoor intake requirements. In our experience, most designers do not have a firm understanding of the ASHRAE 62.1 multiple zone, mixed air provisions and hence, appropriately complying with this provision poses challenges.
- *Single-zone VAV requirements:* Stipulations for multiple-zone VAV systems are extended to larger single zone systems with motors over 5 hp or a cooling capacity over 9.2 tons (the latter takes effect 1-Jan-2012). Two-speed or variable speed motors may be used to vary the volume. These requirements are not considered a concern given the number compliant systems we already see in the market and the indication that manufacturers already have units widely available.
- *Supply air reheat limitations:* Where reheat is allowed, the supply air is not allowed to be delivered at more than 20°F above the space setpoint if the supply and return air openings are over six feet above the floor.
- *Supply air temperature reset:* The common control strategy of raising of the supply air temperature in response to the cooling load has been formally added; several exceptions apply.
- *Enclosed parking garage fan CO control:* Parkade ventilation systems serving enclosed garages over 30,000 ft² with fan systems under 1500 ft² per hp of installed fan capacity shall “automatically detect contaminant levels” and modulate fans accordingly to satisfy the air quality requirements. Note that heated (and cooled) parkades do not need to comply, but we find CO control has long been standard practice in most all situations.
- *Radiant panel insulation:* Mandatory minimum insulation requirements were added for insulating radiant panels on the surface that points away from the conditioned space.
- *Pipe insulation:* Required minimum insulation levels (i.e., thickness) have increased.
- *Chilled and condenser water pumping:* New requirements prescribing maximum flow rates have been introduced, with some notable exceptions and conditions.

Also, the requirement for variable speed control on chilled water pumps has been reduced from 50 hp to 5 hp.

- *Service water booster pumps:* Provisions added to control the pump operation based on pressure required at the critical fixture, including shutting off the pumps when there is no demand.
- *Simplified HVAC Compliance Option (6.3):* Several revisions were made to this method of compliance to make it more stringent. In our experience, however, we have not heard of anyone who sought compliance following this method and hence, the revision would have few market implications.

Lighting

Relatively little concerning lighting was introduced in the 2004 version, but quite significant changes were introduced with the 2010 version. Hence, the following changes apply to the 2010 version, unless otherwise noted.

- *Scope affecting alterations:* The lighting provisions now apply to all luminaires that are added, replaced or removed and to fixtures where only the lamp and ballast are replaced. In other words, if a lamp and ballast in a fixture are replaced (not part of maintenance or repair), the new lamp and ballast must meet the requirements (including the automatic shutoff requirement of Section 9.4.1.1). This applies when 10% or more of the connected lighting power in a space is altered. If actually followed, this requirement could have some significant implications in the market, but similar, less stringent provisions with the 2007 Standard did not appear to be monitored very closely.
- *Luminaire wattage (2007):* Provision added that allows for track and busway type lighting systems to not be limited by circuit breakers and permanently installed current limiters below a value of 30 W per linear foot (98 W per linear meter).
- *Mandatory interior lighting controls:* Many significant additions and revisions were made, including:
  - ✓ Buildings under 5000 ft^2 are no longer exempted.
  - ✓ Any automatic occupancy type lighting control shall either be manually controlled for turning the lights on, or automatically turn the lighting on to no more than 50% of the connected power (exceptions include corridors, restrooms, stairwells, lobbies).
  - ✓ Most spaces with ceiling height partitions must have stepped control, unless the prescribed lighting power density is less than 0.60 W/ft^2.
  - ✓ Occupancy sensors are expanded to be required in the following spaces:
    - All classrooms and lecture halls (except shops and labs);
    - Most storage and supply rooms;
    - Document copy and printing rooms;

    - Office spaces up to 250 ft^2;
    - Restrooms, locker and fitting rooms.

  - ✓ Automatic daylighting harvesting is required via the application of at least multiple stepped daylighting controls, installed for spaces with primary sidelighted and toplighted areas[1].
  - ✓ Stairwell lighting now requires one or more control devices to automatically reduce lighting power by at least 50% within 30 minutes after all occupants have left the stairwell.

- *Mandatory exterior (including parkade) lighting controls:* Many significant additions and revisions were made, including:
  - ✓ Parking garage lighting requires controls that automatically reduce the lighting power by a minimum of 30% when there is no activity detected within a lighting zone (3,600 ft^2 or less) for no more than 30 minutes. Exceptions include the use of HID lamps of 150 Watts or less and induction lamps.
  - ✓ Parkades above ground with at least 40% net wall openings must reduce the lighting power automatically in response to daylight.
  - ✓ Exterior building lighting power includes an exterior lighting power allowance based on one of five newly defined "Exterior Lighting Zones" which effectively pertain to type of neighbourhood the building is situated in. For instance, the Exterior Lighting Zones range from undeveloped parks, etc. (Zone 0) to highly developed commercial district in major metropolitan areas (Zone 4). Table 9.4.3b lists the exterior lighting power allowances for each of the five zones. These new provisions are significant in that they add more compliance calculations for the electrical/lighting consultant. It likely will have little overall impact on energy consumption for commercial projects in urban areas, but for buildings not designated as Zone 4, the exterior building lighting power allowance will be reduced but we don't anticipate it will be difficult to meet.

- *Interior lighting power calculations for the Space by Space Method:* This method for calculating the interior lighting power allowance has become more complicated and/or stringent, including the following potential adjustments:
  - ✓ The additional power allowance for four retail type categories have decreased by approximately 40%.
  - ✓ Additional lighting power allowances are provided for spaces where controls beyond those listed in the mandatory provisions (Section 9.4) are installed. This includes offices, conferences/meeting rooms, classrooms (lecture/training), retail sales areas, lobbies, atria, dining areas, stairways, corridors, gym/pools, mall concourses, and parking garages. The increased lighting power allowances range from 5% to 30% depending on the space type and additional control method employed. This provision is notable since it dictates performing additional compliance calculations;

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[1] ASHRAE 90.1-2010 provides many extensive definitions concerning daylighting concepts and terms, including what constitutes "sidelighting" and "toplighting."

since lighting power allowances have dropped, this credit will likely need to be applied in many cases.

- ✓ Additional lighting power allowance is provided based on the room geometry (similar to what used to be provided in ASHRAE 90.1-1989 and the MNECB). The increased lighting power is based on the "room cavity ratio" (RCR), which takes into account the room height, area and perimeter length. A limit for the RCR is defined for most space types, which if surpassed, the additional lighting power allowance is capped at 20%. This provision is notable since it dictates performing additional compliance calculations and since lighting power allowances have dropped, the RCR credit will likely need to be applied in many cases.

