FINAL REPORT

Verification of LEED-BC v1.0 Energy Credit 1 Point Awards for Building Energy Conservation in British Columbia

prepared for

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Ministry of Competition Science and Enterprise
7th Floor, 1810 Blanshard Street
Victoria, BC V8W 9N1

Tel: (250) 952-0668
Fax: (250) 952-0666
Email: martine.desbois@gems2.gov.bc.ca

prepared by

Curt Hepting and Diane Ehret

EnerSys Analytics Inc.
2989 Delahaye Drive
Coquitlam, B.C.
Canada V3B 6Y9

Contact: Curt Hepting, President
Tel: 604-552-0700
Fax: 604-552-0713
Email: chepting@enersys.ca

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EXECUTIVE SUMMARY

In an effort to apply the U.S. Leadership in Energy and Environmental Design (LEED™) rating system to buildings in British Columbia, the LEED-BC Steering Committee and Natural Resources Canada have commissioned this study to determine how ASHRAE/IESNA Standard 90.1-1999 (ASHRAE 90.1-1999) compares to the Commercial Building Incentive Program's (CBIP's) variation on Canada's Model National Energy Code for Buildings (MNECB). Based on the analysis, this study presents an equivalency rating system that would allow LEED points to be awarded based on compliance to MNECB+CBIP rather than ASHRAE 90.1-1999, following its Energy Cost Budget (ECB) method of compliance.

To determine this equivalency, we developed prototypical "reference models" for eight key building types that represents the vast majority of new commercial building stock across British Columbia. Within each building type, we created prototype models that capture the predominant reference HVAC system configurations and account for typical new construction practices. Finally, we simulated each model using weather data from three regions within British Columbia that represent the major population centres and weather regions across the province.

The prototype MNECB+CBIP and ECB models conformed to the energy performance modelling rules of both respective standards to allow for comparison of their differences. Applying estimated market penetration factors that account for regional market shares by building type and HVAC system, we calculated the sector-wide equivalency between MNECB+CBIP and ASHRAE 90.1-1999, following LEED's policy on how to calculate new design savings.

Figure 1. Comparison of Equivalent Savings Levels

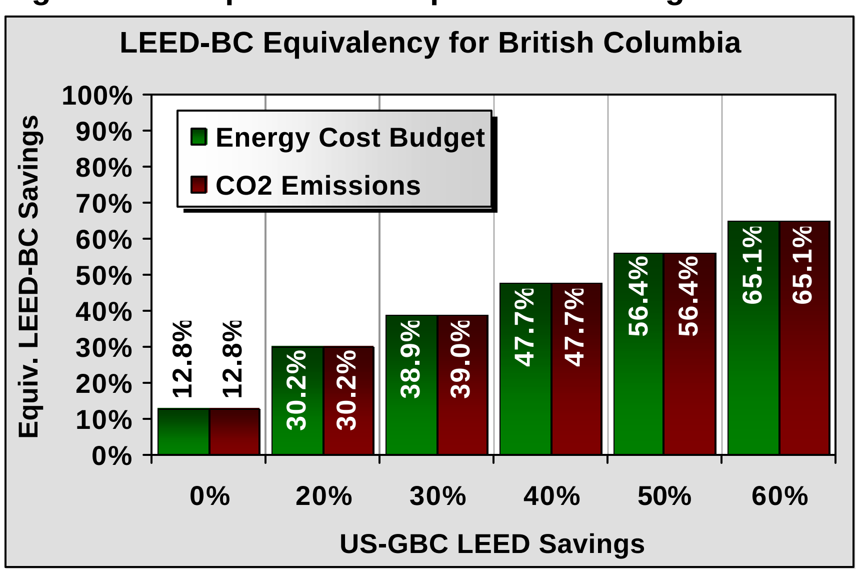


Figure 1 provides the overall result from this analysis process. This chart shows how MNECB+CBIP compares to ASHRAE+LEED using (1) energy costs applied to energy use to calculate the savings (i.e., following the "energy cost budget" method) and (2) carbon dioxide

(CO_2) emissions applied to energy use to calculate relative savings. Finally, Figure 1 projects the required savings levels for MNECB+CBIP that correspond to the point award savings bins provided by the U.S. LEED™ 2.0 system (US-GBC LEED).

As the graph shows, the MNECB+CBIP standard is nearly 13% less stringent than ASHRAE+LEED for the overall commercial building sector (results for individual building types and the different weather regions vary significantly). In other words, new designs would have to show nearly 13% savings over their respective MNECB+CBIP reference cases to even qualify for LEED. After this point, the equivalent credit awards shown on the bars would correspond to the respective 20%, 30%, 40%, 50% and 60% savings levels provided by LEED™. For instance, to receive at least 2 points (assuming the same scoring system as LEED™ 2.0), new designs would have to save over 30% for an equivalent adaptation of LEED for British Columbia (LEED-BC).

Assuming LEED-BC would follow an equivalent scoring system as LEED™ 2.0 from the U.S., a representative point awards table was generated using the results from this study. Following the same approach as illustrated with Table 8 in the Energy & Atmosphere section of the *LEEDÔ Reference Guide 2.0*[1], we generated the following *sample* "LEED-BC Point Interpolation Table." This table could provide a point awards system for energy savings for LEED-BC that would be equivalent to the U.S. LEED™ 2.0 system.

Percent Savings		Points
LEED-BC	LEED 2.0	
< 30%	< 20%	0
30.0 - 34.1%	20.0 - 24.5%	2
34.11 - 38.2%	24.51 - 27.5%	3
38.21 - 42.3%	27.51 - 32.5%	4
42.31 - 46.4%	32.51 - 37.5%	5
46.41 - 50.5%	37.51 - 42.5%	6
50.51 - 54.6%	42.51 - 47.5%	7
54.61 - 58.7%	47.51 - 52.5%	8
58.71 - 62.8%	52.51 - 57.5%	9
> 62.8%	> 57.5%	10

As indicated by the table (and the previous graph), no points would be awarded until 30% savings is reached. This is 10 percentage points higher than LEED™ 2.0. At the highest energy savings level, the maximum 10 points is realized if savings exceed MNECB+CBIP by 63.3%. In contrast, the highest level for LEED™ 2.0 occurs above 57.5% savings—a difference of nearly six percentage points with the equivalent LEED-BC savings level.

The remainder of this report discusses the analysis process, results and assumptions, including results by building type and region.

[1] Page 133.

INTRODUCTION AND BACKGROUND

The LEED-BC Steering Committee and Natural Resources Canada (NRCan) are seeking to establish a British Columbia–wide equivalency that represents the difference in energy consumption between (1) reference modelling following the CBIP[2] application of the Model National Energy Code for Commercial Buildings (MNECB+CBIP) requirements in Canada, and (2) reference modelling following the LEED[3] application of the ASHRAE/IESNA[4] Standard 90.1-1999 (ASHRAE+LEED). The committee suggested that an equivalency be determined by applying this comparison to a representative selection of British Columbia building types and climatic regions. The equivalency will be used to first show compliance, and then to adjust the table of point awards for Energy Credit 1.

We applied the CBIP variation to the MNECB because this is the compliance standard most widely used by designers concerned with creating an energy efficient design. More significantly, the CBIP version is more stringent than MNECB.

The work had the primary goal of ensuring that LEED-BC Energy Credit 1 point awards are equal to or more stringent than point awards resulting from use of ASHRAE/IESNA Standard 90.1-1999 Section 11 (ASHRAE 90.1-1999), as elaborated by the LEED v.2.0 Reference Guide. The LEED-BC point awards could then be determined from energy modelling following the MNECB/CBIP simulation requirements rather than ASHRAE 90.1-1999. A secondary goal of this project was to establish an approach that can facilitate future comparison of the relative building energy performance following ASHRAE 90.1-1999 and the MNECB+CBIP modelling requirements. As a result, the information and methodology developed to fulfill the LEED-BC goal can act as a beneficial foundation for extension to other Canadian regions and building types.

The LEED-BC committee also expressed interest in using the LEED system to influence building designers to make decisions based on anticipated incremental carbon dioxide (CO_2) emissions instead of energy costs. Hence, as a later objective, we were requested to evaluate the implications of applying CO_2 emission factors in determining equivalency.

This report discusses the methodology followed for applying the equivalency analysis to British Columbia building stock and presents the results.

[2] CBIP is the acronym for Natural Resources Canada's (NRCan's) "Commercial Building Incentive Program."

[3] LEED™ stands for "Leadership in Energy and Environmental Design" and is an environmental building rating system copyrighted by the U.S. Green Buildings Council.

[4] ASHRAE is an acronym for the American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc. IESNA is an acronym for the Illuminating Engineering Society of North America.

METHODOLOGY

EnerSys used prototype DOE2.1e models from Natural Resources Canada's CBIP *Technical Guidelines* and Screening Tool as a core component in this analysis effort. The prototype models were developed to represent typical design practices for new buildings across different regions in Canada, including several regions in British Columbia. The model sets included both proposed building design prototypes and MNECB+CBIP Reference case model prototypes. For this study, we developed models from these existing prototypes that serve as equivalent ASHRAE+LEED Budget cases. We compared the energy use from these ASHRAE+LEED reference models to corresponding MNECB+CBIP reference models to help establish an equivalency rating system between the standards.

The following sections describe key issues and our approach for verifying the difference in energy consumption when adhering to the ASHRAE+LEED energy performance modelling approach versus an equivalent MNECB+CBIP approach.

MNECB+CBIP VS. ASHRAE+LEED ANALYSIS ISSUES

The energy performance analysis approach for establishing the Reference case energy use for MNECB+CBIP and the Budget case energy use for ASHRAE+LEED is very similar overall. There are, however, several differences between the standards. Appendix A provides a detailed description of the similarities and differences between the standards by building characteristic. This appendix also provides insights into the analysis approach applied to developing the Reference models.

There are several differences between the standards that must be appreciated and evaluated for their overall impact on this policy-level study. These include:

(1) Differences between how the relative energy performance is derived for the MNECB+CBIP Reference case versus the ASHRAE 90.1-1999 Budget case.

(2) Application of the proposed design's relative energy performance following LEED calculation procedures using a MNECB+CBIP Reference case.

MNECB+CBIP Reference vs. ASHRAE 90.1-1999 Reference

Overall, ASHRAE 90.1-1999 is more stringent than MNECB+CBIP. The most prevalent differences between MNECB+CBIP and ASHRAE 90.1-1999 are listed in Appendix B, as they apply to each prototypical building type. The most obvious general differences between the standards are listed below.

- *Prescriptive thermal performance requirements* for windows, walls, roofs, and floors are more stringent for ASHRAE 90.1-1999 than MNECB+CBIP, in aggregate across the commercial sector. A primary reason for this assessment is based on the window conduction, which is a component of relatively high heat loss. Windows are more stringent for ASHRAE 90.1-1999 in all cases except for electrically heated situations in colder climates (which represents a relatively small market share in British Columbia)[5]. MNECB+CBIP is more stringent in most electrically heated situations (ASHRAE does not differentiate based on heating source type). MNECB+CBIP also is generally more stringent in the colder climates of British Columbia (except for windows in gas-heated situations).

- *Lighting power allowances* are generally lower for ASHRAE 90.1-1999 than MNECB+CBIP (which is based on the previous 1989 version of ASHRAE 90.1). For the office and school segments, which comprise over half of the new commercial building stock, this amounts to 22% and 15% reduced lighting energy, respectively. The multi-unit residential and hotel/motel segments are the only building types analyzed which have higher lighting levels for ASHRAE than MNECB+CBIP. Lighting loads in these building types, however, are relatively low in comparison to most other building types, thus diminishing their influence on overall commercial sector lighting energy use.

- *Heating and cooling equipment efficiencies* are more stringent for ASHRAE 90.1-1999 than MNECB+CBIP in nearly all categories of equipment[6]. In addition, ASHRAE includes provisions for controlling boilers and chillers that increase the differences.

- *Fan energy* is usually lower for ASHRAE 90.1-1999 than MNECB+CBIP due to the requirement of variable speed drives and better fan curves for most comparative Reference cases with variable air systems (i.e., VAV systems).

Besides the relatively obvious differences listed in tables for prescriptive envelope values, lighting levels and equipment efficiencies, there are potentially

[5] Note that the ASHRAE 90.1-1999 Standard is very clear about how the ECB window "U-factor shall be the minimum for the climate, and the solar heat gain coefficient shall be the maximum for the climate and orientation" (p. 58). However, the ASHRAE 90.1-1999 *User's Manual* provides an example in which the ECB case is specified using the U-value and solar heat gain coefficient (SHGC) corresponding with allocated percent of glazing. We have had indications that this latter approach is what ASHRAE intended, but no official revised interpretations have been posted. For this reason, and since most LEED projects have probably followed the what is clearly stated in the ASHRAE 90.1-1999 Standard, we adhered to applying the minimum listed U-value and maximum SHGC for the indicated climate region. For British Columbia (and Canada), this interpretation should be conservative since the U-value typically has a greater influence on energy performance than the SHGC (i.e., the heating savings from applying a lower U-value and higher SHGC typically would outweigh any increases in cooling and fan energy).

[6] MNECB is presently being reviewed for updates to HVAC equipment efficiencies.

more significant differences embodied in the budget case HVAC system definition. The most significant HVAC system differences between MNECB+CBIP and ASHRAE 90.1-1999 include:

- *HVAC system selection* for MNECB+CBIP is simpler than it is for ASHRAE 90.1-1999. MNECB+CBIP requires that one of three different HVAC system types is used in the Reference case, depending on the configuration of the proposed design. In contrast, ASHRAE 90.1-1999 has 11 different HVAC systems that may be used for the Budget case. These typically correspond more closely with the proposed design's HVAC system than do the selections for MNECB+CBIP. Furthermore, ASHRAE is ambiguous in some cases whereas MNECB+CBIP is typically much clearer for defining the appropriate Reference case system. This is an important consideration since the relative savings can vary significantly depending on the reference HVAC system. One clear example of this is for water-source heat pump (WSHP) systems. The MNECB+CBIP Reference case would use a variable air volume system with reheat (except for lodging space functions) whereas the ASHRAE Budget case would have an HVAC system with distributed water-source heat pumps.
- *Exhaust air heat reclaim* is required for ASHRAE 90.1-1999 Budget cases[7] when the outside air is above 70% of the supply airflow, whereas MNECB+CBIP does not stipulate heat reclaim in its Reference case. This *probably* (see below) does not affect offices, but would significantly affect facilities such as extended care homes and multi-unit residential, which typically have high proportions of outside air.

LEED Calculation Procedures Applied to MNECB+CBIP Reference

Another significant difference with LEED is the method for calculating the relative energy performance for the proposed design. Unlike MNECB+CBIP, LEED stipulates that the "non-regulated" general equipment loads (i.e., plug loads) are *not* to be included in the calculation that establishes the relative savings for the proposed design. This means that the equipment load must be removed from both the proposed and Reference cases before calculating the percent savings.

This nuance with LEED can be significant and influences the overall approach for establishing an equivalent table of energy credits ("equivalency table"). Since equipment levels vary among different building types, the resulting equivalency table would not be representative between LEED and MNECB+CBIP. As the proportion of equipment load increases, the savings thresholds in the

[7] ASHRAE 90.1-1999 is vague about how to apply its provision for "exhaust air energy recovery" (Section 6.3.6.1) in situations with 100% make-up air units serving typical fan coil or distributed heat pump systems. We interpreted the application of heat reclaim to only apply in situations where the air was heated to over 60°F, as indicated by one of the exceptions to this provision. We since found that our interpretation is essentially correct from an unofficial interpretation provided by ASHRAE.

equivalency table would have to increase correspondingly to maintain equivalency with the LEED standard thresholds. The discrepancy in the two Standards' savings calculation would make it easier for buildings with relatively high equipment loads to attain the same savings level compared with those having relatively low equipment loads. This would provide for an unequal comparison of British Columbia adaptation of LEED (LEED-BC) with the U.S. LEED rating system since LEED removes the equipment component in the calculation of relative savings.

Recognizing this discrepancy in the savings calculation between the two standards, we netted out the plug load equipment end-use energy as part of the equivalency analysis. This makes the analysis and resulting equivalency table more straightforward and consistent with LEED. However, it requires that users subtract out the proportion of energy cost[8] which corresponds to the equipment load's relative share of the total energy use. This removal of the equipment's proportionate share of the energy cost would have to be carried out for all applicable fuel types (see "Calculating LEED™ energy performance" starting on page 128 of the *LEED™ Reference Guide 2.0*).

APPROACH

In determining the equivalency between MNECB+CBIP and ASHRAE 90.1-1999, we made use of the models originally developed for Natural Resources Canada's CBIP technical guidelines. These models were developed as prototype representations of the average new commercial building stock across Canada, including regional distinctions for British Columbia.

Overview

For the purposes of this policy-level study, the prototype building models required little, if any, updating to reflect current construction trends in British Columbia. Therefore, they made a good starting point for establishing Reference case and Budget case differences between MNECB+CBIP and ASHRAE 90.1-1999, particularly since they were developed to comply with MNECB+CBIP Reference modelling requirements. This provided for a consistent resource upon which the ASHRAE 90.1-1999 Budget models were built. In addition, by using NRCan's models, the methodology of this study can more easily be applied to the rest of Canada (a possible desire of NRCan).

[8] Alternatively, LEED-BC may propose to base its energy budget and relative savings on CO_2 emissions instead of energy costs. We conducted a cursory investigation of the implications of having the equivalency analysis based on emissions as an additional effort to this study.

We examined the building types called out in the original scope for this study since they capture the large majority of commercial floor area in the Province (and across Canada).

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

With the exception of facilities that have large commercial low-temperature refrigeration loads (e.g., grocery stores, ice rinks), other commercial building types are relatively well represented *overall* using the above building types. In other words, the aggregate combination of the above building types, and their associated typical configurations, should prove representative across the entire commercial market. This would include mixed-use facilities that are essentially comprised of the above major building types.

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, using Vancouver weather data (MNECB Region A, ASHRAE T.B-18). Note that the conditions and requirements for the Vancouver Island region (MNECB Region C) are nearly identical to that of the Lower Mainland
- Southern Interior, using Summerland weather data (MNECB Region B [BC Gas], ASHRAE T. B-17)
- Northern Interior, using Prince George weather data (MNECB Region B [PNG], ASHRAE T. B-22)

These weather regions provide for a relatively wide degree of representative weather variations across British Columbia. Additionally, the specific weather sites within the above regions (from a maximum of ten available) represent the major population centres in British Columbia.

The final step in establishing a BC-wide equivalency between MNECB+CBIP and ASHRAE 90.1-1999 involved aggregating the various models together as a representation of the entire commercial British Columbia market. We applied market penetration factors that represent the estimated floor area shares to each building type. Within each building type, we also applied estimated regional market shares for the building stock. Finally, we applied estimated market share factors to the different HVAC system reference configurations, including the expected distribution of electric versus gas space and domestic hot water (DHW) heating.

Process

As a first task, we generated side-by-side comparisons of the overall MNECB+CBIP modelling requirements to those of ASHRAE 90.1-1999, commenting on the significance of each difference. These comparisons appear in Appendix A, with comments relating to the relative differences, including approach and analysis issues. We used this initial assessment of the differences to determine how the standards vary and the relative significance in the differences. This was an important first step in creating adequate prototype Budget case models, which provided for a satisfactory segment-wide energy use representation. At the same time, we had to constrain the number of different possible scenarios to those that are most prevalent. This is an important consideration for maintaining a reasonable scope of work because the various possible configurations are quite vast (e.g., different reference system types, wall constructions, roof constructions, cooling equipment efficiencies, zoning arrangements, etc.).

Our next task involved applying the significant characteristics listed in Appendix A to each specific building prototype. These key attributes for the MNECB+CBIP Reference and comparable ASHRAE 90.1-1999 Budget cases are listed in Appendix B, along with a summary description of the baseline building model. A key component of this task was to identify the major HVAC system characteristics and differences *typically* found in the new construction market. As pointed out earlier, ASHRAE 90.1-1999 often references a different HVAC system than does MNECB+CBIP. In certain cases, this represented a significant difference (e.g., for non-lodging proposed cases with a distributed heat pump system, ASHRAE references a distributed heat pump system whereas MNECB+CBIP references a VAV system with reheat).

Next, we created the appropriate ASHRAE 90.1-1999 Budget case models (or “projects”) using the DOE2 energy performance simulation program, combined with the CBIPTest software used to develop prototypes for the CBIP Web Screening Tool. After performing the simulations, we gathered the annual energy use by fuel type for the “regulated end-uses” into a LEED-BC equivalency analysis workbook configured for each building type.

Within this workbook, we applied appropriate regional electricity and natural gas rates to the energy performance results. We used regional, average blended rates for consistency between the corresponding MNECB+CBIP and ASHRAE+LEED models since both standards require that the proposed and Reference cases use the same rates. A blended rate, as long as it is applied consistently to all cases, gives an accurate representation of energy costs for this study because it mitigates the effects of fuel price fluctuations and rate type variations. Furthermore, LEED indicates to use average regional (i.e., by U.S.

state) energy costs "in absence of a local utility rate schedule."[9] For this type of policy level analysis, it is impossible to precisely specify full rate tariffs since a host of different structures apply and are continually changing.

As an additional sensitivity, we also applied CO_2 emission factors[10] by fuel type to determine the resulting equivalency using an alternative basis of comparison. Applying emissions instead of energy costs to influence savings levels is being considered as a variation to the LEED system for LEED-BC.

We also applied estimated market penetration factors when aggregating the reference model results as described below.

1) The relative proportion of the building stock floor area within each of the three regions was based on figures provided through past BC Hydro studies[11]. Table 1 below provides the estimated regional market share factors. We applied these factors in the weight-averaging process to the prototype's energy use requirements in order to produce overall results by region and for the entire Province.

Table 1. Regional Market Penetration Factors

Building Type	Overall B.C.	Lower Main-land	South Interior	North Interior	Notes
School	18%	15.9%	20.4%	26.7%	From BC Hydro, provided for the "Energy Analysis and Cost Assessment of the Workers' Compensation Board's Proposed Indoor Air Quality Standard," EnerSys Analytics Inc., Oct. 1996.
Large Office	4%	5.1%	1.7%	0.5%	
Small Office	31%	32.2%	30.2%	25.4%	
Non-Food Retail	9%	9.4%	9.9%	9.7%	
Non-Food Retail	9%	9.4%	9.9%	9.7%	
Extended Care	3%	2.7%	2.7%	2.7%	Information for lodging facilities was not readily available; hence, we used the overall average for the above five building types.
Hotel/Motel	9%	8.6%	8.6%	8.6%	
MURB	17%	16.7%	16.7%	16.7%	
Across B.C.	*100%*	*76%*	*11%*	*13%*	

2) The percent of natural gas heated versus electrically heated floor area within the building stock was typically based on figures provided through past BC Hydro studies[12]. In general, the proportion of electric heat seems somewhat

[9] The table of Commercial Sector Average Energy Costs by State in the Energy & Atmosphere section of the *LEED v.2.0 Reference Guide* (p. 128), provides average unit rates by fuel type.
[10] CO_2 emission factors provides by Ian Theaker: 0.525 kg/kWh applied to electric end-uses and 56.6 kg/GJ applied to natural gas end-uses.
[11] Sources include (1) "Energy Analysis and Cost Assessment of the Workers' Compensation Board's Proposed Indoor Air Quality Standard," EnerSys Analytics Inc., October 1996; (2) "BC Hydro Commercial Sector Peak Load Reduction Study: Final Report," ERG International Consultants, December 1992; and (3) BC Hydro's *End-Use Load Forecaster and T36 File Generator (ELF)* software and related studies.
[12] Ibid.

high, but we have seen an increase in electric heating with the increase in gas prices over the past few years. However, electric heating values appeared particularly high for extended care and hotel/motel *for new construction* in our professional opinion.

Table 2. Heating Fuel Source Market Penetration Factors

Building Type	Space Heating		DHW Heating	
	Electric	Gas	Electric	Gas
School	12%	88%	12%	88%
Large Office	17%	83%	30%	70%
Small Office	30%	70%	30%	70%
Big Box Retail	20%	80%	20%	80%
Strip Mall Retail	20%	80%	20%	80%
Extended Care	20%	80%	20%	80%
Hotel/Motel	40%	60%	30%	70%
MURB	32%	68%	40%	68%
Average	*25%*	*75%*	*25%*	*75%*

BC Hydro information listed the penetration of electric heating for extended care (which was combined with hospitals) at 25%, but our experience indicates a much lower proportion of electric heating. Our observations are based upon (1) development of CBIP's *Extended Care Technical Guidelines*, (2) having modelled three extended care CBIP projects, and (3) BC Hydro data derived from its Building Check-Up program. None of the CBIP projects in which we participated considered electric resistance heating. Moreover, of the 22 existing extended care sites which were audited under BC Hydro's Building Check-Up program, only about 23% of the sites had a significant amount of electric heating (which also included heat pumps); in total the electric heating load amounted to about 14% of the total heating load for the 22 building sample. For these reasons, we felt reducing the electric resistance share by 20% was justified.

We also reduced the hotel/motel electric market share by 20%, mainly based on data from audits of dozens of British Columbia hotels and motels through BC Hydro's Building Check-Up program and a load research study we conducted for BC Hydro. Of 29 audits from these efforts, roughly 26% of the total heating load was served by electricity. On the other hand, nearly 59% of these sites had over 10% of their heating energy dedicated to electricity (i.e., small parts of most of the buildings had electric heat). With a significant amount of this electric heating dedicated for heat pump heating, we felt the 50% electric resistance estimate from BC Hydro was high.

3) The estimated allocation of appropriate HVAC systems for the different fuel types required us making professional judgements as to the representation for different system configurations. For example, we developed a distributed heat pump ASHRAE 90.1-1999 Budget cases for the office segments

because of the relatively high occurrence of this HVAC system for newer designs. The remaining office HVAC configurations with gas heating corresponded to Reference and Budget cases with variable air volume (VAV) and reheat. Because statistically significant data regarding HVAC system allocation across building types and regions is not available, we mostly used our professional experience in the commercial sector to estimate the HVAC allocation factors. We also referenced some limited information from past BC Hydro studies[13]. In general, we represented the HVAC systems and heating fuel types as follows:

- Electric heating was represented as single prototype models for both standards. For the purposes of this study, it was only necessary to have a single representative HVAC configuration which would adequately represent the Reference and Budget cases since these correspond to proposed design cases with electric resistance heating.

- Distributed heat pump ASHRAE 90.1-1999 Budget cases were included for the offices hotel/motel, and multi-unit residential building types due to the relatively high occurrence of this system type in new designs. We assumed the following penetration for gas-heated new designs: 30% for offices, 20% for multi-unit residential and 15% for hotel/motel.

- A fan coil system in new non-lodging facilities typically corresponded to a VAV system for both the MNECB+CBIP Reference and ASHRAE 90.1-1999 Budget cases. Hence, the development of VAV reference case models was sufficient for representing nearly all of the gas-heated new construction market for non-lodging type facilities. The exception was for Budget cases with distributed heat pumps.

- Additional gas-heated cases were required for the multi-unit residential building type to capture the prevalence of (1) distributed heat pump systems, (2) fan coil systems and (3) simple residential systems with packaged terminal units or no direct mechanical ventilation. The latter case was allocated with half of the gas-heated market share and fan coils with 30% market share. (Distributed heat pumps were allocated 20%, as mentioned previously.)

[13] Ibid.

RESULTS

This section provides results for the equivalency analysis applied to the overall commercial market within British Columbia. More detailed results for the individual building types and regions appear in Appendix C.

ENERGY CREDIT EQUIVALENCY

The end result of this analysis is an energy performance equivalency table that can be used to show compliance with LEED and to provide energy credits for the British Columbia adaptation of LEED. Table 3 provides the LEED-BC savings levels that correspond to equivalent levels of savings following the U.S. LEED system.

Table 3. LEED-BC Equivalency Table of Energy Credits

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-BC Savings Bins		LEED-BC vs LEED-GBC Difference		ECB vs CO_2 Basis Difference
	$/ft²	kg/m²	ECB	CO_2	ECB	CO_2	
0% (0 pts)	*0.80*	*69.8*	***12.8%***	***12.8%***	*12.8% pt*	*12.8% pt*	*-0.024% pt*
20% (2 pts)	0.64	55.8	**30.2%**	**30.2%**	10.2% pt	10.2% pt	-0.019% pt
30% (4 pts)	0.56	48.9	**38.9%**	**39.0%**	8.9% pt	9.0% pt	-0.017% pt
40% (6 pts)	0.48	41.9	**47.7%**	**47.7%**	7.7% pt	7.7% pt	-0.015% pt
50% (8 pts)	0.40	34.9	**56.4%**	**56.4%**	6.4% pt	6.4% pt	-0.012% pt
60% (10 pts)	0.32	27.9	**65.1%**	**65.1%**	5.1% pt	5.1% pt	-0.010% pt

Table 3 illustrates the overall energy cost budget (ECB) differences between ASHRAE+LEED and MNECB+CBIP. This table also shows the relative performance when using estimated carbon dioxide (CO_2) emission factors instead of energy rates as the basis for establishing the respective reference energy budgets. It demonstrates that the different bases for comparison (i.e., ECB and CO_2) barely differ between each other, when *applied on a sector-wide basis across British Columbia.*

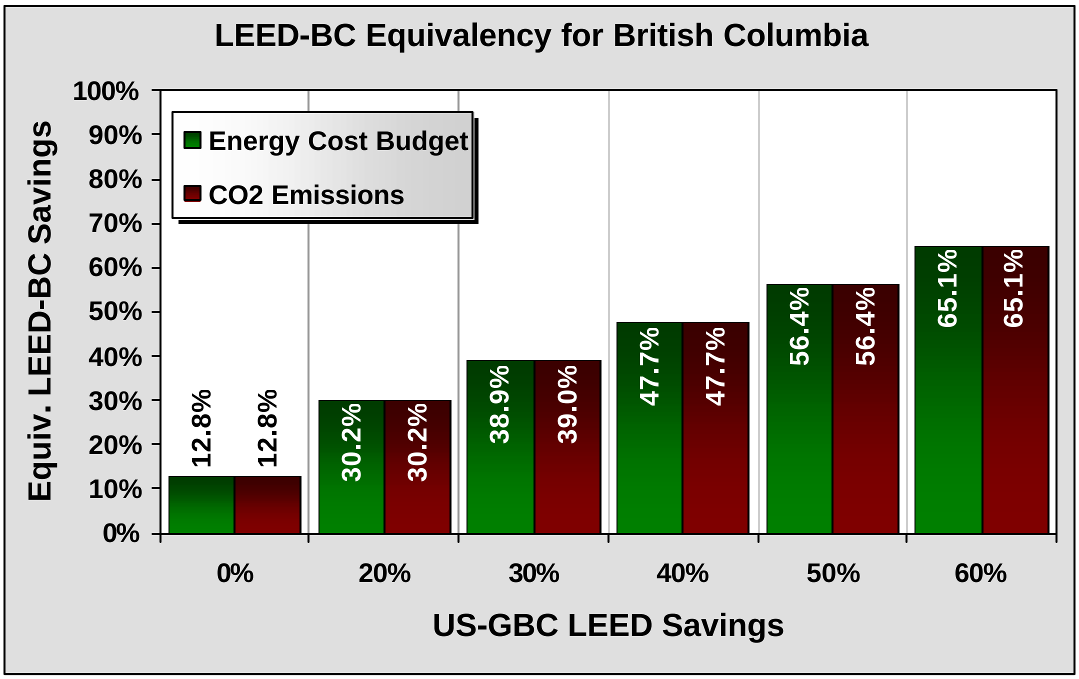
As both Table 3 and Figure 2 show, a new LEED-BC design would need to achieve nearly 13% savings above the MNECBC+CBIP standard to just comply with LEED Prerequisite Number 2. Hence, any prospective LEED-BC project with a regulated energy performance that was not 13% lower than its corresponding MNECB+CBIP Reference case could not qualify for the B.C. adaptation of LEED.

Taking this example further, LEED-BC projects would obtain two points if they achieved 30% savings. This is equivalent to achieving 20% savings using a corresponding ASHRAE+LEED Budget case as the comparison. Achieving the maximum 10 points corresponds to saving at least 60% following the ASHRAE+LEED Standard (when not applying LEED's "point interpolation table").

The equivalent level of comparison following the MNECB+CBIP Standard requires saving over 65% in energy costs (or CO_2).

Hence, the relative difference between the standards in the savings credit levels narrows as the required percent savings increases. This is due to the way in which the relative savings proportions change as the absolute energy use requirements decrease. In other words, the relative differences between the energy use remains consistent but the percent reductions naturally vary as the relative savings increase.

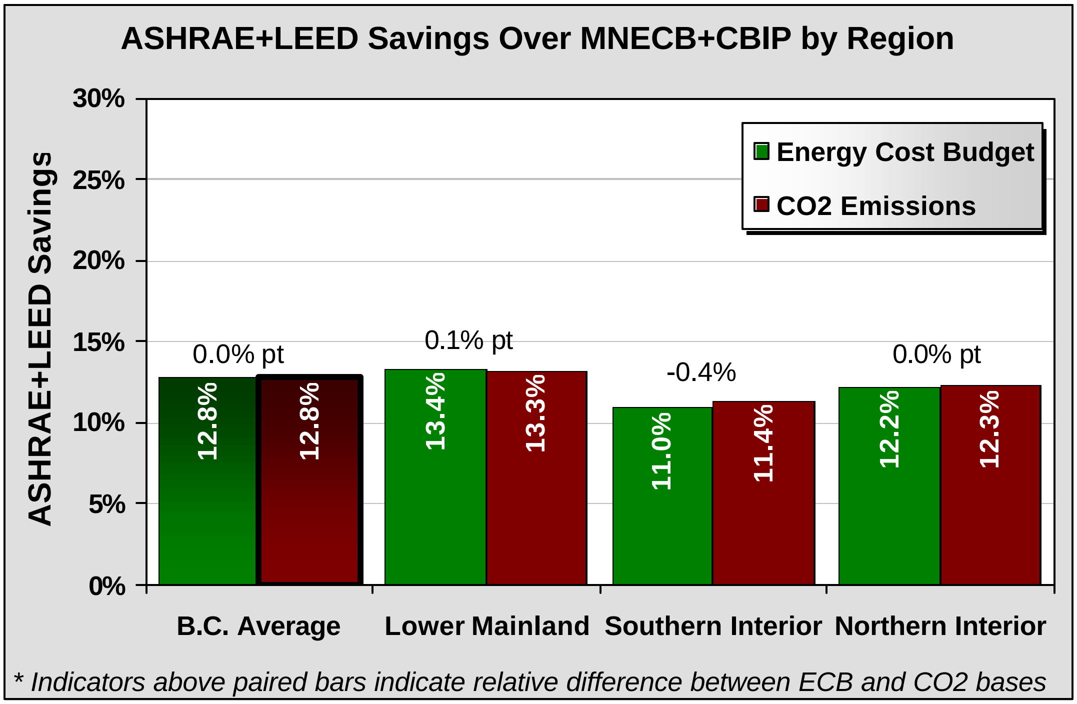
Figure 2. Equivalency Savings Bins for LEED-BC (MNECB+CBIP) Versus U.S. LEED (ASHRAE+LEED)



Regional Results

The following graph provides more detailed results on a regional basis for three regions evaluated as part of this study. For each region, Figure 3 compares the overall MNECB+CBIP Reference energy budget performance to the equivalent ASHRAE+LEED energy budget performance. The results include a weighted average of all building types within each region. As shown in Figure 3, the Southern Interior region exhibits the lowest relative difference between the standards at about 11% difference. The highest regional difference between MNECB+CBIP and ASHRAE+LEED is observed in the Lower Mainland region, at over 13% difference. The numbers above the bars represent the percentage point differences between the energy cost budget and CO_2 analysis results. There is very little difference between the two methods by region, and in fact this difference essentially disappears in the overall B.C. average.

Figure 3. Regional Equivalency Comparisons



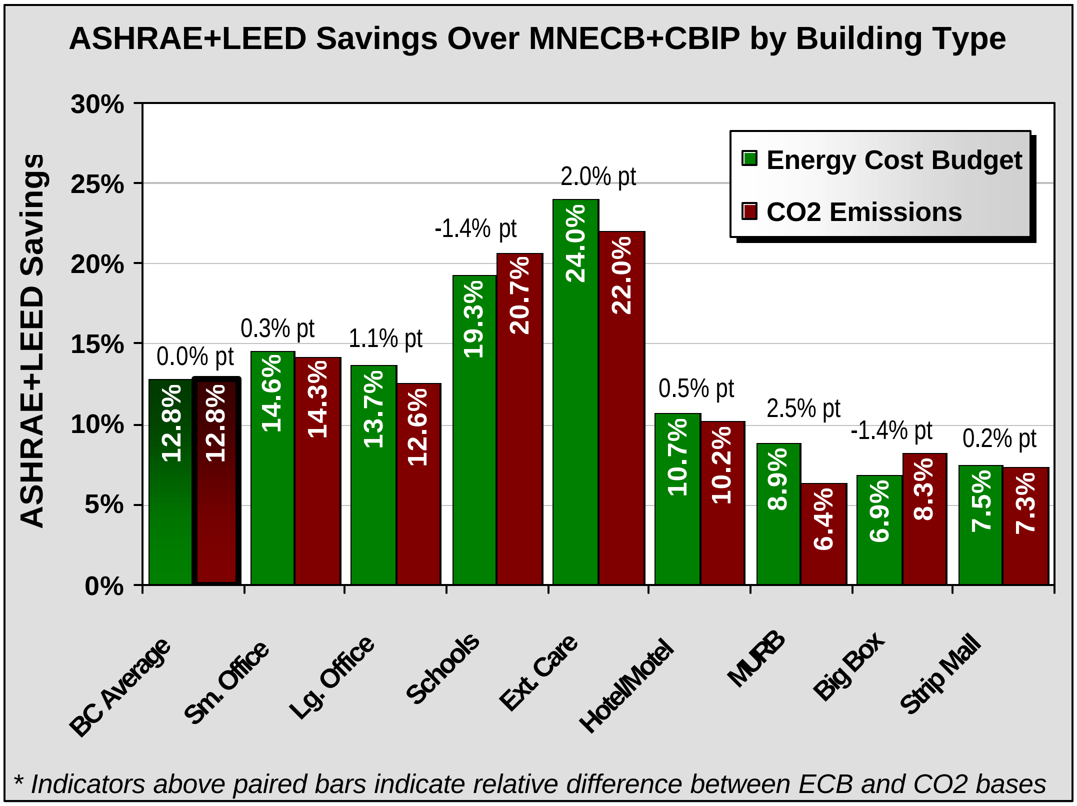
More detailed regional results for annual energy use, energy costs and emissions appear in Appendix C for each building type.

Building Type Results

Figure 4 provides more detailed results for each building type averaged across all three regions. The chart compares the overall MNECB+CBIP Reference energy budget performance to the equivalent ASHRAE+LEED energy budget performance for each building type. As shown in Figure 4, the differences between the standards vary significantly among the building types. Further, the variation from applying CO_2 emissions rather than energy rates is much wider by building type than it was for the different regions or the overall commercial sector average. This difference is greatest for the multi-unit residential (MURB) building type at 2.5 percentage points. While these results point out the differences among the building types and regions, it is important to note that LEED v.2.0 point awards do not differentiate among different building types or regions.

Figure 4 also shows that the extended care segment exhibits the highest relative difference between the standards at 22–24% difference. This relatively high difference between the standards is mostly due to the application of exhaust heat reclaim in the ASHRAE+LEED Budget case, whereas the MNECB+CBIP Reference case does not require heat reclaim. The lowest regional difference between MNECB+CBIP and ASHRAE+LEED is observed in multi-unit residential and retail segments, ranging from 6–9% difference.

Figure 4. Building Segment Equivalency Comparisons



More detailed results by building type appear in Appendix C, which includes energy performance indicators for annual energy use, energy costs and emissions.

CO_2 EMISSIONS VS. ENERGY COST SAVINGS

We also applied CO_2 emission factors for electricity and natural gas to the MNECB+CBIP Reference and ASHRAE+LEED Budget case energy requirements. As has been illustrated with the previous results, there is almost no difference between these two approaches *when applied on a sector-wide basis*.