- *Space by Space method classifications:* Space type definitions have changed in some cases. For instance, five sports arena classifications are now defined versus three before.
- *Interior lighting power allowances based on the Space by Space Method:* Lighting power allowances have decreased for most space types. One exception applies to sports seating, which increased slightly, and open office plan areas were barely reduced. Note that while the overall space by space allowances have decreased, the additional power allowances provided by applying (1) an effective room cavity ratio credit and (2) for additional control strategies may result in little or no change in lighting energy use, depending on the specific situation.
- *Interior lighting power allowances based on the Building Area Method:* Lighting power allowances have decreased for all building types except hotels and hospitals. The decrease ranges from 3% in penitentiaries to 44% in family dining building types. Office building lighting decreased by 10% and schools/universities decreased by 17.5%.
- *Task lighting included in connected load calculations (2007):* Option provided that exempts furniture mounted task lighting if it incorporates automatic shutoff.
- *Lighting power allowance exemption (2007):* Expanded exceptions from only "visually impaired" to a wider range of medical condition needs.

Power and Other Equipment

The following issues were introduced with the 2010 version of ASHRAE 90.1:

- *Motor efficiencies:* Efficiencies are mandatorily increased, but we anticipate this to have little impact with the market already using high efficiency motors (however, we suggest someone with direct expertise with available motor efficiencies double check the new Table 10.8b).
- *Receptacle load control (wiring):* Non-critical receptacle loads are to be separated and automatically controlled (turned off) based on occupancy or scheduling, which infers they need to be placed on separate circuits.

- *Elevators:* For the first time, lighting and ventilation power restrictions are placed on elevator cabs.
- *Step-down transformer efficiencies:* For the first time, minimum efficiency levels for NEMA Class I low-voltage dry-type transformers are provided. As this has been agreed upon by major transformer manufacturers and such equipment will be mandated in the U.S., we don't anticipate this to be an issue. However, experts more knowledgeable in the transformer market should be consulted to confirm.

CONCLUSION

Many more stringent requirements and provisions have been introduced with the 2010 version of ASHRAE 90.1. Further, while a significant portion of the market today does not follow several stipulations introduced by ASHRAE 90.1-2010 versus the 2004 version, several non-compliant issues still exist for the 2004 version as well. Many of the areas of concern listed in our 2004 paper on *Life-cycle Economic Assessment of ASHRAE 90.1-1999 Applied to British Columbia* still apply. And in several cases, the lighting power allowances and controls (e.g., for occupancy sensors) introduced in the 2004 version of ASHRAE 90.1 are not being followed, either. Even further challenges would apply with the 2010 version. Note that the area where the most obvious non-compliance issues exist presently are with the building envelope.

As highlighted in previous related studies, multiunit residential buildings (MURBs) stand out as the building segment that is most often in non-compliance with ASHRAE 90.1 (any version). The retail segment likely is second, with a significant number of buildings without demand controlled ventilation, uninsulated mass walls and non-compliant lighting. The problems in these situations, and others, are not specific to ASHRAE 90.1-2010 as many of the non-compliance issues remain concerns with the 2004 and even earlier versions of ASHRAE 90.1. The 2010 version has further improved the minimum energy performance (reportedly about 26% percent below that of the 2004 version, not including plug loads[2]), further exacerbating potential compliance difficulties.

It is interesting to note that ASHRAE 90.1 still has not significantly addressed the minimum performance requirements associated with combustion heating equipment (e.g., boiler, furnaces). Yet we find that the application of at least mid-efficiency, modulating equipment is nearly always cost-effective and results in significant savings for facilities with natural gas heating.

[2] Based on a U.S. DOE report PNNL-20405 (see reference). It is interesting to note that savings for this assessment also stemmed from changes inherited from the applicable ASHRAE 62.1 Standard, which lowered outside air overall in their comparison analysis.

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Attachment A: Sample Building Envelope Requirements Tables

Building Envelope Requirements Applying to Lower Mainland, Vancouver Island and Southern Interior, B.C.

TABLE 5.5-5 Building Envelope Requirements For Climate Zone 5 (A, B, C)*

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.119	R-7.6 c.i.
Metal Building[a]	~~U-0.065~~ U-0.055	~~R-19.0~~ R-13.0 + R-13.0	~~U-0.065~~ U-0.055	~~R-19.0~~ R-13.0 + R-13.0	~~U-0.097~~ U-0.083	~~R-10.0~~ R-13.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above-Grade						
Mass	U-0.090	R-11.4 c.i.	U-0.080	R-13.3 c.i.	U-0.151[~~a~~b]	R-5.7 c.i.[~~a~~b]
Metal Building	~~U-0.113~~ U-0.069	~~R-13.0~~ R-13.0 + R- 5.6 c.i.	~~U-0.057~~ U-0.069	~~R-13.0 + R-13.0~~ R-13.0 + R- 5.6 c.i.	~~U-0.123~~ U-0.113	~~R-11.0~~ R-13.0
Steel-Framed	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.064	R-13.0 + R-3.8 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0
Walls, Below-Grade						
Below-Grade Wall	C-0.119	R-7.5 c.i.	C-0.119	R-7.5 c.i.	C-1.140	NR
Floors						
Mass	U-0.074	R-10.4 c.i.	U-0.064	R-12.5 c.i.	U-0.137	R-4.2 c.i.
Steel-Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.052	R-19.0
Wood-Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.051	R-19.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.540	R-10 for 24 in.	F-0.730	NR
Heated	F-0.860	R-15 for 24 in.	F-0.860	R-15 for 24 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.500		U-0.700	
Nonswinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**
Vertical Glazing, % of Wall						
Nonmetal framing (all)[~~b~~c]	U-0.35	SHGC-0.40 all	U-0.35	SHGC-0.40 all	U-1.20	SHGC-NR all
Metal framing (curtainwall/storefront)[~~c~~d]	U-0.45		U-0.45		U-1.20	
Metal framing (entrance door)[~~c~~d]	U-0.80		U-0.80		U-1.20	
Metal framing (all other)[~~c~~d]	U-0.55		U-0.55		U-1.20	
Skylight with Curb, Glass, % of Roof						
0%–2.0%	U_{all}–1.17	$SHGC_{all}$–0.49	U_{all}–1.17	$SHGC_{all}$–0.49	U_{all}–1.98	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–1.17	$SHGC_{all}$–0.39	U_{all}–1.17	$SHGC_{all}$–0.39	U_{all}–1.98	$SHGC_{all}$–NR
Skylight with Curb, Plastic, % of Roof						
0%–2.0%	U_{all}–1.10	$SHGC_{all}$–0.77	U_{all}–1.10	$SHGC_{all}$–0.77	U_{all}–1.90	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–1.10	$SHGC_{all}$–0.62	U_{all}–1.10	$SHGC_{all}$–0.62	U_{all}–1.90	$SHGC_{all}$–NR
Skylight without Curb, All, % of Roof						
0%–2.0%	U_{all}–0.69	$SHGC_{all}$–0.49	U_{all}–0.69	$SHGC_{all}$–0.49	U_{all}–1.36	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–0.69	$SHGC_{all}$–0.39	U_{all}–0.69	$SHGC_{all}$–0.39	U_{all}–1.36	$SHGC_{all}$–NR