However, noticeable differences begin to appear on a building-by-building basis. Figure 4 somewhat illustrates this in the differences shown for the different building types. A better illustration of the potential impact between these two approaches is seen when looking at individual projects. As a separate effort, we recently analyzed four building designs that intend to apply for both LEED and CBIP. For that analysis, we constructed MNECB+CBIP Reference cases and ASHRAE+LEED Budget cases for each building. Table 4 presents savings results from these buildings to help show how individual building results vary. As shown by this list of anonymous case studies, the variation between applying energy costs or CO_2 can result in a difference of one or two energy credit points.

Table 4. Comparison of CO_2 vs. ECB for Proposed Designs

Proposed Design (with Electricity and Gas Savings)	Equivalent LEED-BC Savings		LEED-BC Interpolated Points		
	ECB	CO_2	ECB	CO_2	Diff.
Case 1 (17% kWh, -7% GJ)	23.5%	24.6%	0	0	0
Case 2 (18% kWh, 22% GJ)	33.6%	32.9%	1	1	0
Case 3 (-15% kWh, 91% GJ)	41.1%	33.9%	3	2	-1
Case 4 (11% kWh, 100% GJ)	56.2%	49.9%	8	6	-2

The differences between the two approaches widen as the relative electricity and natural gas savings diverge. Case 1 is the only project where electricity savings are proportionately higher than gas savings. This results in slightly higher LEED-BC Budget energy savings, which might provide the project with one extra point if its ECB savings were bordering on the next point award level. Case 2 illustrates how the rating approaches are basically equivalent when electricity and gas savings percentages are relatively close. Cases 3 and 4 show how the two approaches diverge significantly enough to result in one or two points being lost if the CO_2 basis was used instead of the ECB. For Case 3, the extreme divergence in gas versus electricity savings stems from high levels of savings for heating due to exhaust and chiller heat reclaim, which resulted in slight increases in electricity. The last case showed 100% gas savings mainly because it has a ground-source heat pump system, which is compared against a gas-fired Reference. When using the marginal CO_2 emissions factors for electricity, proposed buildings with high gas but low electricity savings would receive a lower LEED-BC rating (up to two points fewer in extreme cases).

The presently proposed incremental emissions factors are 0.525 kg/kWh for electrical energy and 56.6 kg/GJ, which means that electricity savings are provided with nearly 2.6 times more weighting than gas (in equivalent units). Assuming a relative conversion efficiency of 80% on gas-fired heating equipment, this difference is reduced to about 2.1-to-1. In other words, reducing lighting by a kWh would produce about twice the benefit for LEED-BC as reducing the gas heating load by a kWh_e, assuming emission savings are used as the basis of comparison. Electricity savings are also “worth more” than gas savings when energy costs are used for the basis of comparison. However, the ratio is not quite as high at roughly 1.5-to-1, using present 2002 energy rates.

In most cases, the opportunity to save on heating with fossil fuels exceeds the relative electric savings opportunity. This likely becomes the driving factor in how projects will fare when determining savings based on emissions versus energy costs. On average, we believe that applying CO_2 emissions to the Budget case would be conservative since it would generally tend to result in projects achieving *fewer* energy credit points.

CONCLUSIONS

This energy performance analysis of the commercial sector in British Columbia indicates that the Energy Performance (Credit 1) requirements of the U.S. LEED Rating System is nearly 13% more stringent than Canada's MNECB+CBIP energy performance requirements. Additionally, the following point awards table would apply for the draft LEED-BC Applications Guide. To be consistent with LEED v.2.0, we developed an overall commercial sector average and did not differentiate among different building types when developing the points award table for LEED-BC.

Table 5. Energy Credit 1 Point Awards Applied to Entire B.C. Commercial Sector

MNECB+ CBIP Savings	LEED-BC Point Awards	Equivalent U.S. LEED Savings
30%	2	20%
39%	4	30%
48%	6	40%
56%	8	50%
65%	10	60%

Table 5 provides a point awards rating system following a similar approach used for the U.S. LEED rating system. That is, LEED provides a single point awards table (and interpolation table for awards in one-point increments) that is used regardless of the building type or weather region. As indicated previously, overall regional differences between MNECB+CBIP and ASHRAE+LEED are relatively minor. However, larger differences exist between building types. If an energy credit point award system were defined for each of the eight building types represented in this study, it would appear as shown in Table 6. As shown in Table 6, the lowest level at which points are awarded ranges from 26% savings for retail buildings to 39% savings for extended care. At the highest level, the maximum of 10 point is awarded at a minimum of 63% savings for retail buildings to 70% savings for extended care.

Table 6. Energy Credit 1 Point Awards by Building Type

Building Segment	MNECB+CBIP Savings by LEED-BC Point Award Category (ECB Basis)				
	2	**4**	**6**	**8**	**10**
Small Office	32%	40%	49%	57%	66%
Large Office	31%	40%	48%	57%	65%
Schools	35%	44%	52%	60%	68%
Extended Care	39%	47%	54%	62%	70%
Hotel/Motel	29%	37%	46%	55%	64%
Multi-unit Residential	27%	36%	45%	54%	64%
Retail, Big Box	26%	35%	44%	53%	63%
Retail, Strip Mall	26%	35%	44%	54%	63%

The accuracy of the equivalency analysis is dependent on many assumptions, limitations and interpretations of the standards. The most significant assumptions about some of the average building characteristics and market penetrations have been described in this report, including the appendices. This analysis has certain limitations, such as the lack of statistically significant market sector data and DOE2's inability to model certain configurations required by ASHRAE (e.g., VAV with parallel fan-powered boxes and DX cooling). In addition, some interpretations of the Standards, ASHRAE in particular, are not completely clear. However, the results should be quite representative for the policy-level purposes of this study, especially considering the level of detail given to carefully defining the prototype Reference and Budget models. Moreover, the distribution of results across the many building types and weather regions provides for diversity in the overall sector-wide results, which makes the final outcome even more indicative.

APPENDIX A

Final Report:

Verification of LEED-BC v1.0 Energy Credit 1 Point Awards for Building Energy Conservation in British Columbia

Energy Code Comparisons and Analysis Approach Notes

LEED-BC Equivalency Analysis
MNECB+CBIP vs. ASHRAE+LEED Energy Budget Comparison and Approach

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
EXTERIOR SURFACES					
Wall R-Value	Weather and heating fuel type; ASHRAE differentiates based on wall type.	Select appropriate R-value based on primary heating source from MNECB Table A-3.3.1.1.(1) for the applicable administrative region.	Select appropriate R-value based on residential or non-residential building type for four different wall constructions from ASHRAE90.1-1999 Appendix B for the applicable weather region.	R-value substitution as appropriate. Set baseline for new projects at appropriate prescribed level based on estimated mix of wall types.	**Lower Mainland (and Vancouver Island)**: ASHRAE T.B-18, HDD65:5401-7200, CDD50:0-1800 vs. MNECB Region A, <= 3500HDD; **North Interior**: ASHRAE T.B-22, HDD65:9001-10800, CDD50:0-1800 vs. MNECB Region B, >4500HDD (PNG); **Okanagan:** ASHRAE T. B-17,HDD65:5401-7200, CDD50:1801-3600 vs. MNECB Region B, >4500HDD (BC Gas)
Wall Construction	Yes, but insignificant	Reference construction: Outside air film, Face brick, Air space, Polystyrene insulation, Gypsum board, Interior air film	Construction same as Proposed.		Overall thermal mass influence is very minor on commercial buildings, particularly in heating dominated situations. Moreover, the concern is between typical construction and MNECB+CBIP, and not extreme situations. Hence, the most significant sensitivity would be on how an "average baseline" with a light weight curtain wall construction compares to the MNECB Reference construction. Overall, this discrepancy between the Codes would be insignificant.
Roof R-Value	Weather, heating fuel type and roof type	Select appropriate R-value based on primary heating source and roof construction from MNECB Table A-3.3.1.1.(1) for the applicable administrative region.	Select appropriate R-value based on residential or non-residential building type for three different roof constructions from ASHRAE90.1-1999 Appendix B for the applicable weather region.	R-value substitution as appropriate. Set baseline for new projects at appropriate prescribed level based on estimated mix of roof types, as applicable.	**Lower Mainland (and Vancouver Island)**: ASHRAE T.B-18, HDD65:5401-7200, CDD50:0-1800 vs. MNECB Region A, <= 3500HDD; **North Interior**: ASHRAE T.B-22, HDD65:9001-10800, CDD50:0-1800 vs. MNECB Region B, >4500HDD (PNG); **Okanagan:** ASHRAE T. B-17,HDD65:5401-7200, CDD50:1801-3600 vs. MNECB Region B, >4500HDD (BC Gas)
Roof Construction	Yes, but differences with Codes insignificant	Type III Reference construction: Outside air film, Gravel, Built-up roofing, Polystyrene insulation, Metal deck, Interior air film	Construction same as Proposed.		For LEED, the reflectivity is to be set at 0.3. However, for heat dominated buildings this has very little impact. Further, it is not well defined for the typical new commercial building stock and MNECB stipulates that the reflectivity must be the same as in the Reference case. Hence, this parameter may be ignored for equivalency verification purposes.

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
Exposed Floor R-Value	Weather, heating fuel type. Floor type influences MNECB, but this is typically Type II (i.e., concrete slab)	Select appropriate R-value based on primary heating source from MNECB Table A-3.3.1.1.(1) for the applicable administrative region.	Select appropriate R-value based on residential or non-residential building type from ASHRAE90.1-1999 Appendix B for the applicable weather region.	R-value substitution as appropriate. Set baseline for new projects at appropriate prescribed level. Note that only a few NRCan templates have exposed floor R-value.	Only affects prototypes which have exposed floor areas, which primarily are concrete floors. For these building types, it was necessary to revise the project templates so that the exposed R-value can be changed. This required identifying which building types require modification and then fully re-simulating them. Also, Screening Tool system will need to be updated to allow for floor insulation parameterization. **Lower Mainland (and Vancouver Island):** ASHRAE T.B-18, HDD65:5401-7200, CDD50:0-1800 vs. MNECB Region A, <= 3500HDD; **North Interior:** ASHRAE T.B-22, HDD65:9001-10800, CDD50:0-1800 vs. MNECB Region B, >4500HDD (PNG); **Okanagan:** ASHRAE T. B-17,HDD65:5401-7200, CDD50:1801-3600 vs. MNECB Region B, >4500HDD (BC Gas)
Exposed Floor Construction	Weather, heating fuel type. Floor type influences MNECB, but this is typically Type II (i.e., concrete slab)	Type II Reference construction: Outside air film, Gypsum board, Polystyrene insulation, Concrete, Interior air film	Construction same as Proposed.		For building types which have typical exposed floor areas, the MNECB Reference case is relatively thermally similar. Hence, the ASHRAE Reference construction would be essentially identical to the MNECB Reference.
Infiltration	N/A - Same as Reference	MNECB CS 5.3.5.9 indicates infiltration rate of 0.05 cfm/ft² of gross wall area applied to exterior zones 24 hours/day.	No specification indicated	Maintain default levels for both Reference cases.	
GLAZING					
Glazing Percent	Yes	Glazing area same as for proposed design, up to a limit of 40%.	Glazing area same as for proposed design, up to a limit of 50%.	Percent glazing substitution as appropriate.	
Window U-value	Weather, heating fuel type and breakout of fixed versus operable windows	Select appropriate U-value based on primary heating source for 40% glazing from MNECB Table 3.3.1.2 for the applicable administrative region.	Select appropriate U-value based on residential or non-residential building type for 50% glazing from ASHRAE90.1-1999 Table B-18 for the applicable weather region	U-value substitution as appropriate. Set baseline for new projects at appropriate prescribed level, based on mix of fixed and operable windows.	Information on percent of fixed versus operable glazing is not well defined for the new commercial building stock. Further, NRCan models are heavily based on using the more conservative fixed U-value instead of the U-value for operable windows. Aan adjustment in the analysis is made to account for DOE2's automatic window conductance adjustment for the air film; this better assures that the modelled Uo matches the prescriptive requirement. However, note that EE4 does not appropriately adjust for this naunance with DOE2 and therefore understates the Proposed and Reference case window losses.

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
Window Shading Coefficient	Weather and window orientation for ASHRAE; optional for MNECB	MNECB CS 5.3.5.5 indicates window shading coefficient may be same as proposed *or* set at 0.74, whichever is of most benefit.	Select appropriate SC-value based on residential or non-residential building type for the maximum all/North 50% value from ASHRAE90.1-1999 Table B-18 for the applicable weather region	SC substitution as appropriate; however, substitution will need to be distinguished by orientation differently for ASHRAE case. Set baseline for new projects at appropriate prescribed level.	ASHRAE stipulates dividing by 0.86 to obtain SC from SHGC (or multiplying by 1.163), whereas MNECB stipulates multiplying by 1.15. Option of not applying SC for MNECB is typically followed for building types which have very little cooling (e.g., schools and extended care). In these building types, the SC is typically high anyway and hence, setting the MNECB SC at 0.74 is reasonable for this study.
Internal Shading	Derating for internal shading treated identical to Reference case.	Shading coefficient derated by 20% (i.e., multiplied by a 0.8 factor)	No adjustment on shading coefficient for internal shading	Apply equivalent derating to ASHRAE Reference	Adjustment of the SC for the MNECB+CBIP Reference and Proposed design introduces an inconsistency in how energy performance is gauged following ASHRAE rules. *For consistency between the Codes, we applyied the derating equivalently to the ASHRAE Reference as well.* Overall, this will result in lower relative absolute differences, which would tend to make the equivalency to ASHRAE+LEED slightly more stringent (i.e., conservative). Note that the influence of the shading coefficient on the overall commercial building stock's energy performance in B.C. is relatively minor compared to other building characteristics.
Shading Devices (Overhangs and Fins)	N/A	No overhangs or fins	No overhangs or fins		Typical building templates do not have fins. Furthermore, fins typically have a very small influence on overall energy performance.

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
SPACE CONDITIONS					
Schedules	N/A - Same as Reference	If no user-defined schedules, used default schedules (same as Proposed)	If no user-defined schedules, used default schedules (same as Proposed)		Web Screening Tool and background DOE2 files use default schedules, which are derived from the ASHRAE 90.1-1989 standard. Furthermore, most CBIP applications simply utilize the default schedules. Hence, staying with the default MNECB schedules is warranted. Note that using actual schedules for some building types produce significantly different absolute savings results (e.g., schools). However, since the relative savings is generally maintained, apply MNECB default schedules should be valid for the purposes of this study.
Lighting	Building Type or Space function, whichever is applicable	Lighting power allowance based on building type or space function, from ASHRAE/IES Standard 90.1-1989	Lighting power allowance based on building type or space function, from Table 9.3.1.1 or Table 9.3.1.2.	Lighting density substitution as appropriate. Set baseline for new projects at appropriate prescribed level.	Web Screening Tool and background DOE2 files use default building type or space function classifications which are already derived for the typical building types. These are maintained and consistent between the Code references for this analysis. Each prototype was examined to calculate the budget building overall lighting density. For some, this is realtively simple since the space use classification is by Building Type. Others, such as the health care archetype, are classified by space function which required a spreadsheet calculation to calculate the overall lighting power density based on space function and area of each space type.
Equipment density	Building Type or Space function, whichever is applicable. Same as Reference	Equipment power density based on building type or space function, ASHRAE/IES Standard 90.1-1989	Equipment power density set equivalently to MNECB level since ASHRAE does not specify equipment density.	For equivalency of comparison between Codes, separate equipment energy use from remaining "regulated end-uses"	Web Screening Tool and background DOE2 files use default building type or space function classifications which are already derived for the typical building types. These will be maintained and will be identical between the Code references.. Note that LEED stipulates that equipment energy use is removed before calculating the relative savings. To maintain consistency, we need to similarly remove the equipment energy use from the MNECB+CBIP Reference prior to comparing the Codes.

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
HVAC SYSTEM TYPE					
Air Handling	Configuration of serving single or multiple zones, Building type (i.e., with or without lodging space functions)	VAV with reheat serving multiple zone configurations and Constant volume serving single zone configurations, except Unitary packaged A/C-heater or fan coil serving lodging.	VAV with reheat serving multiple zone configurations, except when Proposed design has distributed heat pumps or lodging space functions. Constant volume otherwise.	ASHRAE's Figure 11.4.3 combined with Table 11.4.3A indicates up to 11 system type configurations which do not align directly with the HVAC system type configurations designated by MNECB+CBIP. Hence, we first ascertained the most applicable configurations by building type which is expected to be represented in the new commercial market. These designated the "prototype cells" for the equivalency analysis. After assessing the relative prevalence in new commercial market, the applicable HVAC system type configurations were clearly identified. If the perceived prevalence of a certain HVAC configuration was high enough, *given the scope of this study* , this may have warranted creating some new cells which do not currectly exist in the Web Screening Tool. The development of new cells were weighed against the relative objectives of the analysis and the project scope.	Reheat in MNECB+CBIP prototype modelling is handled using baseboards, whereas ASHRAE indicates using true reheat. Using baseboards is maintained for comparison to ASHRAE since this is consistent and exhibits similar energy performance to using baseboards. Parallel fan-powered boxes are designated for some ASHRAE VAV cases, but this only applies to non-lodging Proposed designs with mulitple zone systems and electric heat or air-source heat pumps. Due to the significance of electric heating in several building types, this new model configuration was justified for this study. ASHRAE indicates the existence of a mechanical cooling system in all cases. However, sizing and thermal comfort conditions must be consistent with the Proposed case. Hence, the net effect is to minimize the cooling requirements for the ASHRAE reference case, making it very similar in overall relative performace to the MNECB+CBIP Reference.
Heating Fuel Type (only most applicable conditions discussed):					
Principal heating source	Electric	Electric resistance heat	Electric resistance unless serving single zone system without water-cooled condensing source (i.e., with DX or no cooling)		
	Heat Pump	Air-source heat pump if Proposed case has air-source heat pump. Typically, gas-fired hydronic boiler if Proposed case with water-source heat pumps.	Electric resistance for multiple zone system; air-source heat pump if single zone system. Water-source heat pump if Proposed case with water-source heat pumps, typically served by a gas-fired hydronic boiler.		
	Natural Gas	Gas-fired furnace if Proposed design has a furnace; otherwise gas-fired hot water boiler.	Gas-fired hydronic boiler for all cases except for non-residential single zone systems served by DX or no cooling, which would have a gas-fired furnace.		

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
Cooling Source	Hydronic (water-cooled), Direct expansion (DX) or No cooling	Chilled water plant if hydronic. Direct expansion (DX) if DX. No cooling if Proposed case has no mechanical cooling capacity.	Chilled water plant if water-cooled, unless Proposed case has water-source heat pumps. Direct expansion (DX) cooling otherwise.	Note that DOE2 does not allow for DX cooling with parallel fan-powered VAV boxes (PIU system), which is required for ASHRAE's System 4. A work-around using an air-source chiller with 0 pumping power must be devised in these cases.	Cooling is a relatively small "regulated" end-use in the B.C. (or Canadian) commerical market. Also, the overall cooling efficiency impacts can be *equivalently* approximated using a consistent cooling source. Hence, it is justified to represent the relative cooling efficiencies between the Codes by maintaining the existing cooling source in the present NRCan models. Otherwise, the modelling scope could double by sub-dividing the cells to provide for DX and hydronically cooled scenarios separately.
FAN SYSTEM					
Air Flow Sizing	Amount of oversizing	Oversizing same as Proposed case, up to a maximum of 30%. Supply air flows to all zones above 0.4 cfm/sf regardless of over-sizing factor.	Oversizing the same as for the proposed design, including having the same number of unmet hours if undersized.		NRCan prototype projects are consistently sized with all loads met; hence, no further adjustments are required.
Minimum Supply Air Flow Rate	N/A	0.4 cfm/sf	0.4 cfm/sf for VAV reference systems		NRCan prototype projects have consistent sizing in regard to the minimum flow rate; hence, no further adjustments are required.
Supply Air Temperature	System Type, including Heating Source for ASHRAE	Minimum of 55º F for cooling and 110º F for heating. Reset on VAV system based on warmest zone (COOL-CONTROL = WARMEST). *Note: EE4 1.32 uses a work-around reset due to previous bugs in DOE2, which often understates and causes poor temperature control in diversely loaded designs. NRCan models use appropriate control strategy, however.*	Minimum and maximum not explicitly defined. Reset on VAV system based on warmest zone (COOL-CONTROL = WARMEST) for non-electrically heated cases; constant reset (COOL-CONTROL = CONSTANT) otherwise.		ASHRAE indicates that "supply air rates for the budget building design shall be based on a supply-air-to-room-air temperature difference of 20°F." Thus, it does not explicitely state the supply air temperatures for energy performance purposes, but only for fan sizing purposes. In most cases, the cooling load dictates the maximum supply air flow (and hence, fan size). This is essentially equivalent between MNECB and ASHRAE. In other words, the cooling load and the difference between supply air temperature and room setpoint dictates the maximum supply air flow. Typically, most projects have supply air temperature of 55° and room setpoint of 75.2°, so a difference of 20.2° is close enough. Note: depending on NRCan's addressing of the erroneous COOL-CONTROL implementation in EE4, projects may be unfairly compared to References whose zone temperatures are inappropriately warm; thereby reducing the relative savings as compared to ASHRAE.