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a]When using R-value compliance method, a thermal spacer block is required; otherwise use the U-factor compliance method. See Table A2.3.
[~~a~~b]Exception to Section A3.1.3.1 applies.
[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[~~c~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

Attachment A: Sample Building Envelope Requirements Tables

Building Envelope Requirements Applying to Most of Northern Interior, B.C. (e.g., Prince George)

TABLE 5.5-7 Building Envelope Requirements For Climate Zone 7*

Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.093	R-10.0 c.i.
Metal Building[a]	U-0.065 <u>U-0.049</u>	R-19.0 <u>R-13.0 + R-19.0</u>	U-0.065 <u>U-0.049</u>	R-19.0 <u>R-13.0 + R-19.0</u>	U-0.097 <u>U-0.072</u>	R-10.0 <u>R-16.0</u>
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.034	R-30.0
Walls, Above-Grade						
Mass	U-0.071	R-15.2 c.i.	U-0.071	R-15.2 c.i.	U-0.123	R-7.6 c.i.
Metal Building	U-0.057	~~R-13.0 + R-13.0~~ <u>R-19.0 + R-5.6 c.i.</u>	U-0.057	~~R-13.0 + R-13.0~~ <u>R-19.0 + R-5.6 c.i.</u>	U-0.113	R-13.0
Steel-Framed	U-0.064	R-13.0 + R-7.5 c.i.	U-0.042	R-13.0 + R-15.6 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.051	R-13.0 + R-7.5 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0
Walls, Below-Grade						
Below-Grade Wall	C-0.119	R-7.5 c.i.	C-0.092	R-10.0 c.i.	C-1.140	NR
Floors						
Mass	U-0.064	R-12.5 c.i.	U-0.051	R-16.7 c.i.	U-0.107	R-6.3 c.i.
Steel-Joist	U-0.038	R-30.0	U-0.032	R-38.0	U-0.052	R-19.0
Wood-Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.051	R-19.0
Slab-On-Grade Floors						
Unheated	F-0.520	R-15 for 24 in.	F-0.520	R-15 for 24 in.	F-0.730	NR
Heated	F-0.843	R-20 for 24in.	F-0.688	R-20 for 48 in.	F-0.900	R-10 for 24 in.
Opaque Doors						
Swinging	U-0.500		U-0.500		U-0.700	
Nonswinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**
Vertical Glazing, 0%–40% of Wall						
Nonmetal framing (all)[~~b~~c]	U-0.35		U-0.35		U-0.65	
Metal framing (curtainwall/storefront)[~~c~~d]	U-0.40	SHGC-0.45 all	U-0.40	SHGC-NR all	U-0.60	SHGC-NR all
Metal framing (entrance door)[~~c~~d]	U-0.80		U-0.80		U-0.90	
Metal framing (all other)[~~c~~d]	U-0.45		U-0.45		U-0.65	
Skylight with Curb, Glass, % of Roof						
0%–2.0%	U_{all}–1.17	$SHGC_{all}$–0.68	U_{all}–1.17	$SHGC_{all}$–0.64	U_{all}–1.98	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–1.17	$SHGC_{all}$–0.64	U_{all}–1.17	$SHGC_{all}$–0.64	U_{all}–1.98	$SHGC_{all}$–NR
Skylight with Curb, Plastic, % of Roof						
0%–2.0%	U_{all}–0.87	$SHGC_{all}$–0.77	U_{all}–0.61	$SHGC_{all}$–0.77	U_{all}–1.90	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–0.87	$SHGC_{all}$–0.71	U_{all}–0.61	$SHGC_{all}$–0.77	U_{all}–1.90	$SHGC_{all}$–NR
Skylight without Curb, All, % of Roof						
0%–2.0%	U_{all}–0.69	$SHGC_{all}$–0.68	U_{all}–0.69	$SHGC_{all}$–0.64	U_{all}–1.36	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–0.69	$SHGC_{all}$–0.64	U_{all}–0.69	$SHGC_{all}$–0.64	U_{all}–1.36	$SHGC_{all}$–NR

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.

<u>[a]When using R-value compliance method, a thermal spacer block is required; otherwise use the U-factor compliance method. See Table A2.3.</u>

[~~a~~b]Exception to Section A3.1.3.1 applies.

[~~b~~c]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

[~~c~~d]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

Appendix D:

Summary Review of the Draft NECB 2011 for B.C.: Comparison to ASHRAE 90.1-2010 and Identification of Potential Market Barriers

SUMMARY REVIEW OF THE DRAFT NECB 2011 FOR B.C.
Comparison to ASHRAE 90.1-2010 and Identification of Potential Market Barriers

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The British Columbia government is considering an update to the BC Building Code (Code) so that the energy performance requirements are more stringent and up-to-date. This may include updates based on the latest ANSI/ASHRAE/IESNA Standard 90.1 (ASHRAE 90.1) 2010 version. It may also include references to the Canadian "National Energy Code for Buildings" 2011 (NECB). At the time of this writing, the NECB was in draft form and scheduled to be release in the fall of 2011[1].

BC Hydro representatives were first interested in the implications of adopting the latest 2010 version of the ASHRAE 90.1 to further the Code advancement. In support of this effort, EnerSys Analytics Inc. performed a comparative review of ASHRAE 90.1-2010 versus 90.1-2004 to identify potential barriers in the market. The summary of this review was previously provided to BC Hydro and was entitled: "Summary Review of ASHRAE 90.1-2010 for B.C.: Comparison to 90.1-2004 and Identification of Potential Market Barriers." [July 7, 2011, revised November 10, 2011]

NECB 2011 COMPARISON AGAINST ASHRAE 90.1

As a second phase, we were asked to review the NECB and summarize the key differences between it and ASHRAE 90.1. More specifically, we focused on the key differences between the 2010 version of ASHRAE 90.1, given our previous summary brief highlighted the differences between the 2010 and 2004 versions of ASHRAE 90.1. As with the previous ASHRAE review effort, we also focus on market barriers that we perceive that a significant portion of the market likely does not follow by (e.g., 10% or more would not be in compliance based on today's design practices). Similarly, we did not review the differences with the "modelling method" of compliance either, since the vast majority of code compliance follows the prescriptive method of compliance (or related trade-off method for envelope and lighting).

The following lists notable differences between the NECB and ASHRAE 90.1-2010. We also highlight some key issues versus previous versions of ASHRAE, since BC presently references ASHRAE 90.1-2004 as part of its building code and the 2007 version for the City of Vancouver Bylaw. Areas of particular concern where market barriers might likely exist, presupposing the NECB was adopted relatively soon, appear in red. Further, differences where the NECB is more stringent than ASHRAE 90.1-2010 is designated with an up arrow (🡅) and where it is lower, by a down arrow (🡇).

Note that this brief represents contains revisions to a previous 31-July-2011 version whereby clarifications and an even closer review of the draft NECB warranted a few updates.

[1] SCEEB working draft of the NECB was provided in confidence to EnerSys in June 2011 for its exclusive use for this effort.

Organization, Structure and Content

The NECB has been re-written to a style similar to other building codes (e.g., BC Building Code, BC Plumbing Code). The goal is to present the NECB in the same format and language style as other building codes. However, the NECB is similar to ASHRAE in general, with a similar division of Sections for envelope, lighting, HVAC, service water heating, miscellaneous equipment and a section concerning energy performance compliance using modelling to effectively trade-off different regulated building components to demonstrate compliance. And the similar references to prescriptive, trade-off and the modelling method to compliance are represented in both the NECB and ASHRAE 90.1. This is not surprising since the NECB strongly referenced the 2007 version of ASHRAE 90.1. It also closely references the previous Model National Energy Code of Canada for Buildings 1997 (MNECB), which was strongly influenced by ASHRAE 90.1-1987.

We found that ASHRAE 90.1 (and the MNECB) are much clearer on precisely what is mandatory. The NECB was difficult for us to determine just what is mandatory, with what appears to be assumed mandatory provisions in the General sub-sections for each respective "Division B" Section. In the case of the HVAC section, for instance, provisions that used to be clearly mandatory in the MNECB were moved to the Prescriptive sub-section, presumably making them no longer mandatory if the much more involved trade-off or modelling approaches are followed.

ASHRAE 90.1 also is more user-friendly with direct references in the document to performance levels derived from other efforts and standards. The NECB unfortunately often provides references to many CAN/CSA standards, which must be separately purchased to confirm the required performance levels. Based on limited research and past experience, the standards provide for performance requirements that are very similar to what ASHRAE 90.1 requires (if not the same or often less stringent). However, we could not confirm this under the scope and schedule for this effort[2].

Envelope

The following are the key differences of the NECB with ASHRAE 90.1-2010 concerning the envelope section (NECB Part 3).

- *Prescriptive requirements by climatic zone:* The NECB requirements for calculating prescriptive envelope performance are significantly simpler than with 90.1-2010, with six climate zones based on heating degree-days. The NECB zones are based on the 90.1-2010 zones but do not necessarily quite align. The NECB now provides a

[2] Not only would it take many more hours to secure and comb through the applicable referenced standards, but the standards are relatively expensive relative to the budget for this effort (e.g., over $500 for just the few referenced in Part 7). Moreover, efforts to quickly purchase a single-license PDF of the National Building Code (NBC), which also is referenced by the NECB, was thwart with delays and complications being able to even open the file.

single overall thermal performance for each envelope component (exterior walls, roofs, floors, etc) based on climate zone. ASHRAE includes multiple types for each envelope component (four wall types, three roof types, etc).

- ↑ *Air leakage rates:* Air leakage rates are significantly more stringent for some items in the NECB. For example, fixed windows and skylights are required to have 80% less leakage than for ASHRAE 90.1-2010 (see Attachment A).

- ↑ *Fenestration- and door-to-wall ratio (FDWR):* The NECB defines the fenestration-to-wall ratio to include all doors, opaque or otherwise, including overhead doors. The maximum FDWR is 40% of the exposed wall area, which is similar to ASHRAE 90.1 except that ASHRAE excludes opaque door area and technically includes below-grade walls in the calculation (to few practitioners knowledge, however). The result is that the NECB effectively reduces the maximum glazing amount allowed for all buildings.

Nearly all prescriptive requirements are more stringent with the NECB than for ASHRAE 90.1-2010. From our experience, many of the prescriptive requirements would not be cost-effective for the incremental difference on a life-cycle basis. The following highlight many of the significant differences, for which further details pertaining to non-residential construction (and most ASHRAE residential classifications as well) are provided in Attachment A.

- ↑ *Roof R-value:* The NECB overall roof requirements are significantly more stringent than all 90.1-2010 roof types except attic/other. Comparing to the NECB using estimated market roof type percentages, the NECB requirements range from 13% higher in Vancouver to 37% higher in Prince George. But for the most prevalent flat roof types (i.e., "insulation entirely *above* deck"), the relative differences range from 20% - 69% higher.

- ↑ *Wall R-value:* The NECB overall wall requirements are significantly more stringent than all 90.1-2010 wall types, except for possible residential wood stud construction in some Lower Mainland locations. For instance, comparing ASHRAE 90.1 to the NECB using estimated market wall type percentages for non-residential construction, the NECB requirements range from 13% higher in Vancouver to 64% in Prince George. The wall types arguably facing the biggest challenges would be for metal-framed walls.

- ↑ *Exposed Floor R-value:* The NECB exposed floor insulation requirements are significantly higher than the 90.1-2010 exposed floor requirements in all cases. For instance, Vancouver requires 110% more insulation and Penticton requires 133% more insulation for non-residential construction. Moreover, the most prevalent "mass" floor construction varies from 125% - 149% higher for the NECB versus ASHRAE's non-residential classification (residential construction is closer, but the NECB still is at least 28% higher than ASHRAE).

- ↑ *Below-Grade Walls:* The NECB requirements for below grade walls are more stringent than with ASHRAE, ranging from 25% more stringent in Vancouver to 62.5% more stringent in Prince George for non-residential construction.