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
Fan Power	System Type, including Cooling Source; Supply air volume and fan power	Overall fan static pressure/efficiency: 1) Single zone central units at 1.3"/40% or 2.0"/50% for supply and 0" or 0.6"/25% for return, depending on cooling source; Multiple zone central units at 3.0"/45% or 4.0"/55% for supply and 0.6"/25% or 1.0"/30% for return, depending on cooling source; Zonal units at 0.5"/25%.	1) Fan system efficiency same as proposed up to limits established in 6.3.3.1, which prescribes maximum BHP/cfm levels based on supply air volume and fan system type (i.e., constant or variable volume). 2) Fan motor efficiency set at minimum motor efficiency prescribed in 10.2. 3) Exception for	If necessary, appropriately adjust fan efficiency and/or static pressure. Set as baseline for new projects.	ASHRAE indicates at below 20,000 cfm, the maximum fan power is 1.2 hp/1000 cfm for constant volume systems and 1.7 hp/1000 cfm for VAV systems. At 20,000 cfm and higher, the maximum fan efficiency is 1.1 hp/1000 cfm and 1.5 hp/1000 cfm, respectively. An additional allowance is provided for cases with heat reclaim. The appropriate motor efficiency from Table 10.2 is then applied to determine the overall fan power. Overall, our observation is that MNECB fan power is higher than the corresponding Proposed designs. However, ASHRAE's limits tend to be higher than seen in new designs from what we've seen. Hence, comparing the ASHRAE requirements for fan power directly to the MNECB Reference is conservative and justified--particularly since more detailed information on typical new construction fan power requirements is lacking. We assessed the relative differences in fan power for a representative cross-section of NRCan prototype cases based on experience to account for reasonable differences between ASHRAE and typical new designs.
Outside Air	Yes	Same as Proposed.	Same as Proposed.	Keep at levels established in MNECB+CBIP, which are mostly based on the MNECB defaults (derived from ASHRAE).	Many new designs designate outdoor air levels which are higher than the minimum MNECB mandatory defaults, and data on the prevalence of this is scant. The typical approach for designating outdoor air in EE4 is to use the defaults. Because of these factors, combined with the general condition that the outdoor air is to be equivalently represented in all cases, the outdoor air levels were kept at the present defaults established by NRCan.
Fan Curve (VAV systems)	Fan Power	Progressively more efficient fan curves at differently power levels: a) < 7.5 kW, b) 7.5 - 25 kW and c) > 25 kW	Use VSDs for fans greater than 25 hp (~37 kW at 91% motor efficiency); otherwise use forward curved with inlet vanes.	Set fan curve as appropriate directly in models.	For prototype cases with VAV fan systems under 37 kW, the default MNECB type (c) fan curve may be used if the fan power is greater than 25 kW. Otherwise, use the CBIP VSD fan curve.
Heat Reclaim	Percent outside air	No exhaust air heat reclaim.	Exhaust air heat reclaim at 50% effectiveness if outside air is 70% or more of supply air.	Set heat reclaim appropriately.	NRCan removed the requirement for heat reclaim in CBIP since this made it very difficult for MURB, health care, and motel/hotel facilities to achieve the minimum 25% CBIP energy savings threshold.

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
HVAC CONTROL					
Heating and cooling setpoints	Yes	Heating and cooling setpoint and setback temperatures and schedules same as for proposed design.	Heating and cooling setpoint and setback temperatures and schedules same as for proposed design.		MNECB default for NRCan prototypes is defined at 71.6°F for heating and 75.2°F for cooling, although some building types (e.g., extended care) have different typical values.
Economizer	Building type (i.e., with or without lodging space functions); ASHRAE also depends on cooling source (which indicates the reference system type), cooling capacity and weather.	If not lodging, enthalpy economizer.	Dry bulb economizer depending on 1) number of hours between 8am-4pm with dry bulb temp between 55° - 69°F combined with 2) cooling capacity, as shown in Table 6.3.1.	Set economizer where applicable, including as a dry bulb type in baseline for new ASHRAE projects.	Fan coil systems, distributed heat pump systems and systems serving lodging generally do not require economizer control. Refer to ASHRAE 6.3.1 for further details on the applicability of economizer control on a case-by-base basis--particularly Table 6.3.1 which indicates when an economizer is required based on weather data and cooling capacity. Because MNECB requires use of an enthalpy economizer, many NRCan prototypes have readily available the ability to switch between no economizer control and enthalpy economizer control, but not to dry bulb temperature economizer control. However, the difference between dry bulb and enthalpy economizer control is barely discernable in our experience with modelling facilities in the applicable B.C. weather regions.
Humidification	Humidification RH, if any	Same as Proposed	Same as Proposed (assumed, but cannot find this explicitly called out)		Humidification is prevalent in very few building types and weather locations (e.g., extended care for Interior)
HEATING PLANT					
Boiler	Natural gas principal heating source with hydronic heating; ASHRAE also depends on cooling source	One one/off gas-fired boiler at 80% combustion efficiency.	If plant load < 600,000 Btuh, one one/off gas-fired boiler at 80% combustion efficiency; otherwise, two equally size boilers.	Set heating efficiency appropriately. Set two boilers as baseline for new projects where applicable.	Cases where two boilers apply could have sensitivity runs performed to ascertain the appropriate efficiency adjustment required which would account for the improved seasonal performance. However, appropriately setting the number of boilers in the new projects will eliminate the need to perform supplemental sensitivity analysis.
Hot Water Temperature	If hydronic heating applies	Temperature drop of 29°F.	Temperature drop of 50°F.	Set baseline for ASHRAE references at 50°F instead of 29°F.	The hot water temperature drop is fixed in the NRCan Screening Tool projects and cannot be directly changed. Depending on the significance, an appropriate change to the pumping and/or heating efficiency may be required to represent the energy savings. Hence, creating new ASHRAE projects will be more effective.

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
Hot water flow	If hydronic heating applies	Constant flow hot water circulation.	Variable flow down to 50% flow, riding curve if head is less than 100' and pump power < 50 hp	Set pump VSDs appropriately. Revise parametric PLR to 0.8 for VSD parametric run for new projects.	Note that in DOE2, setting the pump VSDs with a 0.5 part-load ratio setting proves to be much better than riding a pump curve to 50%. The pumping power is at about 80% of peak when riding the curve to 50%, whereas the VSD curve results in about 30% of peak power at the same point. Therefore, we estimate an equivalent representation of ASHRAE's requirement by applying VSDs down to only 80%.
Hot water reset	If hydronic heating applies	No reset	Outdoor air reset unless variable flow pumping applies	Increase heating efficiency by 1.5% pts if <5000°C HDD, 2% pts. otherwise.	The version of DOE2 used for NRCan's projects did not allow for directly modelling outdoor air boiler reset. Further, CBIP has already conservatively established reset on non-modulating boilers based on modelling analysis (contact Mike Lubun).
Furnace	Natural gas principal heating source without hydronic heating; ASHRAE also depends on system type, building type, and cooling source	Gas-fired furnace at 80% combustion efficiency.	Gas-fired furnace at 80% combustion efficiency if >225 MBtuh; 80.5% otherwise.	Set heating efficiency appropriately.	Furnace only applies to ASHRAE in cases where the Proposed design has a single zone HVAC system with gas-fired heating and no water cooling source serving a non-lodging building type (i.e., System 11 in Table 11.4.3A). Note that most of NRCan's templates make use of hydronic gas-fired boilers instead of furnaces because the energy performance difference between the two are minimal (i.e., the part-load performance and 80% efficiency are nearly identical). The relative differences with ASHRAE would be even less since the slight auxilary energy differences would net out. Hence, gas-fired cases are only need be represented with either boilers or furnaces, but not both.
Heat Pumps	Principal heating source as heat pump	Air-source heat pump at a COP of 3.0	Air- or water-source heat pumps, depending on reference system type, with efficiencies as listed in 6.2.1B or 6.2.1D, whichever is applicable.	Set heat pump *cooling* efficiency appropriately. Set baseline cooling vs. heating COP appropriately, if not already input correctly.	We will need to double-check applicability for MNECB cases. For instance, I'm not positive about MURB cases with PTHPs served by gas-fired MAU. Heat pump heating efficiency is linked with the cooling efficiency in the NRCan projects. If this preset relationship is significantly different for ASHRAE, account for this in new projects.
Sizing	Amount of oversizing	Oversizing same as Proposed case, up to a maximum of 30%.	Oversizing the same as for the proposed design, including having the same number of unmet hours if undersized.		NRCan prototype projects are consistently sized with all loads met; hence, no further adjustments are required.

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
COOLING					
Chiller	Hydronic cooling; ASHRAE also depends on if system type includes heat pumps	One reciprocating chiller with COP of 3.8 if capacity < 200T; One centrifugal chiller with COP of 5.2 if capacity 200T - 600T; Otherwise, two centrifugal chillers with COP of 5.2.	One reciprocating chiller with COP of 4.2 if capacity < 100T; One screw chiller with COP of 4.45 (if <150T) or 4.9 if capacity < 300T; Two centrifugal chillers with COP of 6.1 if capacity 300T - 600T; Otherwise, 2 or more equally sized centrifugal chillers with COP of 6.1, with no chiller > 800T.	Set cooling efficiency appropriately. Represent average cooling efficiency for appropriate cross-section of equipment since efficiency is often based on size, which cannot always be discerned for commercial sector-based analysis purposes.	The relative difference between the chiller types for ASHRAE and MNECB is somewhat moot since the efficiency and part-load performance are the two indicators which characterize the relative modelled performance of any chiller, regardless of the type. MNECB provides specific part-load curves, whereas ASHRAE provides minimum integrated part-load values (IPLVs). Unless standard part-load curves have been developed for ECB modelling purposes, the IPLVs cannot be readily correlated with MNECB part-load performance since the IPLV is determined "on the basis of weighted operation at various load capacities," which probably can be derived from the appropriate ARI test procedure. Deriving exact part-load curves for each type of ASHRAE cooling equipment would be quite intensive, problematic and considered beyond scope. Thus, we propose to stay with the MNECB part-load curves used in the NRCan templates and change the full-load efficiency. For cooling equipment which is reasonably sized, the differences between the Codes would be minimal (if there is any difference, considering MNECB consulted ASHRAE heavily in establishing such performance standards). This relatively small difference is further minimized by the fact that cooling energy comprises a relatively small portion (e.g., ~<5%) of the the commercial stock building energy use. Note that NRCan's EE4 program doesn't allow modification of part-load performance, making the equivalency comparison somewhat inconsistent from a modelling implementation standpoint for a typical user. Finally, all NRCan templates use the defaul centrifugal part-load curve default, regardless of the chiller size.
Chilled water temperature	If hydronic cooling applies	Temperature rise of 10°F. Supply T of 45°F.	Temperature rise of 12°F. Supply T of 44°F.	Set baseline at 12°F for new projects.	A 2°F temperature difference between the Codes makes very little difference in the relative overall energy performances. The difference in the minimum supply temperature makes even less difference. However, these differences would be captured in the newly generated projects (as necessary).

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
Chilled water reset	If hydronic cooling applies	No reset	Outdoor air reset unless variable flow pumping applies.	Increase cooling efficiency by 9%, 21%, and 7% for the Vancouver, Summerland and Prince George, respectively; from sensitivity analysis performed using DOE2 eca133 on cases with hydronic cooling on large office prototype.	The version of DOE2 used for NRCan's projects did not allow for directly modelling outdoor air boiler reset. Hence, we converted the large office CBIP References to work with the latest (non-public) version of DOE2 and applied the new chilled water reset feature.. Note that we did this to estimate an appropriate increase in the cooling efficiency (including cooling tower savings) to apply to the NRCan models. We did not convert all projects to work with the latest version of DOE2 since this would reach far beyond the scope considering the amount of work required to do this for all projects versus the relative benefits.
Chilled water flow	If hydronic cooling applies	Constant flow chilled water circulation.	Variable flow down to 50% flow, riding curve if head is less than 100' and pump power < 50 hp	Set pump VSDs appropriately. Revise parametric PLR to 0.8 for VSD parametric run for new projects.	Note that in DOE2, setting the pump VSDs with a 0.5 part-load ratio setting proves to be much better than riding a pump curve to 50%. The pumping power is at about 80% of peak when riding the curve to 50%, whereas the VSD curve results in about 30% of peak power at the same point. Therefore, we estimate an equivalent representation of ASHRAE's requirement by applying VSDs down to only 80%.
Cooling Tower	If hydronic cooling applies	Two cell cooling tower with 85°F - 95°F temperature rise, and a constant speed fan with cycling control and 5.9 hp/1000 MBH. Constant speed tower pump at head same as proposed (default 60') and combined efficiency of 70%.	Axial fan cooling tower with 78°F - 88°F temperature rise with wet bulb reset control down to 70°F and a constant speed fan with cycling control and 32.8 gpm/hp of fan power. Two speed if fans greater than 7.5 hp. Pumping peak power same as MNECB.	Set baseline cooling tower characteristics as indicated by ASHRAE for new projects (e.g,. E-I-R = 0.021)	ASHRAE's cooling tower pumping power is the same for the proposed case, which for NRCan's projects, is defaulted to the MNECB Reference.

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
Direct Expansion (DX) Cooling	Cooling source (i.e,. if DX); for ASHRAE, type of DX equipment indicates efficiency.	DX cooling with a SEER of 8.5 (COP = 2.5)	DX cooling with with efficiencies as listed in 6.2.1A or 6.2.1D, depending on equipment type.	Set cooling efficiency appropriately. Represent average cooling efficiency for appropriate cross-section of equipment since efficiency is often based on size, which cannot always be discerned for commercial sector-based analysis purposes.	If the Proposed case has DX cooling, the respective Code references must also have DX cooling. For ASHRAE, the reference case has water-source heat pumps if the Proposed case has distributed heat pumps, whereas MNECB would have a chiller in the reference case. ASHRAE also varies from MNECB if the Proposed case has an air-cooled chiller, in which case, the reference case has DX cooling. Note that the BC Energy Efficiency Act, which appears to be identical to ASHRAE 90.1-1989, indicates more stringent efficiency requirements. MNECB and CBIP, however, do not reference this standard for energy budget purposes.
Heat Pumps	Principal heating source as heat pump	Air-source heat pump at a SEER of 8.5 (COP = 2.5)	Air- or water-source heat pumps, depending on reference system type, with efficiencies as listed in 6.2.1B or 6.2.1D, whichever is applicable.	Set heat pump cooling efficiency appropriately. Adjust baseline for heating versus cooling efficiency if different from 1.2.	We will need to double-check applicability for MNECB cases. For instance, I'm not positive about MURB cases with PTHPs served by gas-fired MAU. Heat pump heating efficiency is linked with the cooling efficiency in the NRCan projects. If this preset relationship is significantly different for ASHRAE, account for this in new projects.
DHW					
Heating Fuel Source				Set DHW efficiency appropriately. Use gas since it makes up over 99% of DHW heating.	Representation of electric heating in commercial market is minimal and hence, will not be included in the matrix of representative projects. Besides, electric DHW efficiency in DOE2 is forced to 100% and only losses can be changed. But the level of DHW losses are mandatory requirements (for any fuel source), and are not included in the EE4 energy performance modelling, although many of the CBIP models include it. Hence, for the purposes of this study, the Codes are considered equivalent in this category.
	Electric	Electric resistance at 100% heating efficiency	Electric resistance with overall efficiency of <=93%, but this appears to include losses		
	Natural Gas	Gas-fired water heating at 80% efficiency	Gas-fired water heating at 80% efficiency		
Load	Yes	Same as for proposed	Same as for proposed	Maintain default MNECB levels for both Reference cases.	For some reason, MNECB models the DHW load using a constant 70°F temperature difference instead of using a more realistic monthly profile (e.g., 140°F - inlet temperature). However, the DHW load is consistently described and correlates with the default levels for each respective space function. In other words, the DHW load is consistent with how most EE4 modellers would describe it, even if the modelling approach is somewhat flawed from reality.

APPENDIX B

Final Report:

Verification of LEED-BC v1.0 Energy Credit 1 Point Awards for Building Energy Conservation in British Columbia

Prototype MNECB+CBIP Reference and ASHRAE+LEED Budget Model Building Descriptions

(Supplement to Appendix A: Energy Code Comparisons and Analysis Approach Notes

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 CBIP and ECB Reference models. In many cases information for certain characteristics are the same between the Reference models, but we provide information since it is unique to the building type and/or of significance to the energy performance. This table is complimented by the *Table of Energy Code Comparisons and Analysis Approaches* , which provides further details on modelling approaches and reasons for these approaches.

Item	MNECB+CBIP		ASHRAE+LEED ECB					Discussion/Issues
EXTERIOR SURFACES								
Wall Overall R-Value	Electric Heat Source	Gas Heat Source	Mass	Metal	Steel	Other	R_o	Allocation of construction types is based solely on professional experience in the commercial sector and is not statistically proven nor supported by market research. A "mass" type construction would likely include tilt-up concrete and brick. Steel stud and curtainwall systems would be considered as "steel" (framed). Other includes wood stud construction.
Lower Mainland	12.6	7.0	50% 8.1	0% 8.8	50% 8.1	0% 11.2	8.1	
Okanagan	15.3	12.6	50% 8.13	0% 8.85	30% 11.9	20% 11.2	9.9	
North Interior	15.3	12.6	50% 11.1	0% 17.5	30% 15.6	20% 11.2	12.5	
Roof Overall R-Value	Electric Heat Source	Gas Heat Source	Insulation Entirely above Deck					For this building type, all roof types as flat roofs with continuous insulation (i.e., "Type III" for MNECB). This is based on professional experience in the commercial sector and is not statistically proven nor supported by market research.
Lower Mainland	13.8	12.1	15.9					
Okanagan	19.6	12.1	15.9					
North Interior	19.6	13.8	15.9					
Exposed Floor R-Value	Electric Heat Source	Gas Heat Source	Mass	Steel	Other		R_o	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. A "Type II" floor corresponds to "mass" type for ASHRAE and would include concrete deck. "Type I" MNECB floors correspond to "other" and "steel" types for ASHRAE.
Lower Mainland	13.8	13.8	100% 9.3	0% 19.2	0% 19.6		9.3	
Okanagan	22.1	17.6	60% 11.5	0% 19.2	40% 30.3		19.0	
North Interior	22.1	18.6	60% 11.5	0% 26.3	40% 30.3		19.0	
GLAZING								
Glazing Percent	40%		40%					From BC Hydro survey information on 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 MNECB maximum based on professional observation and estimates.