- ↑ *Floors on ground:* The NECB requires more insulation with a configuration many designers and builders do not follow, especially for non-residential classifications and floors with imbedded heating. For the latter, they are to be insulated under their full area (as with the MNECB). The NECB requires at least R-7.5 insulation extending vertically four feet around the perimeter whereas ASHRAE does not even require insulation in many cases (e.g., unheated slabs in Vancouver and Penticton)

- *Window U-value:* The NECB provides a single overall fenestration thermal performance for each climate zone versus ASHRAE with four glazing types. Based on an estimated market mix of fenestration types, the NECB overall glazing performance ranges from 31% higher in Vancouver to 64% higher in Prince George. Note that vinyl and fiberglass framed windows typically installed in low-rise residential applications are lower for ASHRAE than the NECB. However, some curtainwall and operable metal framed windows (e.g., mostly glazed "entrance door") would have difficulty meeting the NECB requirements.

- ↑ *Skylight U-value:* The NECB provides for significantly higher prescriptive requirements than for ASHRAE. The NECB references the same U-value requirements as for vertical windows, which would be quite problematic to meet in many situations.

- *Solar heat gain (shading coefficient) requirements:* The NECB has no requirements for the SHGC or SC, unlike ASHRAE.

Mechanical

The following are the notable differences of the NECB with ASHRAE 90.1-2010 concerning HVAC and service water heating (NECB Parts 5 and 6, respectively).

- *Vestibule maximum temperature control:* The NECB has a new prescriptive requirement for controlling vestibules such that the space temperature is limited to 15°C, whereas ASHRAE has no such provision.

- *Heat recovery requirement inappropriately based on exhaust sensible heat content:* The NECB bases the requirement of applying 50% effective exhaust heat recovery on the heat content of the exhaust air stream, which is determined based on the 2.5% heating design temperature. This doesn't necessarily make sense for systems with relatively low percentage of outside air. For instance, in Vancouver, systems with exhaust air levels over 8900 cfm (4200 L/s) would require heat recovery. For an air system that delivers a minimum of 30,000 cfm, the outside air percentage equates to nearly 30%. Thus, the mixed air temperature without heat recovery for systems with reheat (e.g., typical hospital systems) might be about (70% x 75°F +

30% x 19°F) = 58°F at rarely occurring design conditions; it would only be higher at higher OA temperatures. Thus, the heat recovery would have to be by-passed all the time to avoid re-cooling the supply air to satisfy the warmest zone.

- *Exhaust heat recovery effectiveness:* NECB dictates 50% sensible heat recovery effectiveness, whereas ASHRAE dictates 50% total effectiveness (i.e., on enthalpy), making the NECB less stringent in this regard. Most systems are rated for at least this effectiveness and hence, should not be a concern either way.

- *Exhaust heat recovery:* For most cases *except residential situations* (see below), the NECB is less stringent than ASHRAE 90.1 for when (i.e., at what size of air system) heat recovery is required:
  - Coastal climates generally require heat recovery applied to smaller air systems when the outside air level is 50% (e.g., for Vancouver, nearly 18,000 cfm for the NECB versus 26,000 cfm for ASHRAE 90.1). However, at 60% O/A and above, ASHRAE is more stringent in that it requires heat recovery applied to smaller systems than for the NECB.
  - Southern Interior climates would generally require heat recovery applied to larger air systems when the outside air level is 30% for climates that are classified as "moist" by ASHRAE (e.g., for Kelowna, over 22,000 cfm for the NECB versus 5,500 cfm); this disparity only widens as the O/A amount increases.
  - However, Southern Interior climates classified as "dry" in Zone 5 (5C) by ASHRAE, the NECB would be more stringent below 70% O/A since ASHRAE doesn't require heat recovery, yet it would be less stringent above 70% O/A (e.g., for Kamloops, 7,800 cfm for the NECB versus 5,000 cfm for ASHRAE).
  - Northern Interior climates would require heat recovery applied to larger air systems when the outside air level is 30% for colder climates (e.g., for Prince George, nearly 16,000 cfm for the NECB versus 2,500 cfm); above 50% O/A, ASHRAE requires heat recovery no matter how small the air system is (e.g., for Prince George, the NECB wouldn't require heat recovery for systems below 9400 cfm at 50% O/A).

- *Specialized system heat recovery:* The NECB does not require heat recovery for "specialized exhaust systems," whereas ASHRAE has provisions that apply to laboratory and kitchen exhaust systems.

- *Heat recovery in multi-unit residential buildings (MURBs):* The NECB's provisions for exhaust heat recovery applied to central air systems serving MURBs are the same as previously referenced for any other air system. However, the NECB does not provide for the same exception that ASHRAE allows for situations "where the largest source of air exhausted at a single location at the building exterior is less than 75% of the design outdoor air flow rate." At first glance, this appears to make the NECB significantly more stringent than ASHRAE for most typical MURB air system configurations. However, the NECB is based on "the exhaust air system" in determining if the associated sensible heat content is large enough to dictate heat recovery. Thus, most MURB configurations with individual suite exhaust would presumably not require heat recovery, depending on how heat recovery requirements for *dwelling units* is interpreted (see below).

- *Heat recovery in dwelling units:* The NECB calls for special exhaust heat recovery provisions that apply to the small systems that would serve residential units, whereas ASHRAE is typically limited to larger air systems except for the colder climates with relatively high outside air percentages (of supply air). However, the NECB provides an exception for most of the Lower Mainland and Vancouver Island (NECB zone 4) and only applies to "self-contained mechanical ventilation system[s]." Hence, typical MURBs with rooftop mechanical ventilation systems would presumably not require heat recovery under the provisions of NECB Section 5.2.10.4.

- ↑ *Heat recovery from dehumidification applied to pools:* The NECB has more explicit requirements which apply to pools. ASHRAE provides an exception to pool air systems from requiring exhaust heat recovery if employing "energy recovery in series with the cooling coil." However, how much heat must be recovered is not indicated in ASHRAE whereas the NECB stipulates 40% of the sensible heat from the exhaust must be recovered. Note that one of the most common methods to satisfying the requirement for pool covers (in the DHW sections) is to utilize "site-recovered energy" from the pool exhaust. Hence, new projects very commonly exceed this provision for heat recovery to meet the exception to satisfying the requirement for pool covers.

- ↑ *Heat recovery from ice plants in arenas and curling rinks:* The NECB calls for applying recovered rejected heat from ice plants to serve space or service water heating, but is not specific regarding how much of the rejected heat should be utilized. It only indicates "to the extent that the heat recovered can by used...," which seems relatively loose. However, ASHRAE has no such provisions dictating any level of utilization of rejected heat from ice arena and curling rinks.