Small Office: Key Building Characteristics

Window U-value	Electric Heat Source	Gas Heat Source	Oper-able	Fixed	U_o	
Lower Mainland	0.57	0.57	10% 0.47	90% 0.46	0.46	Operable windows are becoming more prevalent in new construction, but is still relatively low overall. Factors are based on professional experience in the commercial sector 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.
Okanagan	0.32	0.57	10% 0.47	90% 0.46	0.46	
North Interior	0.32	0.57	10% 0.47	90% 0.46	0.46	
Window Shading Coefficient						ASHRAE differentiates between North-facing windows separately from all other windows.
Lower Mainland	0.74		0.57 (all orientations) / 0.74 (North)			
Okanagan	0.74		0.57 (all orientations, including North)			
North Interior	0.74		0.57 (all orientations) / 0.74 (North)			
SPACE CONDITIONS						
Schedules	MNECB Schedule A		Same as MNECB+CBIP			Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines
Lighting	1.67 W/ft²		1.3 W/ft²			
Equipment density	0.70 W/ft²		0.70 W/ft²			
HVAC SYSTEM TYPE						
Air Handling	VAV reheat		a) VAV reheat (System 4) b) Distributed heat pump (System 6) c) VAV with parallel fan-powered boxes (System 3)			System ID indicated for ASHRAE refers to system type identified in Table 11.4.3A. System 4 (packaged VAV) is referenced for small offices instead of System 2 since most smaller projects use air-cooled chillers or DX cooling.
Principle Heating Fuel Type	1) Gas (L02g??r) 2) Electric (L02e??r)		a) Gas for System 4 (L02g??rB) b) Gas for System 6 (L02g??2B) c) Electric for System 3 (L02e??rB)			IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	Hydronic		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		Minimum based on warmest zone for System 2, constant for System 3			Minimum supply air temperature control only applies to VAV systems.
Fan Power	4.0"/55% fan efficiency for supply and 1.0"/30% fan efficiency for return		Keep at MNECB+CBIP defaults; including using 1.3"/40% fan efficiency for MAU and 0.5"/25% for heat pumps for distributed HP			MNECB default total static pressures and fan efficiencies have typically aligned with most proposed designs, including cases with DX cooling, which dictates different static pressures and fan efficiencies for MNECB. However, proposed designs also agree relatively well with these defaults in such situations and hence, no adjustment is warranted since the *relative differences* are minimal.

Small Office: Key Building Characteristics

Outside Air	0.08 cfm/ft²	Same as MNECB+CBIP	
Fan Curve (VAV only)	MNECB "top-level" fan curve (Type c)	VSD	MNECB Type c curve is very similar in performance to a VSD curve from 50% - 100% loading, but drops off in relative performance below 50%.
Heat Reclaim	N/A	N/A	
HVAC CONTROL			
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Same as MNECB+CBIP	
Economizer	Enthalpy	Temperature for VAV; N/A for distributed HP	
HEATING PLANT			
Central Heating Efficiency	One 80% efficient boiler; no HW reset	Two 80% 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.
Lower Mainland		81.5%	
Okanagan		81.5%	
North Interior		82.0%	
Hot Water Flow	Constant flow hot water circulation.	Variable flow down to 50% flow, riding curve	Default CBIP models set at 50' head.
Heat Pumps	N/A	4.2 COP for distributed HP system	
COOLING			
Central Cooling Efficiency	Reciprocating chiller at 3.8 COP; no CHW reset	Unitary air-cooled AC at 2.9 (average across all size of units)	The default CBIP Reference employs hydronic cooling, which is the appropriate reference cooling equipment for air-cooled chillers. From our experience, air-cooled chillers are prevalent for new small buildings. However, some CBIP jobs would require the use of DX cooling in the CBIP Reference, with a 2.5 COP (but no cooling tower). **Refer to associated LEED-BC Equivalency report for more discussion on the identification of cooling equipment for the prototype Reference models.**
Chilled Water Temperature	10°F rise; 45°F supply	N/A	
Chilled Water Flow	Constant flow hot water circulation.	N/A	Default CBIP models set at 50' head.

Small Office: Key Building Characteristics

Cooling Tower	Two cell cooling tower with 85°F - 95°F temperature rise, and a constant speed fan with cycling control and 5.9 hp/1000 MBH. Constant speed tower pump at 40' head and combined efficiency of 70%.	N/A	
Heat Pumps	N/A	12 EER for distributed HP system	ASHRAE lists different efficiency levels based on size of heat pump, but we cannot distinguish the HP size for a ficticious Reference case. Hence, used highest rating to be conservative (which applies to 2 of 3 categories anyway).
Domesting Hot Water (DHW)			
Heating Efficiency	80%	80%	Losses set at 3% in CBIP prototype models.
Avg. Load (Btu/sf/day)	2.77	Same as MNECB+CBIP	

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 CBIP and ECB Reference models. In many cases information for certain characteristics are the same between the Reference models, but we provide information since it is unique to the building type and/or of significance to the energy performance. This table is complimented by the *Table of Energy Code Comparisons and Analysis Approaches* , which provides further details on modelling approaches and reasons for these approaches.

Item	MNECB+CBIP		ASHRAE+LEED ECB						Discussion/Issues
EXTERIOR SURFACES									
Wall Overall R-Value	Electric Heat Source	Gas Heat Source	Mass	Metal	Steel	Other		R_o	Allocation of construction types is based solely on professional experience in the commercial sector and is not statistically proven nor supported by market research. A "mass" type construction would likely include tilt-up concrete and brick. Steel stud and curtainwall systems would be considered as "steel" (framed). Other includes wood stud construction.
Lower Mainland	12.6	7.0	25%	0%	75%	0%		8.1	
			8.1	8.8	8.1	11.2			
Okanagan	15.3	12.6	25%	0%	75%	0%		11.0	
			8.13	8.85	11.9	11.2			
North Interior	15.3	12.6	25%	0%	75%	0%		14.5	
			11.1	17.5	15.6	11.2			
Roof Overall R-Value	Electric Heat Source	Gas Heat Source	Insulation Entirely above Deck						For this building type, all roof types as flat roofs with continuous insulation (i.e., "Type III" for MNECB). This is based on professional experience in the commercial sector and is not statistically proven nor supported by market research.
Lower Mainland	13.8	12.1	15.9						
Okanagan	19.6	12.1	15.9						
North Interior	19.6	13.8	15.9						
Exposed Floor R-Value	Electric Heat Source	Gas Heat Source	Mass	Steel	Other			R_o	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. A "Type II" floor corresponds to "mass" type for ASHRAE and would include concrete deck. "Type I" MNECB floors correspond to "other" and "steel" types for ASHRAE.
Lower Mainland	13.8	13.8	100%	0%	0%			9.3	
			9.3	19.2	19.6				
Okanagan	19.6	12.1	100%	0%	0%			11.5	
			11.5	19.2	30.3				
North Interior	19.6	13.8	100%	0%	0%			11.5	
			11.5	26.3	30.3				
GLAZING									
Glazing Percent	40%		50%						From BC Hydro survey information on existing offices, the average percent window area is about 40%. However, since newer buildings have much higher percentages of glazing, estimated new construction percent at above both Standards' maximum based on professional observation and estimates.

Large Office: Key Building Characteristics

Window U-value	Electric Heat Source	Gas Heat Source	Oper-able	Fixed	U_o	Notes
Lower Mainland	0.56	0.56	5%	95%	0.46	Operable windows are becoming more prevalent in new construction, but is still relatively low overall. Factors are based on professional experience in the commercial sector 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.
			0.47	0.46		
Okanagan	0.31	0.56	5%	95%	0.46	
			0.47	0.46		
North Interior	0.31	0.56	5%	95%	0.46	
			0.47	0.46		

Window Shading Coefficient			ASHRAE differentiates between North-facing windows separately from all other windows.
Lower Mainland	0.74	0.57 (all orientations) / 0.74 (North)	
Okanagan	0.74	0.57 (all orientations, including North)	
North Interior	0.74	0.57 (all orientations) / 0.74 (North)	
SPACE CONDITIONS			
Schedules	MNECB Schedule A	Same as MNECB+CBIP	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines
Lighting	1.67 W/ft²	1.3 W/ft²	
Equipment density	0.70 W/ft²	0.70 W/ft²	
HVAC SYSTEM TYPE			
Air Handling	VAV reheat	a) VAV reheat (System 2) b) Distributed heat pump (System 6) c) VAV with parallel fan-powered boxes (System 1)	System ID indicated for ASHRAE refers to system type identified in Table 11.4.3A.
Principle Heating Fuel Type	1) Gas (L01g??r) 2) Electric (L01e??r)	a) Gas for System 2 (L01g??rB) b) Gas for System 6 (L01g??2B) c) Electric for System 1 (L01e??rB)	IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	Hydronic	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	Minimum based on warmest zone for System 2, constant for System 1	Minimum supply air temperature control only applies to VAV systems.
Fan Power	4.0"/55% fan efficiency for supply and 1.0"/30% fan efficiency for return	Keep at MNECB+CBIP defaults; including using 1.3"/40% fan efficiency for MAU and 0.5"/25% for heat pumps for distributed HP	MNECB default total static pressures and fan efficiencies have typically aligned with most proposed designs, including cases with DX cooling, which dictates different static pressures and fan efficiencies for MNECB. However, proposed designs also agree relatively well with these defaults in such situations and hence, no adjustment is warranted since the *relative differences* are minimal.

Large Office: Key Building Characteristics

Outside Air	0.08 cfm/ft²	Same as MNECB+CBIP	
Fan Curve (VAV only)	MNECB "top-level" fan curve (Type c)	VSD	MNECB Type c curve is very similar in performance to a VSD curve from 50% - 100% loading, but drops off in relative performance below 50%.
Heat Reclaim	N/A	N/A	
HVAC CONTROL			
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Same as MNECB+CBIP	
Economizer	Enthalpy	Temperature for VAV; N/A for distributed HP	
HEATING PLANT			
Central Heating Efficiency	One 80% efficient boiler; no HW reset	Two 80% 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.
Lower Mainland		81.5%	
Okanagan		81.5%	
North Interior		82.0%	
Hot Water Temperature	30°F drop; 140°F supply	50°F drop; 180°F supply	
Hot Water Flow	Constant flow hot water circulation.	Variable flow down to 50% flow, riding curve	Default CBIP models set at 50' head.
Heat Pumps	N/A	4.2 COP for distributed HP system	
COOLING			
Central Cooling Efficiency	Centrifigual chiller at 5.2 COP; no CHW reset	Use 2 screw or centrifugal chillers depending on region; effectively increase COP by 8% - 21% for reset	Air-cooled chillers may be present in some new large buildings, but we went with the most prevalent situation. **Refer to associated LEED-BC Equivalency report for more discussion on the identification of cooling equipment for the prototype Reference models.** MNECB does not specify a screw chiller part-load curve, but we used one provided by DOE2's Sample Run book since other CBIP chillers also align with DOE2. This part-load curve improved seasonal performance making the equivalency analysis more conservative.
Lower Mainland		2 screw chillers at COP of 4.9 + 0.4 = 5.3	
Okanagan		2 centrifugal chillers at COP of 6.1 + 1.3 = 7.4	
North Interior		2 screw chillers at COP of 4.9 + 0.3 = 5.2	
Chilled Water Temperature	10°F rise; 45°F supply	12°F rise; 44°F supply	
Chilled Water Flow	Constant flow chilled water circulation.	Variable flow down to 50% flow, riding curve	Default CBIP models set at 50' head.

Large Office: Key Building Characteristics

Cooling Tower	Two cell cooling tower with 85°F - 95°F temperature rise, and a constant speed fan with cycling control and 5.9 hp/1000 MBH. Constant speed tower pump at 40' head and combined efficiency of 70% (DOE2 TWR-EIR = 0.015)	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)	
Heat Pumps	N/A	12 EER for distributed HP system	ASHRAE lists different efficiency levels based on size of heat pump, but we cannot distinguish the HP size for a ficticious Reference case. Hence, used highest rating to be conservative (which applies to 2 of 3 categories anyway).
Domesting Hot Water (DHW)			
Heating Efficiency	80%	80%	Losses set at 3% in CBIP prototype models.
Avg. Load (Btu/sf/day)	2.77	Same as MNECB+CBIP	

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.

The following listing provides the key building characteristics which differ between the CBIP and ECB Reference models. In many cases information for certain characteristics are the same between the Reference models, but we provide information since it is unique to the building type and/or of significance to the energy performance. This table is complimented by the *Table of Energy Code Comparisons and Analysis Approaches* , which provides further details on modelling approaches and reasons for these approaches.

<table>
<tr><th>Item</th><th colspan="2">MNECB+CBIP</th><th colspan="5">ASHRAE+LEED ECB</th><th>Discussion/Issues</th></tr>
<tr><td colspan="9">EXTERIOR SURFACES</td></tr>
<tr><td>Wall Overall R-Value</td><td>Electric Heat Source</td><td>Gas Heat Source</td><td>Mass</td><td>Metal</td><td>Steel</td><td>Other</td><td>R_o</td><td rowspan="4">Allocation of construction types is based solely on professional experience in the commercial sector and is not statistically proven nor supported by market research.
Recent new Design Assistance schools have been steel framed, tilt-up or concrete block (particularly in gyms), and wood framed for small elementary schools. Thus, it appears that an even mix of constructions is apparent.</td></tr>
<tr><td>Lower Mainland</td><td>12.6</td><td>7.0</td><td>33%
8.1</td><td>0%
8.8</td><td>33%
8.1</td><td>33%
11.2</td><td>9.1</td></tr>
<tr><td>Okanagan</td><td>15.3</td><td>12.6</td><td>33%
8.13</td><td>0%
8.85</td><td>33%
11.9</td><td>33%
11.2</td><td>10.4</td></tr>
<tr><td>North Interior</td><td>15.3</td><td>12.6</td><td>33%
11.1</td><td>0%
17.5</td><td>33%
15.6</td><td>33%
11.2</td><td>12.7</td></tr>
<tr><td>Roof Overall R-Value</td><td>Electric Heat Source</td><td>Gas Heat Source</td><td colspan="5">Insulation Entirely above Deck</td><td rowspan="4">For this building type, all roof types as flat roofs with continuous insulation (i.e., "Type III" for MNECB). 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 experience in the commercial sector and is not statistically proven nor supported by market research.</td></tr>
<tr><td>Lower Mainland</td><td>13.8</td><td>12.1</td><td colspan="5">15.9</td></tr>
<tr><td>Okanagan</td><td>19.6</td><td>12.1</td><td colspan="5">15.9</td></tr>
<tr><td>North Interior</td><td>19.6</td><td>13.8</td><td colspan="5">15.9</td></tr>
<tr><td>Exposed Floor R-Value</td><td colspan="2">N/A</td><td colspan="5">N/A</td><td>Exposed floor is not a significant characteristic and NRCan archetypes do not include them in the models.</td></tr>
<tr><td colspan="9">GLAZING</td></tr>
<tr><td>Glazing Percent</td><td colspan="2">16%</td><td colspan="5">16%</td><td>From BC Hydro survey information on existing schools, the average percent window area is about 16%. This is confirmed by new designs and Provincial design guidelines.</td></tr>
<tr><td>Window U-value</td><td>Electric Heat Source</td><td>Gas Heat Source</td><td colspan="2">Oper-able</td><td colspan="2">Fixed</td><td>U_o</td><td rowspan="4">Operable windows are becoming more prevalent in new construction, but is still relatively low overall. Factors are based on professional experience in the commercial sector 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.</td></tr>
<tr><td>Lower Mainland</td><td>0.57</td><td>0.57</td><td colspan="2">25%
0.47</td><td colspan="2">75%
0.46</td><td>0.46</td></tr>
<tr><td>Okanagan</td><td>0.34</td><td>0.57</td><td colspan="2">25%
0.47</td><td colspan="2">75%
0.46</td><td>0.46</td></tr>
<tr><td>North Interior</td><td>0.34</td><td>0.57</td><td colspan="2">25%
0.47</td><td colspan="2">75%
0.46</td><td>0.46</td></tr>
</table>

School: Key Building Characteristics

Window Shading Coefficient			ASHRAE differentiates between North-facing windows separately from all other windows.
Lower Mainland	0.74	0.57 (all orientations) / 0.74 (North)	
Okanagan	0.74	0.57 (all orientations, including North)	
North Interior	0.74	0.57 (all orientations) / 0.74 (North)	
SPACE CONDITIONS			
Schedules	MNECB Schedule A	Same as MNECB+CBIP	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines
Lighting	1.77 W/ft²	1.5 W/ft²	
Equipment density	0.46 W/ft²	0.46 W/ft²	
HVAC SYSTEM TYPE			
Air Handling	VAV Reheat (baseboards) PSZ serving Gym	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)	System ID indicated for ASHRAE refers to system type identified in Table 11.4.3A. System 4 (packaged VAV) is referenced instead of System 2 since most smaller projects use air-cooled chillers or DX cooling. Note that a PIU system for school does not make much sense and behaves pecularly with DOE2 with unmet heating loads in the middle of summer, but this is what is requred by ASHRAE.
Principle Heating Fuel Type	1) Gas (S01g??r) 2) Electric (S01e??r)	a) Gas for System 4 (S01g??rB) b) Electric for System 3, with air-source heat pump for Gym (S01e??rB)	IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	Hydronic in Okanagan, DX in Vancouver and Prince George	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 for all but the Okanagan, which typically has air-cooled chillers.
FAN SYSTEM			
Supply Air Temperature Control	Minimum based on warmest zone	Minimum based on warmest zone for System 4; Constant for System 3	Minimum supply air temperature control only applies to VAV systems.
Fan Power	Hydronic Cooling: 4.0"/55% fan efficiency for supply and 1.0"/30% fan efficiency for return Single zone cooling at 1.3" supply static	Static pressure set at MNECB default for DX/no cooling since it is closer to typical proposed designs: multiple zone systems at 3.0"/45% fan efficiency for supply and 0.6"/25% fan efficiency for return; Single zone systems same as MNECB+CBIP	MNECB default total static pressures and fan efficiencies have typically aligned with most proposed designs, including cases with DX cooling, which dictates different static pressures and fan efficiencies for MNECB. However, the fan power in schools for proposed designs is typically lower than specified by MNECB for the default archetype model, requiring that the ECB case also be lower. PIU system for modelling parallel boxes required increasing the peak fan sizing to produce more reasonable hours of unmet heating loads.

School: Key Building Characteristics

Outside Air	0.20 cfm/ft²	Same as MNECB+CBIP	
Fan Curve (VAV only)	MNECB "mid-level" fan curve (Type b) This varies from Web Screening Tool which used Type c curve (see note)	MNECB "top-level" fan curve (Type c) for VAV system	NRCan prototype bunches most zones all into a single system when schools are typically design with several systems. Hence, the fan size rarely would be over 25 HP (the point at which a VSD is required) or 25 kW (the point at which the MNECB best fan curve is used). Thus, use "next lower" fan curve for each Code, respectively.
Heat Reclaim	N/A	N/A	
HVAC CONTROL			
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Same as MNECB+CBIP	
Economizer	Enthalpy	Temperature for VAV and PSZ	
HEATING PLANT			
Central Heating Efficiency	One 80% efficient boiler; no HW reset	Two 80% efficient boilers, plus 1.5% - 2.0% pts. for reset, as indicated below. Gas furnace for Gym at 80% efficiency	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.
Lower Mainland		81.5%	
Okanagan		81.5%	
North Interior		82.0%	
Hot Water Temperature	30°F drop; 140°F supply	50°F drop; 180°F supply	
Hot Water Flow	Constant flow hot water circulation.	Variable flow down to 50% flow, riding curve	Default CBIP models set at 60' head.
Heat Pumps	N/A	Air-source at 3.2	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 (closer to 1.2x for water-source). Since size of unit influences efficiency and a typical size is difficult to ascertain, we placed heating efficiency at 1.1x cooling efficiency. This would be conservative.

School: Key Building Characteristics

COOLING: *Applies only to about 20% of Lower Mainland and North Interior regions, and 80% of Okanagan regions (gyms are rarely cooled). NRCan templates are not set up to allow for easy removal of this level of cooling. Instead, reduced resulting cooling end-use by 80% as is done in Web Screening Tool. This is appropriate since air systems are typically sized to deliver supply air based on the assumption that mechanical cooling would be present.*

Central Cooling Efficiency	Okanagan: reciprocating chiller at 3.8 COP without CHW reset; other regions with DX at 2.5 COP	Unitary air-cooled AC at 2.9 COP (average across all size of units)	The default CBIP Reference employs hydronic cooling, which is the appropriate reference cooling equipment for air-cooled chillers. From our experience, air-cooled chillers are prevalent for new small buildings. However, some CBIP jobs would require the use of DX cooling in the CBIP Reference, with a 2.5 COP (but no cooling tower). **Refer to associated LEED-BC Equivalency report for more discussion on the identification of cooling equipment for the prototype Reference models.**
Chilled Water Temperature	10°F rise; 45°F supply	N/A	
Chilled Water Flow	Constant flow chilled water circulation.	N/A	Default CBIP models set at 60' head.
Cooling Tower	Two cell cooling tower with 85°F - 95°F temperature rise, and a constant speed fan with cycling control and 5.9 hp/1000 MBH. Constant speed tower pump at 40' head and combined efficiency of 70%. DOE2 TWR-EIR = 0.015.	N/A	
Heat Pumps	N/A	Air-source only - same as listed above	
Domesting Hot Water (DHW)			
Heating Efficiency	80%	80%	Losses set at 3% in CBIP prototype models.
Avg. Load (Btu/sf/day)	7.3	Same as MNECB+CBIP	

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 CBIP and ECB Reference models. In many cases information for certain characteristics are the same between the Reference models, but we provide information since it is unique to the building type and/or of significance to the energy performance. This table is complimented by the *Table of Energy Code Comparisons and Analysis Approaches* , which provides further details on modelling approaches and reasons for these approaches.