- ↓ *Fan power limit:* Differences exist in how the NECB and ASHRAE calculate the maximum allowable fan power. ASHRAE is more logical as it has more allowances for fan system components that would affect fan power (e.g., filtration, heat recovery, fume hoods, etc.) and hence, is more appropriate for wider range of conditions. In either case, the provisions are not onerous for the most part – an exception might be with the NECB for systems requiring a high degree of filtration, heat recovery, fume hoods, etc. (e.g., hospital and lab systems).
  - *Constant volume* fans are limited in the NECB to 1.6 W per L/s, or 0.00101 bhp/cfm, versus Option 2 of ASHRAE 90.1 which may be as low as 0.00094 bhp/cfm for simple air handlers. However, the limit under ASHRAE quickly increases to over what the NECB allows with added components such as ducted return/exhaust system, filters, heat recovery, etc.

- ↓ *Variable volume* fan systems are limited to 2.65 W per L/s, or 0.00167 bhp/cfm with the NECB, versus ASHRAE 90.1 as low as 0.0013 bhp/cfm, but increasing to 0.00193 for a ducted return/exhaust system with a MERV 13 filter and heat recovery (run-around loop). However, with only ducted return/exhaust, ASHRAE is a fair bit lower than the NECB at 0.00142 bhp/cfm, and is still lower when adding most common filter types.

- ↓ *Part-load power requirements for VAV fan systems:* The NECB provision for lowering fan power to 30% at half of the design flow kicks in at 33 hp, whereas ASHRAE 90.1 applies at only 10 hp. At 10 hp, the NECB only dictates 45% fan power drop at half the flow. Note that this isn't considered significant since we see VSDs applied quite commonly between 10 - 33 hp, with the same variable flow control ASHRAE dictates (or better).

- ↓ *Damper stipulations:* Provisions in ASHRAE 90.1 are mandatory whereas they have been moved to the prescriptive sub-section in the NECB.

- *Economizer requirements:* Economizers are required starting at 3179 cfm and 5.7T with the NECB, versus 4.5T for most systems in ASHRAE 90.1, except for computer rooms starting at 5.4 - 11.3T.

- *Controls associated with reheating or recooling:* The NECB continues to reference the 0.4 cfm/sf minimum supply air flows of the MNECB's and previous versions of ASHRAE 90.1. ASHRAE 90.1-2010 has advanced these provisions to align with ASHRAE 62.1 and ASHRAE 55, which sometimes dictate applying higher minimum air flows in order to reduce outside air requirements and/or provide adequate comfort levels.

- ↓ *Demand controlled ventilation:* Unlike the NECB, ASHRAE 90.1 has mandatory requirements for controlling ventilation based on occupancy – something which the 2010 version made more stringent than in previous versions.

- ↑ *Boiler efficiency:* The NECB references what is typically considered mid-efficiency equipment ranging from about 83-85% efficiency, whereas ASHRAE is at 77-82% minimum efficiency levels (oil-fired boilers are slightly higher).

- ↑ *Boiler part-load performance:* The NECB requires that boiler plants over 600 MBH (176 kW) provide for smaller, multiple boilers, staged boilers and/or fully modulating boilers, which can significantly improve part-load performance. ASHRAE has no such provisions. The NECB requirement is not considered significant as we find the BC market already follows these practices (or better).

- ↑ *Furnace efficiency:* The NECB efficiencies are slightly higher for all categories, with the most significant improvement for smaller gas-fired furnaces effectively required to be condensing units at an AFUE of 92.4% versus ASHRAE's 78%.

- ↓ *Air conditioning equipment performance requirements:* The NECB is organized differently and harder to use. For instance, some equipment references a different CAN/CSA standard (e.g., ground- and water-source heat pumps) that must be purchased -- typically only to find that effectively the same or older standards are applied as for ASHRAE. Another example concerns how it is not clear for heat pumps when the cooling versus heating COP is being referenced. Further, more equipment types appear in ASHRAE, although the NECB has some categories that are missing and should be listed (e.g., unitary air cooled heat pumps under 21T).

  In some cases, the NECB efficiency levels are the same or lower than ASHRAE 90.1-2010, which does not cause a concern since the North American industry produces equipment satisfying ASHRAE standards. However, in some cases, the NECB is more stringent, such as the following significant situations:

  - ↑ *AC units under 5.4T* – Split systems are 15% higher than ASHRAE 90.1 and single package 8% higher.
  - ↑ *Medium size AC units (21 - 63T)* – Air cooled types up to 12% higher; unlike ASHRAE the efficiency depends on the capacity of the heating section, with lower capacities demanding higher cooling efficiencies.
  - ↑ *Large HP units (>21T)* – Air cooled types up to 14% higher; unlike ASHRAE the efficiency depends on the capacity of the heating section, with lower capacities demanding higher cooling efficiencies. Interestingly, the corresponding heating efficiencies are about the same, although this would make a bigger energy difference in BC.
  - *Packaged terminal AC and HP units:* Efficiencies are the same or lower than ASHRAE, but there appears to be an error in the efficiency formulas for calculating the cooling COP.

- ↓ *Pipe insulation for heating systems:* The NECB mostly provides for less pipe insulation than ASHRAE, especially for higher temperature applications. Some of the specific differences for the more common building heating configurations include:

  - ✓ The NECB requires at least 0.5" less pipe insulation than ASHRAE at a mean temperature rating of 125° for systems operating at 141°-200°F.
  - ✓ The NECB requires 0.5" less pipe insulation than ASHRAE for pipe sizes from 1.5 - 4" for systems operating at 105°-140°F, except for service water piping where the NECB inconsistently provides for the 2.5" - 4" pipe size the same as ASHRAE 90.1.

- *Pipe insulation for cooling systems:* For chilled water system operating at 40°-60°F, the NECB requires 0.5" more pipe insulation than with ASHRAE for pipe sizes below 1". Note that the comparative pipe insulation levels for cooling systems operating below 40°F (5°C) differ but cannot be easily compared since the levels are provided for difference mean temperature ratings, with the NECB referencing 24°C (75°F) and ASHRAE referencing 50°F.

- ↓ *Pumping Requirements:* The previous MNECB mandatory provisions on pumping have not changed but are still relative comparable to ASHRAE's requirements, except that ASHRAE lowered requirements on maximum flow rates and VSDs applied to chilled water systems (to only 5 hp).

- ↓ *Water-to-water heat pumps:* Unlike ASHRAE 90.1, the NECB has no provisions for hydronic heat pumps and water-cooled unitary air conditioners to be outfitted with variable flow capability (e.g., two-position valves); this applies to units connected to a pump system exceeding 5 hp.

- *Service water rating efficiency discrepancies:* For some of the ratings, it is apparent that the volume is intended to be in liters and not gallons as indicated at the bottom of the table (e.g., small gas-fired equipment), but then for others it's exactly the same as for ASHRAE's IP version (i.e., in gallons).

- *Service water heating (SWH) equipment efficiencies:* The NECB appears generally to be the same as ASHRAE, although the classification of equipment is not quite the same with some notable differences:

  - ↑ *Boilers* – Unlike ASHRAE 90.1, the NECB does not list natural gas boilers for SWH, but if the intent is that they are the same as referenced in the HVAC section, the performance requirements are higher than for ASHRAE.

  - ↓ *Small electric service water heater ratings appear inappropriate* – The formulas provided for tank heaters below 12 kW result in efficiency levels of only 37.6 - 54.3, which we assume is supposed to be percent and the volume is converted to US gallons as indicated in the table note. If it is indeed percent, this is significantly worse than ASHRAE (or any equipment that should be available on the market). Even if the volume factor is actually supposed to be applied to liters, the efficiency factors still are significantly lower than ASHRAE except for at the largest volume for "bottom inlet" equipment.

  - ↑ *Heat pump water heaters* – The NECB lists an efficiency factor of only 2.1 but this is versus ASHRAE at an unbelievably low 0.90 or less. Note that ASHRAE's rating for heat pump "electric water heaters" is much worse than units actually available on the market and, in fact, is curiously the same as for ASHRAE's rating for small resistance "table top water heaters." Also, note that ASHRAE lists "heat pump pool heaters" at a 4.0 COP; the NECB has no such rating category.

- ↑ *Showerheads and faucets:* Minimum requirements concerning shower and faucet flows are introduced in the NECB, whereas ASHRAE has no such provisions. The NECB also provides self-closing control requirements on showers served by a single temperature control (e.g., as in some locker rooms). The added requirements are not significant since they are already standard practice.

- ↓ *Pool covers no longer required for swimming pools:* The NECB has done away with this provision, including the exception to satisfy the stipulation with site-recovered heat or solar energy. ASHRAE still maintains this stipulation. (This exclusion would be even less stringent if the provision for exhaust heat recovery, including on pool dehumidification, did not exist in the NECB.)

- ↓ *Service water booster pumps:* Unlike with ASHRAE 90.1, NECB has no provisions for automatically controlling the pump operation based on pressure required at the critical fixture, including shutting off the pumps when there is no demand.

- *Trade-off compliance methods:* New alternative compliance approaches for both the HVAC and service water heating (SWH) parts have been added. They are unique and completely different from what is provided in ASHRAE 90.1 for an alternative compliance path, with ASHRAE only having a seldom used "Simplified HVAC Compliance Option" (and no alternative method for SWH). These trade-off methods reference a "Trade-Off Index" that must equate to greater than zero to demonstrate compliance. The approach is onerous and involved, especially for the HVAC part, which we cannot see anyone applying unless the procedure is codified into a user-friendly program.

Lighting

Relatively few differences exist in the NECB versus ASHRAE 90.1-2010 concerning the lighting section (NECB Part 4). Note that lighting follows the envelope section with the NECB but appears after HVAC, service water heating and power in ASHRAE 90.1-2010 (Section 9).

- ↑ *Luminaire wattage:* The NECB has adopted the ASHRAE 90.1-2010 requirements for calculating total luminaire wattage, including providing allowances for track lighting. The NECB defines the same space types as ASHRAE except for one notable difference – it excludes furniture-mounted task lighting whereas the NECB includes this task lighting.

- ↓ *Interior Lighting Power Allowances:* Both ASHRAE and the NECB employ the Building Area method and the Space-By-Space method for calculating the prescriptive interior lighting power allowance (LPA). The LPAs are nearly all identical except for a few space type a few spaces where the NECB allowance is slightly higher than the 90.1-2010 allowance. Locker rooms and electrical/ mechanical rooms are two of these spaces, for instance.

- ↑ *Room geometry adjustment on the LPA:* ASHRAE 90.1-2010 includes a Room Cavity Ratio (RCR) adjustment allowance on the lighting power allowance. The RCR provides for an increase in the LPA of up to 20% for cases where the lighting task is relatively far removed from the lighting source, relative to the room geometry. The NECB does not include such an adjustment factor based on the room geometry,

- ↓ *Lighting alterations:* Unlike ASHRAE 90.1, the NECB does not include lighting alterations in its scope. As lighting alterations typically are not monitored closely, this difference will have little impact.

- ↑ *Gross lighted area:* Unlike ASHRAE 90.1, the NECB excludes elevator and service shafts from the area calculation, but this difference will rarely be noted and typically is not very significant.

- ↓ *Parkade lighting controls:* ASHRAE 90.1-2010 defines mandatory requirements for occupancy and daylighting sensors for parking garage lighting, whereas the NECB does not address lighting requirements for parking garages. This is significant because such lighting controls are not standard practice.

- *Exterior Lighting:* The NECB exterior lighting requirements for power allowance and control are very similar to those in ASHRAE, with both standards having adopted the "Exterior Lighting Zone" concept. The higher the zone number, the higher the exterior lighting power allowance (e.g., Zone 0 is for undeveloped areas such as for parks and forest land; Zone 5 is intended for high activity commercial and industrial districts). The NECB, however, does not include the ASHRAE definitions for tradable and non-tradable surfaces, making calculations for the exterior power allowance somewhat less onerous for the NECB.

Power, Motors and Other Equipment

Relatively little of significance has changed between the MNECB and NECB versions for Part 7, other than referencing of updated CSA standards for transformers and motors.

- ↓ A couple stipulations that ASHRAE addresses which do not appear in the NECB are:
  - *Receptacle load control (wiring):* With ASHRAE 90.1, non-critical receptacle loads are to be separated and automatically controlled (turned off) based on occupancy or scheduling, which infers they need to be placed on separate circuits.
  - *Elevators:* ASHRAE 90.1-2010 introduced lighting and ventilation power restrictions on elevator cabs.

- ↑ On the other hand, the NECB effectively maintains the MNECB requirements to separately monitor the electrical energy use of "individual tenant or dwelling units," which is already common practice in BC.