Item	MNECB+CBIP		ASHRAE+LEED ECB					Discussion/Issues
EXTERIOR SURFACES								
Wall Overall R-Value	Electric Heat Source	Gas Heat Source	Mass	Metal	Steel	Other	R_o	Allocation of construction types is based solely on professional experience in the commercial sector and is not statistically proven nor supported by market research. We have observed several design with steel studs, but also with brick vaneer, which would qualify as "mass" type instead of "steel" according to ASHRAE definitions on thermal capacitance.
Lower Mainland	12.6	7.0	40%	0%	40%	20%	8.7	
			8.1	8.8	8.1	11.2		
Okanagan	15.3	12.6	40%	0%	40%	20%	10.3	
			8.13	8.85	11.9	11.2		
North Interior	15.3	12.6	40%	0%	40%	20%	12.9	
			11.1	17.5	15.6	11.2		
Roof Overall R-Value	Electric Heat Source	Gas Heat Source	Insulation above Deck	Attic and Other			R_o	For this building type, indications were that roofs there is a split between flat and attic type roofs (i.e., "Type III" and "Type I" for MNECB), 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. However, it is not statistically proven nor supported by market research.
Lower Mainland	20.5	17.0	75%	25%			19.3	
			15.9	29.4				
Okanagan	30.1	21.8	50%	50%			22.6	
			15.9	29.4				
North Interior	30.1	27.2	50%	50%			26.5	
			15.9	37.0				
Exposed Floor R-Value	N/A		N/A					Exposed floor is not a significant characteristic and NRCan archetypes do not include them in the models.
GLAZING								
Glazing Percent	24%		24%					Average specified in NRCan archetypes and appears reasonable based on our experience.
Window U-value	Electric Heat Source	Gas Heat Source	Oper-able	Fixed			U_o	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. Factors are based on professional experience in the commercial sector 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.
Lower Mainland	0.57	0.57	25%	75%			0.46	
			0.47	0.46				
Okanagan	0.34	0.57	25%	75%			0.46	
			0.47	0.46				
North Interior	0.34	0.57	25%	75%			0.46	
			0.47	0.46				

Extended Care Facility: Key Building Characteristics

Window Shading Coefficient			ASHRAE differentiates between North-facing windows separately from all other windows.
Lower Mainland	0.74	0.57 (all orientations) / 0.74 (North)	
Okanagan		0.57 (all orientations, including North)	
North Interior		0.57 (all orientations) / 0.74 (North)	
SPACE CONDITIONS			
Schedules	MNECB Schedule A	Same as MNECB+CBIP	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines
Lighting	1.54 W/ft²	1.4 W/ft²	The MNECB and ASHRAE Lighting loads are based on Space Function for a typical Extended Care home from the NRCan Health Care Study. A significant difference between ASHRAE and MNECB is that lighting area factors (LAFs) were used to calculate the MNECB Reference Case, which increases the lighting power allowance (LPA). Otherwise, the LPAs would be nearly equal.
Equipment density	0.2 W/ft²	0.2 W/ft²	
HVAC SYSTEM TYPE			
Air Handling	PSZ or PTAC serving Suites, PVAV serving common	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)	System ID indicated for ASHRAE refers to system type identified in Table 11.4.3A. 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.
Principle Heating Fuel Type	1) Gas (H01g??r) 2) Electric (H01e??r1)	a) Gas for Systems 4 & 10 (H01g??rB) b) Electric for Systems 8 & 3 (H01e??rB)	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	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 VAV	Minimum based on warmest zone for System 4; Constant for System 3	Minimum supply air temperature control only applies to VAV systems.

Extended Care Facility: Key Building Characteristics

Fan Power	Suites: 0.5"/25% supply, no return; Common: 3.0"/45% supply, 0.6"/25% return	Keep at MNECB+CBIP defaults	MNECB default total static pressures and fan efficiencies have typically aligned with most proposed designs, including cases with DX cooling, which dictates different static pressures and fan efficiencies for MNECB. However, proposed designs also agree relatively well with these defaults in such situations and hence, no adjustment is warranted since the *relative differences* are minimal.
Outside Air	0.32 cfm/ft²	Same as MNECB+CBIP	
Fan Curve (VAV only)	MNECB "low-level" fan curve (Type a)	MNECB "top-level" fan curve (Type c)	MNECB Type c curve is very similar in performance to a VSD curve from 50% - 100% loading, but drops off in relative performance below 50%.
Heat Reclaim	N/A	50% effectiveness applied to 90% of outdoor air (<u>45% overall</u>)	Most spaces within an extended care facility require 100% outside air, with the possible exception of some common areas (e.g., admin spaces). Hence, reduced overall effectiveness for ASHRAE case accordingly.
HVAC CONTROL			
Heating and Cooling Setpoints	Occupied: Common with 72°/77°, setback to 65°/85°; 74° minimum at all times in a quarter of suites	Same as MNECB+CBIP	NRCan templates indicated different setpoints for Okanagan and Northern Interior based on adapting characteristics from Regina archetype due to closest climate similarity. We reset back to setting for B.C.
Economizer	Enthalpy	Temperature for VAV and PSZ	
HEATING PLANT			
Central Heating Efficiency	One 80% efficient boiler; no HW reset	Two 80% 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.
Lower Mainland		81.5%	
Okanagan		81.5%	
North Interior		82.0%	
Hot Water Temperature	30°F drop; 140°F supply	50°F drop; 180°F supply	
Hot Water Flow	Constant flow hot water circulation.	Variable flow down to 50% flow, riding curve	Default CBIP models set at 40' head.
Heat Pumps	N/A	Air-source at 3.2	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 (closer to 1.2x for water-source). Since size of unit influences efficiency and a typical size is difficult to ascertain, we placed heating efficiency at 1.1x cooling efficiency. This would be conservative.

Extended Care Facility: Key Building Characteristics

COOLING			
Central Cooling Efficiency	DX cooling with COP at 2.5	Suites with DX at 2.9 COP; Common with DX at COP = 2.9	For ASHRAE from Table 6.2.1D, suites PTHP efficiencies range from 10.8 EER to 9.1 EER, as the size increases. Common spaces could have nearly any size of equipment, which dictates the efficiency for ASHRAE. However, most extended care situations have small units and hence, specified the highest rating in Table 6.2.1A for the smallest unit. The high end of suite PTHPs also corresponded to this efficiency and hence, we placed them both at the same efficiency level for simplicity and to maintain a conservative approach.
Heat Pumps	N/A	Air-source only - same as listed above	
Domesting Hot Water (DHW)			
Heating Efficiency	80%	80%	No losses in CBIP prototype models, as is consistent with EE4.
Avg. Load (Btu/sf/day)	28.3	Same as MNECB+CBIP	Includes any losses in addition to MNECB default requirements.. From experience and BC Hydro load research information, actual hot water demand in extended care homes is lower than the MNECB defaults. Since we created the NRCan archetypes, this was integrated into the models.

Motel/Hotel: Key Building Characteristics

The motel/hotel archetype from NRCan represents a 123,500 ft^2 (11,500 m^2), nine storey building. The building has a wall-to-roof area ratio of 2.5. The functional zones include guest rooms, lobby, banquet room, kitchen, meeting room, fitness centre, restaurant, and corridors.

The following listing provides the key building characteristics which differ between the CBIP and ECB Reference models. In many cases information for certain characteristics are the same between the Reference models, but we provide information since it is unique to the building type and/or of significance to the energy performance. This table is complimented by the *Table of Energy Code Comparisons and Analysis Approaches* , which provides further details on modelling approaches and reasons for these approaches.

Item	MNECB+CBIP		ASHRAE+LEED ECB					Discussion/Issues
EXTERIOR SURFACES								
Wall Overall R-Value	Electric Heat Source	Gas Heat Source	Mass	Metal	Steel	Other	R_o	Allocation of construction types is based solely on professional experience in the commercial sector and is not statistically proven nor supported by market research.
Lower Mainland	12.6	7.0	30% / 8.1	0% / 8.8	60% / 8.1	10% / 11.2	8.4	
Okanagan	15.3	12.6	45% / 8.13	0% / 8.85	45% / 11.9	10% / 11.2	10.1	
North Interior	15.3	12.6	45% / 11.1	0% / 17.5	45% / 15.6	10% / 11.2	13.2	
Roof Overall R-Value	Electric Heat Source	Gas Heat Source	Insulation Entirely above Deck					For this building type, all roof types as flat roofs with continuous insulation (i.e., "Type III" for MNECB). 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 experience in the commercial sector and is not statistically proven nor supported by market research.
Lower Mainland	13.8	12.1	15.9					
Okanagan	19.6	12.1	15.9					
North Interior	19.6	13.8	15.9					
Exposed Floor R-Value	N/A		N/A					Exposed floor is not a significant characteristic and NRCan archetypes do not include them in the models.
GLAZING								
Glazing Percent	35%		35%					From BC Hydro survey information on existing hotels/motels, the average percent window area is ~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	Electric Heat Source	Gas Heat Source	Oper-able		Fixed		U_o	Operable windows are common in low rise hotels/motels and some high rise hotels. Factors are based on professional experience in the commercial sector 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.
Lower Mainland	0.57	0.57	25% / 0.47		75% / 0.46		0.46	
Okanagan	0.34	0.57	25% / 0.47		75% / 0.46		0.46	
North Interior	0.34	0.57	25% / 0.47		75% / 0.46		0.46	

Motel/Hotel: Key Building Characteristics

Window Shading Coefficient			ASHRAE differentiates between North-facing windows separately from all other windows.
Lower Mainland	0.74	0.57 (all orientations) / 0.74 (North)	
Okanagan	0.74	0.57 (all orientations, including North)	
North Interior	0.74	0.57 (all orientations) / 0.74 (North)	
SPACE CONDITIONS			
Schedules	MNECB Schedule A	Same as MNECB+CBIP	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines
Lighting	1.77 W/ft²	1.85 W/ft²	ASHRAE distinguishes between hotel and motel building types at 1.7 and 2.0 W/sf, respectively. Assume an equal weighting of both building types for an average of 1.85 W/sf.
Equipment density	0.23 W/ft²	0.23 W/ft²	
HVAC SYSTEM TYPE			
Air Handling	1) FPFC serving rooms with non-suite areas served by VAV (Gas heated case) 2) PTAC serving rooms with non-suite areas served by packaged single zone (Electric heated case)	a) FPFC (System 7) serving suites, VAV (System 2) for non-suite areas b) WSHP throughout (System 6) c) PTHP (System 8) serving suites, PSZ with heat pump for non-suite area (System 9)	Reference and ECB models correspond to the most common proposed cases which are served by: 1) fan coils or distributed heat pumps, which are 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 is effectively represented with the fan coil case. System ID indicated for ASHRAE refers to system type identified in Table 11.4.3A.
Principle Heating Fuel Type	1) Gas (M01g??1) 2) Electric (M01e??1)	a) Gas for Systems 7, 2 (M01g??1B) b) Gas for System 6 (M01g??2B) c) Electric for Systems 8, 9 (M01e??1B)	Early interpretations of MNECB+CBIP, which are maintained in the Screening Tool, allowed fan coils to serve suites in the Reference if the proposed case was a distributed zonal system (e.g., fan coils or distributed heat pumps). This is essentially maintained for systems serving residential spaces with EE4 creating a Reference case with single zone RHFS for each zone. However, EE4 version 1.32 incorrectly assigns all suites to a single VAV system if the building type is hotel/motel. IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	1) Hydronic 2) DX	a) Hydronic for Systems 7, 2 b) and c) DX for Systems 6, 8, 9	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 (constant otherwise)	Minimum based on warmest zone for System 2 (constant otherwise)	Minimum supply air temperature control only applies to VAV systems.

Motel/Hotel: Key Building Characteristics

Fan Power	Suites: 0.5"/25% supply, no return with MAU serving suites at 1.3"/40%. Non-suites, with hydronic cooling: 4.0"/55% supply, 1.0"/30% for return; with DX cooling: 3.0"/45% for supply, 0.6"/25% for return	Keep at MNECB+CBIP defaults	MNECB default total static pressures and fan efficiencies have typically aligned with most proposed designs, including cases with DX cooling, which dictates different static pressures and fan efficiencies for MNECB. However, proposed designs also agree relatively well with these defaults in such situations and hence, no adjustment is warranted since the *relative differences* are minimal.
Outside Air	0.15 cfm/ft²	Same as MNECB+CBIP	
Fan Curve (VAV only)	MNECB "middle-level" fan curve (Type b) for banquet/restaurant; MNECB "low-level" curve (Type a) for other VAV systems	MNECB "top-level" fan curve (Type c)	MNECB Type c curve is very similar in performance to a VSD curve from 50% - 100% loading, but drops off in relative performance below 50%.
Heat Reclaim	N/A	50% effectiveness applied to 40% of outdoor air (20% overall)	In hotels (not motels) with a typical corridor pressurization configuration, 100% outdoor air is delivered to corridors which are conditioned to 60° or higher. Further, at the MNECB requirement for outdoor air, a hotel would have to be at least 100,000 sf for heat reclaim to apply; this assumes that the entire area provides the minimum OA from a single MAU >5,000 cfm. From BC Hydro data, out of nearly 30 audited hotels and motels, 57% of the building stock area was for buildings greater than 100,000 sf. However, this sample was skewed by a research study which focused on large hotels (representing 40% of the samples). Hence, the segment-wide heat reclaim effectiveness was conservatively reduced by 60%.
HVAC CONTROL			
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Same as MNECB+CBIP	
Economizer	Enthalpy	Temperature for VAV and PSZ	
HEATING PLANT			
Central Heating Efficiency	One 80% efficient boiler; no HW reset	Two 80% 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.
Lower Mainland		81.5%	
Okanagan		81.5%	
North Interior		82.0%	

Motel/Hotel: Key Building Characteristics

Hot Water Temperature	Constant flow hot water circulation.	Variable flow down to 50% flow, riding curve	Default CBIP models set at 38' head
Hot Water Flow	30°F drop; 140°F supply	50°F drop; 180°F supply	
Heat Pumps	N/A	Distributed heat pumps at 4.2 COP; Air-source heat pumps at 3.2 COP	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 approximately 1.2 times for water-source heat pumps. Since size of unit influences efficiency and a typical size is difficult to ascertain, we placed heating efficiency at 1.1x cooling efficiency for air source heat pumps. This would be conservative.

Motel/Hotel: Key Building Characteristics

COOLING			
Central Cooling Efficiency	1) Reciprocating chiller at 3.8 COP 2) DX cooling with COP at 2.5	a) Use 1 screw chiller with increasing efficiency for larger units (i.e., depending on region); effectively increase COP by 8% - 21% for reset c) Suite DX at COP of 2.9; Non-suite with DX at COP of 2.9.	Air-cooled chillers may be present in some new large buildings, but we went with the most prevalent situation. Okanagan chiller size based on observed size from NRCan models of roughly 140 - 180 tons. **Refer to associated LEED-BC Equivalency report for more discussion on the identification of cooling equipment for the prototype Reference models.** MNECB does not specify a screw chiller part-load curve, but we used one provided by DOE2's Sample Run book since other CBIP chillers also align with DOE2. This part-load curve improved seasonal performance making the equivalency analysis more conservative. See following discussion on Heat Pumps for specification of DX efficiencies.
Lower Mainland		a) 1 screw chiller at COP of 4.5 + 0.4 = 4.9	
Okanagan		a) 1 screw chiller at COP of 4.9 + 1.0 = 5.9	
North Interior		a) 1 screw chiller at COP of 4.5 + 0.3 = 4.8	
Chilled Water Temperature	10°F rise; 45°F supply	12°F rise; 44°F supply	
Chilled Water Flow	Constant flow chilled water circulation.	Variable flow down to 50% flow, riding curve	Default CBIP models set at 38' head
Cooling Tower	Two cell cooling tower with 85°F - 95°F temperature rise, and a constant speed fan with cycling control and 5.9 hp/1000 MBH. Constant speed tower pump at 40' head and combined efficiency of 70% (DOE2 TWR-EIR = 0.015)	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)	
Heat Pumps	N/A	b) 12 EER for distributed HP system c) Air-source same as listed above for DX	For ASHRAE from Table 6.2.1D, suites PTHP efficiencies range from 10.8 EER to 9.1 EER, as the size increases. Common spaces could have nearly any size of equipment, which dictates the efficiency for ASHRAE. However, most situations have small units and hence, specified the highest rating in Table 6.2.1A for the smallest unit. The high end of suite PTHPs also corresponded to this efficiency and hence, we placed them both at the same efficiency level for simplicity and to maintain a conservative approach.
Domesting Hot Water (DHW)			
Heating Efficiency	80%	80%	No losses in CBIP prototype models, as is consistent with EE4.
Avg. Load (Btu/sf/day)	55.02	Same as MNECB+CBIP	Includes any losses in addition to MNECB default requirements.

MURB: Key Building Characteristics

The MURB archetype from NRCan represents a 56,000 ft² (5,200 m²), five storey building. The baseline model has a wall-to-roof area ratio of 2.2 and includes apartments, corridors, and a lounge on the main floor. 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. Also, note that the NRCan models do not explicitly have a make-up air unit (MAU) serving corridors, although this is quite common. This model configuration is still satisfactory since a) a MAU is not always present, particularly for shorter buildings and b) the accounting for the heating of outdoor air is fully represented in the model (although at the zone level). Any MAU fan energy deficiencies are somewhat captured at the zone level with non-cycling fans and are netted out since the fan energy is the same between the Reference and ECB cases.

The following listing provides the key building characteristics which differ between the CBIP and ECB Reference models. In many cases information for certain characteristics are the same between the Reference models, but we provide information since it is unique to the building type and/or of significance to the energy performance. This table is complimented by the *Table of Energy Code Comparisons and Analysis Approaches* , which provides further details on modelling approaches and reasons for these approaches.