CONCLUSION

The NECB and ASHRAE 90.1-2010 are relatively similar but have some significant differences. The NECB is more stringent for the envelope requirements, especially for non-residential construction, but we find ASHRAE's requirements are already at or above life-cycle economic levels as further increasing insulation levels provides diminishing savings. Lighting is very similar with both standards being mostly equivalent. ASHRAE is a bit more stringent with restrictions on parkade lighting controls but the NECB has fewer allowances on interior lighting power levels.

Mechanical stipulations are more mixed in the comparative stringency. Of significance, exhaust heat recovery is generally required for smaller non-residential systems for ASHRAE, but the NECB requires heat recovery in some cases where ASHRAE does not due to the percent of outside air delivery compared to the maximum supply air flow. And ASHRAE dictates heat recovery applied to lab and kitchen exhaust systems when the NECB does not. Also of significance, is the lack of requirements with the NECB for demand controlled ventilation and pool cover provisions for swimming pools.

Based on assessments from ASHRAE and NRCan's own indications that the NECB is 25% more efficient than the MNECB 97, this infers that ASHRAE should result in significantly higher savings. From ASHRAE's assessment that 90.1-2010 is 30% more efficient than the 2004 version [Thorton, PNNL], combined with our past equivalency assessments, this would peg ASHRAE at roughly 23% more efficient than the NECB. We tend to disagree with the claim that ASHRAE would provide for more savings.[3] Further, we question the savings that have been proclaimed ASHRAE 90.1-2010 would provide – at least for the British Columbia (and Canadian) conditions. One main reason stems from consistency applied with outside air levels, as the PNNL ASHRAE study included reductions in outside air attributed to changes in ASHRAE 62.1, which presumably would also apply to the NECB[4].

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[3] In an earlier release of this document, we suggested ASHRAE 90.1-2010 would provide for slightly higher savings than the NECB 2011. However, our further review and quantitative assessment indicates that the NECB should provide for lower energy use.

[4] Details behind the "Heads Up Energy Efficiency Newsletter" article claiming 25% improvement over the MNECB 97 were not available to ascertain if changes to outside air standards were included in the assessment, as they were with the PNNL ASHRAE study. However, based on past similar studies, we assume this aspect that is not part of the Code was kept neutral (i.e., not changed).

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Attachment A: Prescriptive Envelope Comparisons

Table A-1 Air Leakage Rates

	Air Leakage Rate L/s/m^2			
	NECB		2010	
Building Component	Pressure Pa	Leakage	Pressure Pa	Leakage
Metal and glass curtain walls	75	0.2	75	0.3
Fixed windows and skylights	75	0.2	75	1
Operable windows and skylights	75	0.5	75	1.5
Doors	75	0.5	75	5
Revolving Doors & others	75	5	75	5

Note: "others", as noted in the NECB, includes overhead doors, main entry exterior doors tested as a complete unit, automatic sliding doors.

The following tables compare the NECB with 90.1-2010 non-residential buildings. Residential buildings have some minor differences, mainly slightly better thermal performance requirements for some components depending on climate zone.

Table A-2 Exterior Walls

	NECB			ASHRAE 90.1-2011					
ENVELOPE COMPONENT									
Wall Overall R-Value	Zone	Usi	R_o	Zone	Mass	Metal	Steel	Other	R_o
Vancouver	4	0.315	18.0	5	40%	5%	50%	5%	13.8
					11.1	14.5	15.6	15.6	
Penticton	5	0.276	20.6	5	30%	15%	35%	20%	14.1
					11.1	14.5	15.6	15.6	
Prince George	7A	0.210	27.0	7	30%	15%	30%	25%	16.4
					14.1	17.5	15.6	19.6	
Dawson Creek	7B	0.210	27.0	7	30%	15%	20%	35%	16.8
					14.1	17.5	15.6	19.6	

Table A-3 Roofs

	NECB			ASHRAE 90.1-2011				
ENVELOPE COMPONENT								
Roof Overall R-Value	Zone	Usi	R_o	Zone	Above	Metal	Other	R_o
Vancouver	4	0.227	25.0	5	80%	10%	10%	22.2
					20.8	18.2	37.0	
Penticton	5	0.183	31.0	5	60%	10%	30%	25.4
					20.8	18.2	37.0	
Prince George	7A	0.162	35.1	7	55%	15%	30%	25.6
					20.8	20.4	37.0	
Dawson Creek	7B	0.162	35.1	7	40%	10%	50%	28.9
					20.8	20.4	37	

Table A-4 Exposed Floors

	NECB			ASHRAE 90.1-2010				
ENVELOPE COMPONENT								
Exposed Floor R-value	Zone	Usi	R_o	Zone	Mass	Steel	Other	R_o
Vancouver	4	0.227	25.0	5	80% 13.5	10% 26.3	10% 30.3	16.5
Penticton	5	0.183	31.0	5	60% 13.5	10% 26.3	30% 30.3	19.8
Prince George	7A	0.162	35.1	7	55% 15.6	15% 26.3	30% 30.3	21.6
Dawson Creek	7B	0.162	35.1	7	40% 15.6	10% 26.3	50% 30.3	24.0

Table A-4 Glazing

	NECB			ASHRAE 90.1-2011					
Fenestration Vertical									
Glazing Percent	40%			40%					
Window U-value	Zone	Usi	U_o	Zone	Non-Metal	Curtain/Store	Entrance Door	Other	Uo
Vancouver	4	2.4	0.42	5	20% 0.35	40% 0.45	5% 0.8	35% 0.55	0.48
Penticton	5	2.2	0.39	5	25% 0.35	30% 0.45	5% 0.8	40% 0.55	0.48
Prince George	7A	2.2	0.39	7	30% 0.35	25% 0.4	5% 0.8	40% 0.45	0.43
Dawson Creek	7B	2.2	0.39	7	40% 0.35	15% 0.4	5% 0.8	40% 0.45	0.42

Table A-5 Skylights

	NECB			ASHRAE 90.1-2011				
Skylights								
Skylight U-value	Zone	Usi	U_o	Zone	Glass, Curb	Plastic, Curb	No Curb	U_o
Vancouver	4	2.4	0.42	5	33% 1.17	33% 1.10	33% 0.69	1.0
Penticton	5	2.2	0.39	5	33% 1.17	33% 0.87	33% 0.69	0.9
Prince George	7A	2.2	0.39	7	33% 1.17	33% 0.87	33% 0.69	0.9
Dawson Creek	7B	2.2	0.39	7	33% 1.17	33% 0.87	33% 0.69	0.9