Item	MNECB+CBIP		ASHRAE+LEED ECB					Discussion/Issues
EXTERIOR SURFACES								
Wall Overall R-Value	Electric Heat Source	Gas Heat Source	Mass	Metal	Steel	Other	R_o	Allocation of construction types is based solely on professional experience in the commercial sector and is not statistically proven nor supported by market research. General observation is that the South Coastal areas have higher concentrations of curtain wall construction than other areas.
Lower Mainland	12.6	7.0	25%	0%	50%	25%	8.9	
			8.1	8.8	8.1	11.2		
Okanagan	15.3	12.6	30%	0%	40%	30%	10.6	
			8.13	8.85	11.9	11.2		
North Interior	15.3	12.6	30%	0%	40%	30%	13.0	
			11.1	17.5	15.6	11.2		
Roof Overall R-Value	Electric Heat Source	Gas Heat Source	Insulation Entirely above Deck					For this building type, all roof types as flat roofs with continuous insulation (i.e., "Type III" for MNECB). This is based on professional experience in the commercial sector and is not statistically proven nor supported by market research. In some cases, steel joist with metal decking and built-up roofing. Some cases are wood joists with plywood and build-up roofing.
Lower Mainland	13.8	12.1	15.9					
Okanagan	19.6	12.1	15.9					
North Interior	19.6	13.8	15.9					
Exposed Floor R-Value	Electric Heat Source	Gas Heat Source	Mass	Steel	Other		R_o	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. A "Type II" floor corresponds to "mass" type for ASHRAE and would include concrete deck. "Type I" MNECB floors correspond to "other" and "steel" types for ASHRAE.
Lower Mainland	18.6	18.6	60%	0%	40%		13.5	
			9.3	19.2	19.6			
Okanagan	22.1	17.6	60%	0%	40%		19.0	
			11.5	19.2	30.3			
North Interior	22.1	18.6	60%	0%	40%		19.0	
			11.5	26.3	30.3			

MURB: Key Building Characteristics

<table>
<tr><td colspan="7">GLAZING</td></tr>
<tr><td>Glazing Percent</td><td colspan="2">40%</td><td colspan="3">50%</td><td>From the BC Hydro "High- and Low-Rise Apartment Building Audit and Simulation Study" (October 1994), the average percent window area for new buildings is about 50%, which is a significant increase over existing survey information from BC Hydro and NRCan (at about half this level).</td></tr>
<tr><td>Window U-value</td><td>Electric Heat Source</td><td>Gas Heat Source</td><td>Oper-able</td><td>Fixed</td><td>U$_o$</td><td rowspan="7">Operable windows are prevalent in MURBs, but most windows are still fixed. Factors are based on professional experience in the commercial sector 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.</td></tr>
<tr><td rowspan="2">Lower Mainland</td><td rowspan="2">0.58</td><td rowspan="2">0.58</td><td>35%</td><td>65%</td><td rowspan="2">0.46</td></tr>
<tr><td>0.47</td><td>0.46</td></tr>
<tr><td rowspan="2">Okanagan</td><td rowspan="2">0.36</td><td rowspan="2">0.58</td><td>35%</td><td>65%</td><td rowspan="2">0.46</td></tr>
<tr><td>0.47</td><td>0.46</td></tr>
<tr><td rowspan="2">North Interior</td><td rowspan="2">0.36</td><td rowspan="2">0.58</td><td>35%</td><td>65%</td><td rowspan="2">0.46</td></tr>
<tr><td>0.47</td><td>0.46</td></tr>
<tr><td colspan="6">Window Shading Coefficient</td><td rowspan="4">ASHRAE differentiates between North-facing windows separately from all other windows.
Note that the NRCan prototypes are oriented at 45° from north with no windows facing directly north. Consequently, the difference in the north orientation's shading coefficient doesn't apply for ASHRAE.</td></tr>
<tr><td>Lower Mainland</td><td colspan="2" rowspan="3">0.74</td><td colspan="3">0.57 (all orientations) / 0.74 (North)</td></tr>
<tr><td>Okanagan</td><td colspan="3">0.57 (all orientations, including North)</td></tr>
<tr><td>North Interior</td><td colspan="3">0.57 (all orientations) / 0.74 (North)</td></tr>
<tr><td colspan="7">SPACE CONDITIONS</td></tr>
<tr><td>Schedules</td><td colspan="2">MNECB Schedule A</td><td colspan="3">Same as MNECB+CBIP</td><td>Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines</td></tr>
<tr><td>Lighting</td><td colspan="2">0.84 W/ft²</td><td colspan="3">1.0 W/ft²</td><td>For CBIP, lighting credit for suites is not available. Prototype models are therefore configured such that the suite lighting is fixed at the MNECB level. For ASHRAE, this level was increased accordingly.</td></tr>
<tr><td>Equipment density</td><td colspan="2">0.46 W/ft²</td><td colspan="3">0.46 W/ft²</td><td></td></tr>
<tr><td colspan="7">HVAC SYSTEM TYPE</td></tr>
<tr><td>Air Handling</td><td colspan="2">1) FPFC
2) PTAC with baseboards serving suites with common areas served by PSZ
3) PTAC serving suites with common areas served by PSZ</td><td colspan="3">a) FPFC (System 7)
b) WSHP with gas-fired MAU (System 6)
c) PTAC (System 10) serving suites, PSZ with furnace for common areas (System 11)
d) PTHP (System 8) serving suites, PSZ with heat pump for common areas (System 9)</td><td>Reference and ECB models correspond to the most common proposed cases which are served by: 1) fan coils or distributed heat pumps (less common, though), which are 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 heat source and cooling is effectively represented with the fan coil case. However, a third case with only baseboards was added to represent the many fossil-heated cases with no cooling
System ID indicated for ASHRAE refers to system type identified in Table 11.4.3A.</td></tr>
</table>

MURB: Key Building Characteristics

Principle Heating Fuel Type	1) Gas (R01g??1) 2) Gas (R01g??3) 3) Electric (R01g??3a)	a) Gas for System 7 (R01g??1B) b) Gas for System 6 (R01g??2B) c) Gas for Systems 10, 11 (R01g??3B) d) Electric for Systems 8, 9 (R01e??3B)	IDs in parenthesis refer to internal project references (i.e., "PRJ IDs") used for identifying the prototype model.
Cooling Source	1) Hydronic 2) & 3) DX	a) Hydronic for System 7 b), c) & d) DX for Systems 6, 8, 9, 10, 11	Note that method of cooling is not as important as the relative differences in the cooling efficiencies. In cases with central hydronic cooling, air-cooled chillers would typically be used.
FAN SYSTEM			
Supply Air Temperature Control	Constant	Constant	Minimum supply air temperature control only applies to VAV systems.
Fan Power	Suites: 0.5"/25% supply, no return Common areas with DX cooling: 1.3"/40% supply, no return; with hydronic cooling: 2.0"/50% supply, 0.6"/25% return	Keep at MNECB+CBIP defaults	MNECB default total static pressures and fan efficiencies have typically aligned with most proposed designs, including cases with DX cooling, which dictates different static pressures and fan efficiencies for MNECB. However, proposed designs also agree relatively well with these defaults in such situations and hence, no adjustment is warranted since the *relative differences* are minimal.
Outside Air	0.08 cfm/ft²	Same as MNECB+CBIP	
Heat Reclaim	N/A	50% effectiveness applied to 70% of outdoor air (35% overall)	Most high-rise MURBs have a typical corridor pressurization configuration where 100% outdoor air is delivered to corridors which are conditioned to 60° or higher. At the MNECB requirement for outdoor air and based on BC Hydro survey data, a MURB would have to be > 65,000 sf to warrant heat reclaim; this assumes that the entire area provides the minimum OA from a single MAU which is >5,000 cfm. From BC Hydro data, out of sample of 11 (only) audited MURBs, ~70% of the building stock's outside air was from MAUs which would require heat reclaim under ASHRAE rules.
HVAC CONTROL			
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Same as MNECB+CBIP	
Economizer	N/A	N/A	

MURB: Key Building Characteristics

HEATING PLANT			
Central Heating Efficiency	One 80% efficient boiler; no HW reset	80% efficient boiler(s), 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.
Lower Mainland		One at 81.5%	
Okanagan		Two at 81.5%	
North Interior		Two at 82%	
Hot Water Temperature	30°F drop; 140°F supply	50°F drop; 180°F supply	
Hot Water Flow	Constant flow hot water circulation.	Variable flow down to 50% flow, riding curve	Default CBIP models set at 30' head.
Heat Pumps	N/A	Distributed heat pumps at 4.2 COP; Air-source heat pumps at 3.2 COP	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 approximately 1.2 times for water-source heat pumps. Since size of unit influences efficiency and a typical size is difficult to ascertain, we placed heating efficiency at 1.1x cooling efficiency for air source heat pumps. This would be conservative.
COOLING			
Central Cooling Efficiency	1) Reciprocating chiller at 3.8 COP 2) & 3) DX cooling with COP at 2.5	a) Use 1 reciprocating chiller; effectively increase COP by 8% - 21% for reset c) & d) Suite DX at COP of 2.9; Common areas with DX at COP of 2.9.	The default Reference for FPFC employs a chiller, which is the appropriate reference cooling equipment for air-cooled chillers. Chiller type and size based on observation of cooling load at well under 100 tons for all regions. **Refer to associated LEED-BC Equivalency report for more discussion on the identification of cooling equipment for the prototype Reference models.** See following discussion on Heat Pumps for specification of DX efficiencies.
Lower Mainland		a) COP of 4.2 + 0.3 = 4.5	
Okanagan		a) COP of 4.2 + 0.9 = 5.1	
North Interior		a) COP of 4.2 + 0.3 = 4.5	
Chilled Water Temperature	10°F rise; 45°F supply	12°F rise; 44°F supply	
Chilled Water Flow	N/A	Variable flow down to 50% flow, riding curve	Default CBIP models set at 30' head.
Cooling Tower	N/A	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)	

MURB: Key Building Characteristics

Heat Pumps	N/A	b) 12 EER for distributed HP system c) & d) Air-source same as listed above for DX	For ASHRAE from Table 6.2.1D, suites PTHP efficiencies range from 10.8 EER to 9.1 EER, as the size increases. Common spaces could have nearly any size of equipment, which dictates the efficiency for ASHRAE. However, most situations have small units and hence, specified the highest rating in Table 6.2.1A for the smallest unit. The high end of suite PTHPs also corresponded to this efficiency and hence, we placed them both at the same efficiency level for simplicity and to maintain a conservative approach.
Domesting Hot Water (DHW)			
Heating Efficiency	80%	80%	No losses in CBIP prototype models, as is consistent with EE4.
Avg. Load (Btu/sf/day)	18.3	Same as MNECB+CBIP	Includes any losses in addition to MNECB default requirements.

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 CBIP and ECB Reference models. In many cases information for certain characteristics are the same between the Reference models, but we provide information since it is unique to the building type and/or of significance to the energy performance. This table is complimented by the *Table of Energy Code Comparisons and Analysis Approaches* , which provides further details on modelling approaches and reasons for these approaches.

Item	MNECB+CBIP		ASHRAE+LEED ECB					Discussion/Issues
EXTERIOR SURFACES								
Wall Overall R-Value	Electric Heat Source	Gas Heat Source	Mass	Metal	Steel	Other	R_o	Allocation of construction types is based solely on professional experience in the commercial sector and is not statistically proven nor supported by market research.
Lower Mainland	12.6	7.0	50%	0%	30%	20%	8.7	
			8.1	8.8	8.1	11.2		
Okanagan	15.3	12.6	50%	0%	30%	20%	9.9	
			8.13	8.85	11.9	11.2		
North Interior	15.3	12.6	50%	0%	30%	20%	12.5	
			11.1	17.5	15.6	11.2		
Roof Overall R-Value	Electric Heat Source	Gas Heat Source	Insulation Entirely above Deck					For this building type, all roof types as flat roofs with continuous insulation (i.e., "Type III" for MNECB). 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 experience in the commercial sector and is not statistically proven nor supported by market research.
Lower Mainland	13.8	12.1	15.9					
Okanagan	19.6	12.1	15.9					
North Interior	19.6	13.8	15.9					
Exposed Floor R-Value	N/A		N/A					Exposed floor is not a significant characteristic and NRCan archetypes do not include them in the models.
GLAZING								
Glazing Percent	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.
Window U-value	Electric Heat Source	Gas Heat Source	Oper-able		Fixed		U_o	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 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.
Lower Mainland	0.56	0.56	0%		100%		0.46	
			0.47		0.46			
Okanagan	0.30	0.56	0%		100%		0.46	
			0.47		0.46			
North Interior	0.30	0.56	0%		100%		0.46	
			0.47		0.46			

Strip Mall: Key Building Characteristics

Window Shading Coefficient			ASHRAE differentiates between North-facing windows separately from all other windows.
Lower Mainland	0.74	0.57 (all orientations) / 0.74 (North)	
Okanagan		0.57 (all orientations, including North)	
North Interior		0.57 (all orientations) / 0.74 (North)	
SPACE CONDITIONS			
Schedules	MNECB Schedule A	Same as MNECB+CBIP	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines
Lighting	2.47 W/ft²	2.37 W/ft²	The MNECB and ASHRAE Lighting loads are based on Space Function. ASHRAE allows up to an additional 1.6 W/sf for display lighting for general retail and up to 3.9 W/sf for fine display. We allowed an average of 0.5 W/sf additional display lighting for the retail spaces.
Equipment Density	0.2 W/ft²	0.2 W/ft²	
HVAC SYSTEM TYPE			
Air Handling	PSZ, with heat pump for electric heat case	PSZ, with heat pump for electrically heated case	Most facilities served with individual packaged single zone units.
Principle Heating Fuel Type	a) Gas (B02g??1) b) Electric (B02e??1)	a) Gas using System 11 (B02g??1B) b) Electric, with heat pump, using System 9 (B02e??1B)	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	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	Minimum supply air temperature control only applies to VAV systems.
Fan Power	DX cooling for single zone systems: 1.3"/40% supply, no return	Keep at MNECB+CBIP defaults	MNECB default total static pressures and fan efficiencies have typically aligned with most proposed designs, including cases with DX cooling, which dictates different static pressures and fan efficiencies for MNECB. However, proposed designs also agree relatively well with these defaults in such situations and hence, no adjustment is warranted since the *relative differences* are minimal.
Outside Air	0.17 cfm/ft²	Same as MNECB+CBIP	
Heat Reclaim	N/A	N/A	
HVAC CONTROL			
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Same as MNECB+CBIP	
Economizer	Enthalpy	Temperature	

Strip Mall: Key Building Characteristics

HEATING PLANT			
Central Heating Efficiency	80% furnaces	80% furnaces	Some new designs may use boilers instead of furnaces, 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, particularly since this is prevalent in strip malls for metering/billing purposes.
Heat Pumps	Air-source for all-electric case at 3.0	Air-source at 3.2	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 for ASHRAE (closer to 1.2x for water-source). Since size of unit influences efficiency and a typical size is difficult to ascertain, we placed heating efficiency at 1.1x cooling efficiency. This would be conservative. Note that MNECB sets the heating COP at 1.2 times that of the cooling COP.
COOLING			
Central Cooling Efficiency	DX cooling with COP at 2.5	Unitary air-cooled AC at 2.9 COP (average across all size of units)	
Heat Pumps	Air-source only - same as listed above	Air-source only - same as listed above	
Domesting Hot Water (DHW)			
Heating Efficiency	80%	80%	No losses in CBIP prototype models, as is consistent with EE4.
Avg. Load (Btu/sf/day)	9.64	Same as MNECB+CBIP	Includes any losses in addition to MNECB default requirements.

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. The project is modelled as a retail building type.

The following listing provides the key building characteristics which differ between the CBIP and ECB Reference models. In many cases information for certain characteristics are the same between the Reference models, but we provide information since it is unique to the building type and/or of significance to the energy performance. This table is complimented by the *Table of Energy Code Comparisons and Analysis Approaches* , which provides further details on modelling approaches and reasons for these approaches.

Item	MNECB+CBIP		ASHRAE+LEED ECB					Discussion/Issues
EXTERIOR SURFACES								
Wall Overall R-Value	Electric Heat Source	Gas Heat Source	Mass	Metal	Steel	Other	R_o	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 portion of west wall in archetype template was not adjusted to allow for correct R-value in all regions, and was corrected for all cases within 3 weather regions. However, tests show that this makes very little difference in the energy performance.
Lower Mainland	12.6	7.0	70%	0%	25%	5%	8.3	
			8.1	8.8	8.1	11.2		
Okanagan	15.3	12.6	70%	0%	25%	5%	9.2	
			8.13	8.85	11.9	11.2		
North Interior	15.3	12.6	70%	0%	25%	5%	12.2	
			11.1	17.5	15.6	11.2		
Roof Overall R-Value	Electric Heat Source	Gas Heat Source	Insulation Entirely above Deck					For this building type, all roof types as flat roofs with continuous insulation (i.e., "Type III" for MNECB). 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 experience in the commercial sector and is not statistically proven nor supported by market research.
Lower Mainland	13.8	12.1	15.9					
Okanagan	19.6	12.1	15.9					
North Interior	19.6	13.8	15.9					
Exposed Floor R-Value	N/A		N/A					Exposed floor is not a significant characteristic and NRCan archetypes do not include them in the models.
GLAZING								
Glazing Percent	10%		10%					Average specified in NRCan archetypes and appears reasonable based on our experience.
Window U-value	Electric Heat Source	Gas Heat Source	Oper-able		Fixed		U_o	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 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.
Lower Mainland	0.56	0.56	0%		100%		0.46	
			0.47		0.46			
Okanagan	0.30	0.56	0%		100%		0.46	
			0.47		0.46			
North Interior	0.30	0.56	0%		100%		0.46	
			0.47		0.46			

Big Box Retail: Key Building Characteristics

Window Shading Coefficient			ASHRAE differentiates between North-facing windows separately from all other windows.
Lower Mainland	0.74	0.57 (all orientations) / 0.74 (North)	
Okanagan		0.57 (all orientations, including North)	
North Interior		0.57 (all orientations) / 0.74 (North)	
SPACE CONDITIONS			
Schedules	MNECB Schedule A	Same as MNECB+CBIP	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines
Lighting	2.79 W/ft²	2.4 W/ft²	The MNECB and ASHRAE Lighting loads are based on building type. ASHRAE allows up to an additional 1.6 W/sf for display lighting for general retail and up to 3.9 W/sf for fine display. We allowed an average of 0.5 W/sf additional display lighting.
Equipment density	0.2 W/ft²	0.2 W/ft²	
HVAC SYSTEM TYPE			
Air Handling	PSZ, with heat pump for electric heat case	PSZ, with heat pump for electrically heated case	
Principle Heating Fuel Type	a) Gas (B01g??1) b) Heat pumps with electric resistance (B01e??1)	a) Gas using System 11 (B01g??1B) b) Electric, with heat pump, using System 9 (B01e??1B)	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	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	Minimum supply air temperature control only applies to VAV systems.
Fan Power	DX cooling for single zone systems: 1.3"/40% supply, no return	Keep at MNECB+CBIP defaults	MNECB default total static pressures and fan efficiencies have typically aligned with most proposed designs, including cases with DX cooling, which dictates different static pressures and fan efficiencies for MNECB. However, proposed designs also agree relatively well with these defaults in such situations and hence, no adjustment is warranted since the *relative differences* are minimal.
Outside Air	0.20 cfm/ft²	Same as MNECB+CBIP	
Heat Reclaim	N/A	N/A	
HVAC CONTROL			
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Same as MNECB+CBIP	
Economizer	Enthalpy	Temperature	

Big Box Retail: Key Building Characteristics

HEATING PLANT			
Central Heating Efficiency	80% furnaces	80% furnaces	Some designs may use boilers instead of furnaces, 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, particularly since this is prevalent in the retail segment.
Heat Pumps	Air-source for all-electric case at 3.0	Air-source at 3.2	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 for ASHRAE (closer to 1.2x for water-source). Since size of unit influences efficiency and a typical size is difficult to ascertain, we placed heating efficiency at 1.1x cooling efficiency. This would be conservative. Note that MNECB sets the heating COP at 1.2 times that of the cooling COP.
COOLING			
Central Cooling Efficiency	DX cooling with COP at 2.5	Unitary air-cooled AC at 2.9 COP (average across all size of units)	
Heat Pumps	Air-source only - same as listed above	Air-source only - same as listed above	
Domesting Hot Water (DHW)			
Heating Efficiency	80%	80%	No losses in CBIP prototype models, as is consistent with EE4.
Avg. Load (Btu/sf/day)	3.34	Same as MNECB+CBIP	Includes any losses in addition to MNECB default requirements.

APPENDIX C

Final Report:

Verification of LEED-BC v1.0 Energy Credit 1 Point Awards for Building Energy Conservation in British Columbia

Energy Performance Results by Building Type

RESULTS FOR INDIVIDUAL BUILDING TYPES

This appendix includes results for the eight different building types: small office, large office, schools, extended care facilities, hotel/motel, multi-unit residential, big box retail, and strip mall retail. For each building type, the following graphs and tables are shown. Note that the table and figure numbering repeats for each building type for easier comparison among the different building types.

- Table 1 and Figure 1 illustrate the overall energy cost budget (ECB) differences between ASHRAE+LEED and MNECB+CBIP. They also shows the relative performance differences when using estimated carbon dioxide (CO_2) emission factors instead of energy rates as the basis for establishing the respective reference energy budgets. It also demonstrates how the different bases for comparison (i.e., ECB vs. CO_2) vary between each other.

- Figure 2 compares the Budget and Reference cases energy use for the indicated building type across British Columbia and for the three identified regions.

- Finally, Figures 3 and 4 show the results from applying cost and emission factors to the energy use to determine the regional energy costs and CO_2 emissions.

RESULTS FOR SMALL OFFICE

LEED-BC Equivalency Table of Energy Credits: Applied to the Small Office Segment

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-BC Savings Bins		LEED-BC vs LEED-GBC Difference		ECB vs CO_2 Basis Difference
	$/ft²	kg/m²	ECB	CO_2	ECB	CO_2	
0%	*0.66*	*55.5*	*14.6%*	*14.3%*	*14.6% pt*	*14.3% pt*	*0.3% pt*
20%	0.53	44.4	31.7%	31.4%	11.7% pt	11.4% pt	0.3% pt
30%	0.46	38.8	40.2%	40.0%	10.2% pt	10.0% pt	0.2% pt
40%	0.40	33.3	48.8%	48.6%	8.8% pt	8.6% pt	0.2% pt
50%	0.33	27.7	57.3%	57.1%	7.3% pt	7.1% pt	0.2% pt
60%	0.26	22.2	65.8%	65.7%	5.8% pt	5.7% pt	0.1% pt

Figure 1. Equivalency for LEED-BC (MNECB+CBIP) Versus U.S. LEED (ASHRAE+LEED): Applied to Small Offices

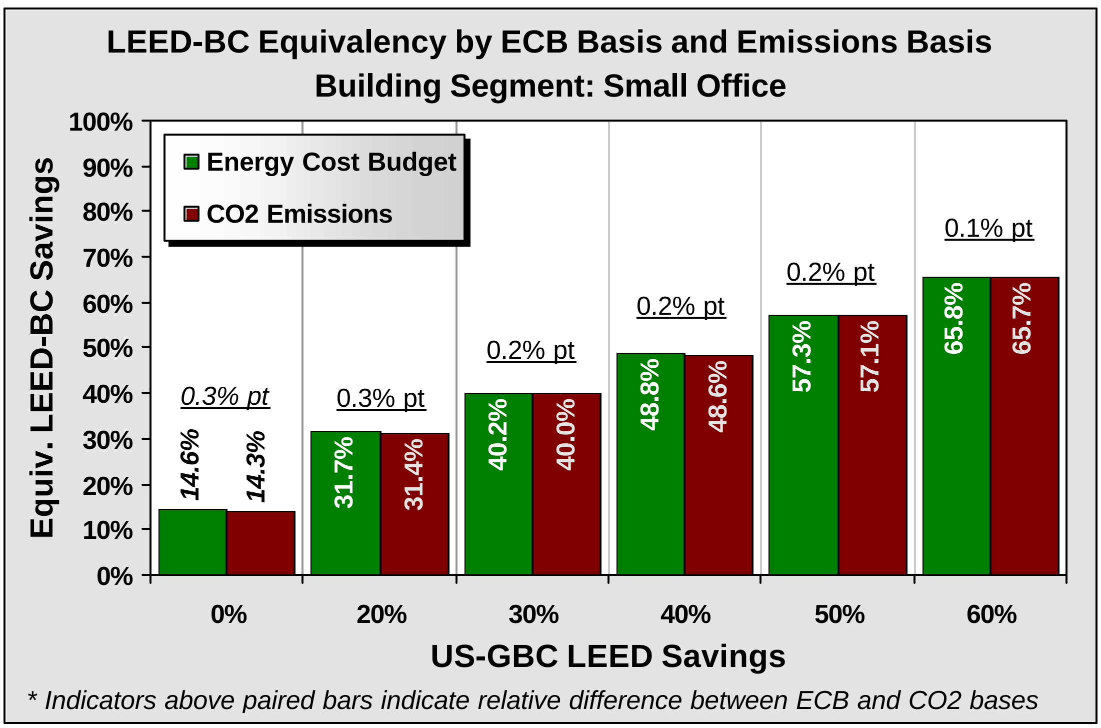


Figure 2. Small Office Regional Reference Energy Use

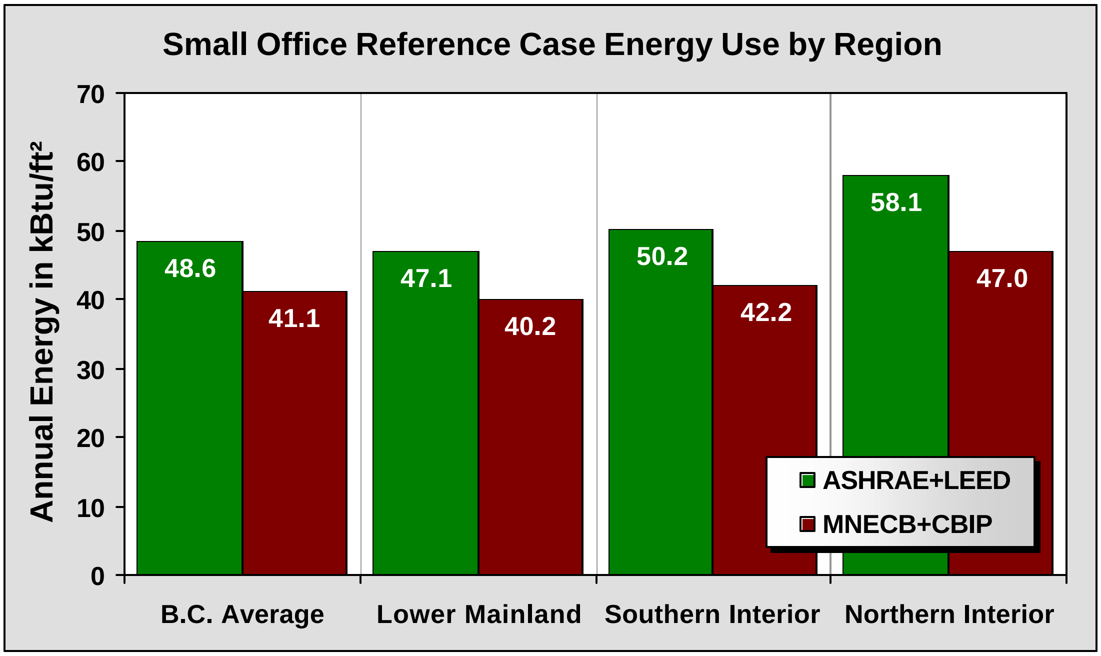
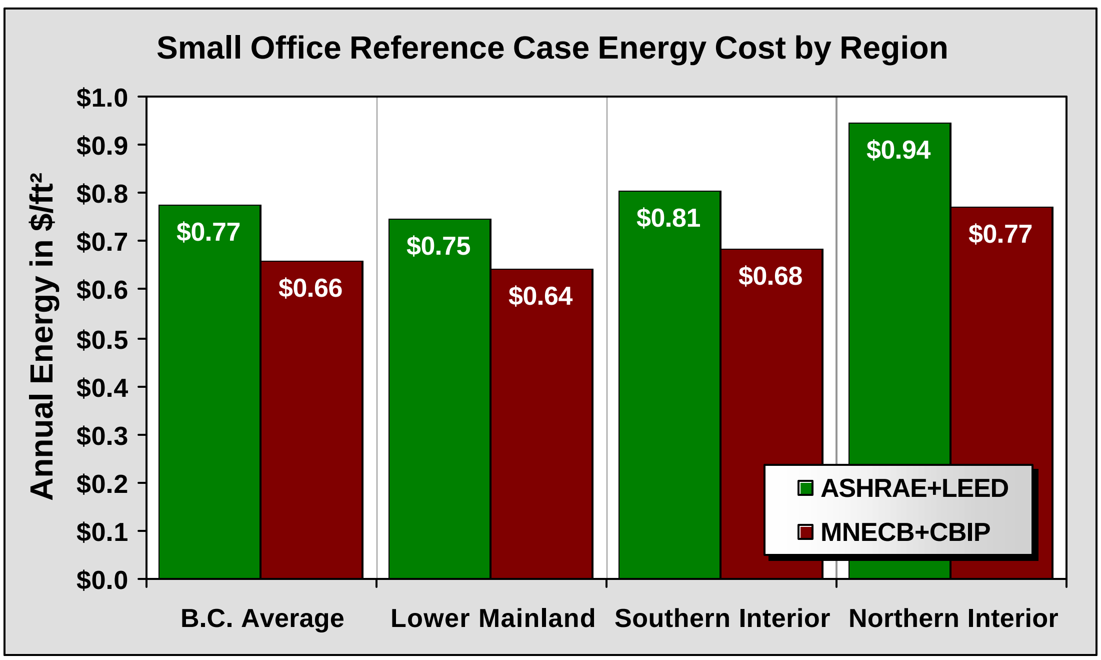


Figure 3. Small Office Regional Energy Costs



RESULTS FOR LARGE OFFICE

Table 1. LEED-BC Equivalency Table of Energy Credits: Applied to the Large Office Segment

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-BC Savings Bins		LEED-BC vs LEED-GBC Difference		ECB vs CO_2 Basis Difference
	$/ft²	kg/m²	ECB	CO_2	ECB	CO_2	
0%	*0.59*	*52.0*	*13.7%*	*12.6%*	*13.7% pt*	*12.6% pt*	*1.1% pt*
20%	0.47	41.6	31.0%	30.1%	11.0% pt	10.1% pt	0.9% pt
30%	0.41	36.4	39.6%	38.8%	9.6% pt	8.8% pt	0.8% pt
40%	0.35	31.2	48.2%	47.5%	8.2% pt	7.5% pt	0.7% pt
50%	0.30	26.0	56.9%	56.3%	6.9% pt	6.3% pt	0.6% pt
60%	0.24	20.8	65.5%	65.0%	5.5% pt	5.0% pt	0.5% pt

Figure 1. Equivalency for LEED-BC (MNECB+CBIP) Versus U.S. LEED (ASHRAE+LEED): Applied to Large Offices

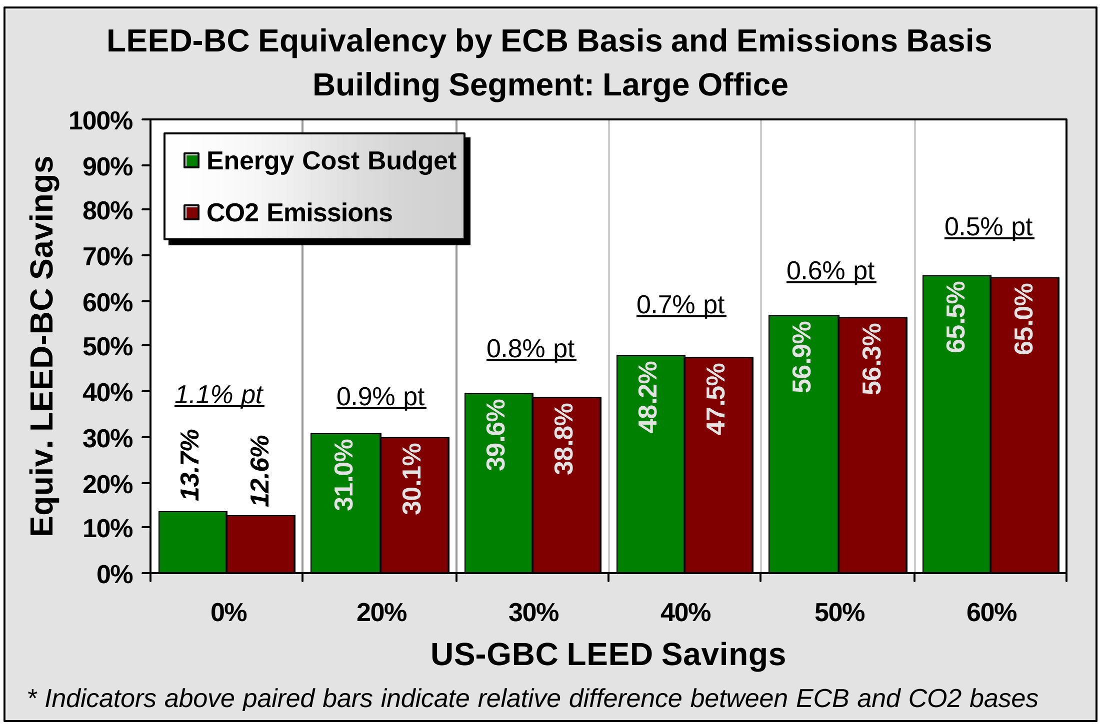


Figure 2. Large Office Regional Reference Energy Use

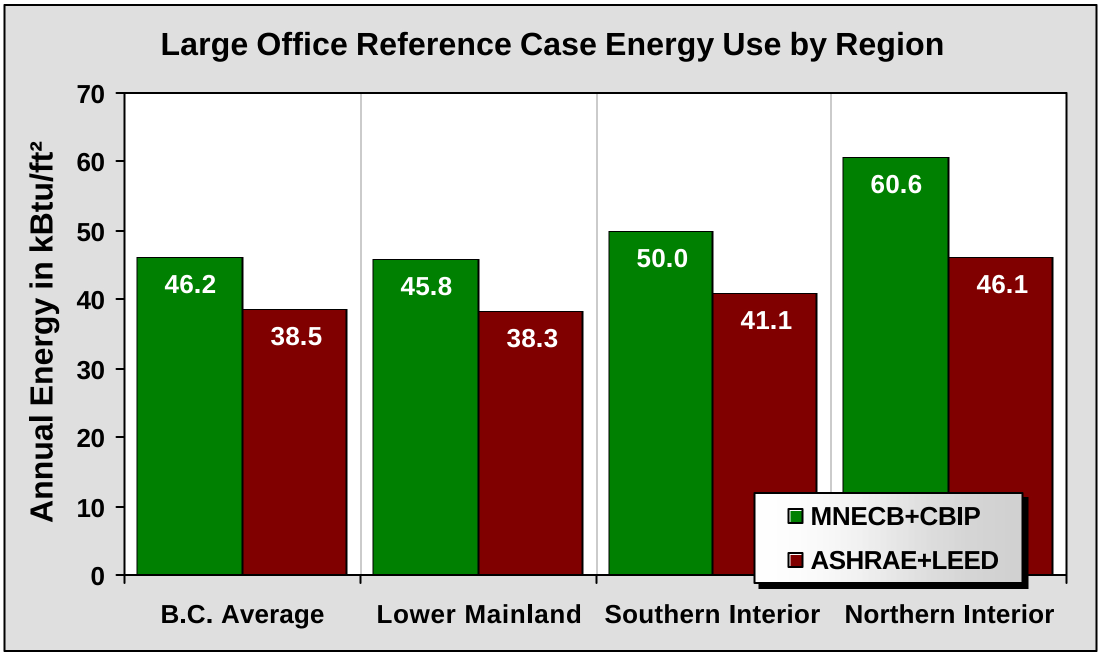
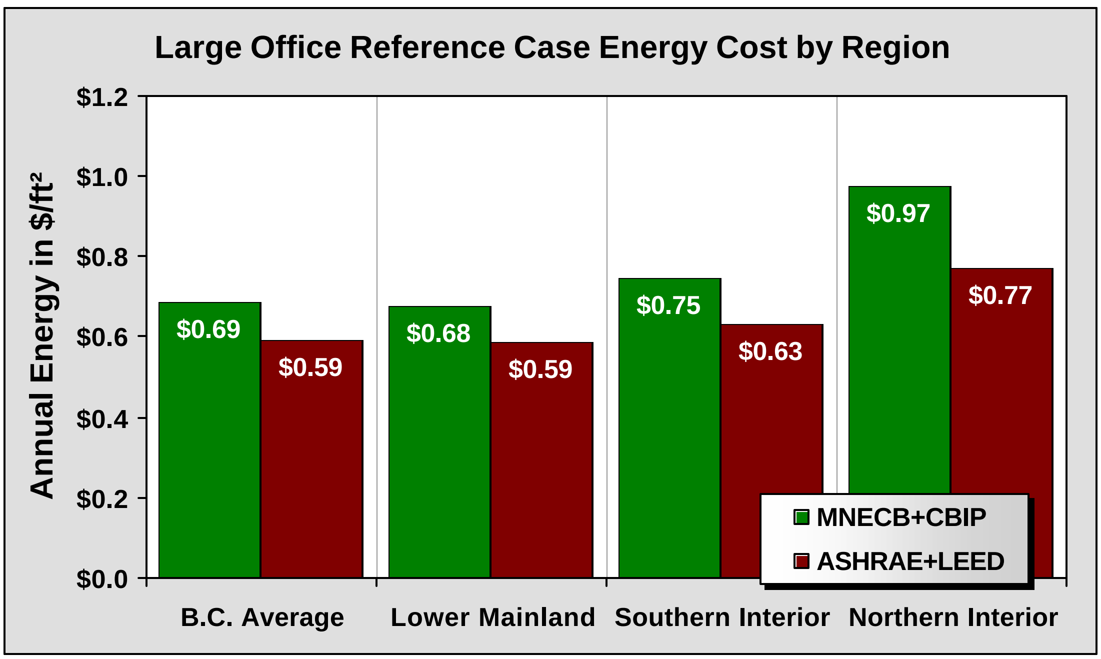


Figure 3. Large Office Regional Energy Costs



RESULTS FOR SCHOOLS

Table 1. LEED-BC Equivalency Table of Energy Credits: Applied to the Schools Segment

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-BC Savings Bins		LEED-BC vs LEED-GBC Difference		ECB vs CO_2 Basis Difference
	$/ft²	kg/m²	ECB	CO_2	ECB	CO_2	
0%	*0.74*	*67.8*	*19.3%*	*20.7%*	*19.3% pt*	*20.7% pt*	*-1.4% pt*
20%	0.59	54.2	35.4%	36.6%	15.4% pt	16.6% pt	-1.1% pt
30%	0.52	47.4	43.5%	44.5%	13.5% pt	14.5% pt	-1.0% pt
40%	0.44	40.7	51.6%	52.4%	11.6% pt	12.4% pt	-0.9% pt
50%	0.37	33.9	59.7%	60.4%	9.7% pt	10.4% pt	-0.7% pt
60%	0.30	27.1	67.7%	68.3%	7.7% pt	8.3% pt	-0.6% pt

Figure 1. Equivalency for LEED-BC (MNECB+CBIP) Versus U.S. LEED (ASHRAE+LEED): Applied to Schools

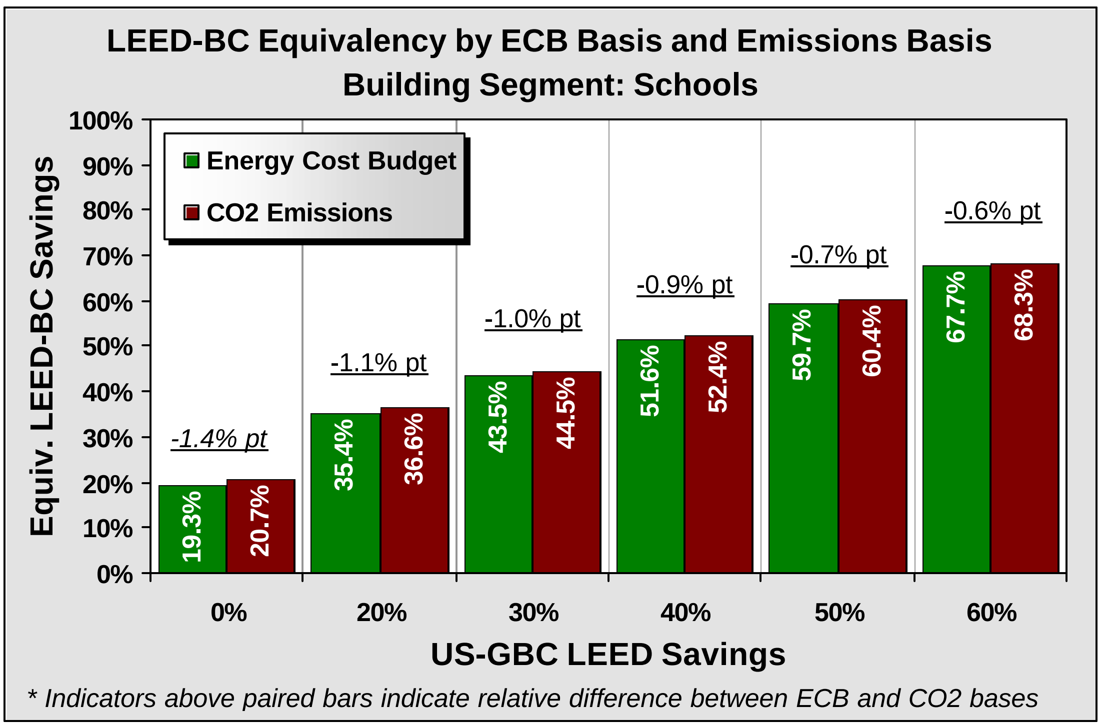


Figure 2. Schools Regional Reference Energy Use

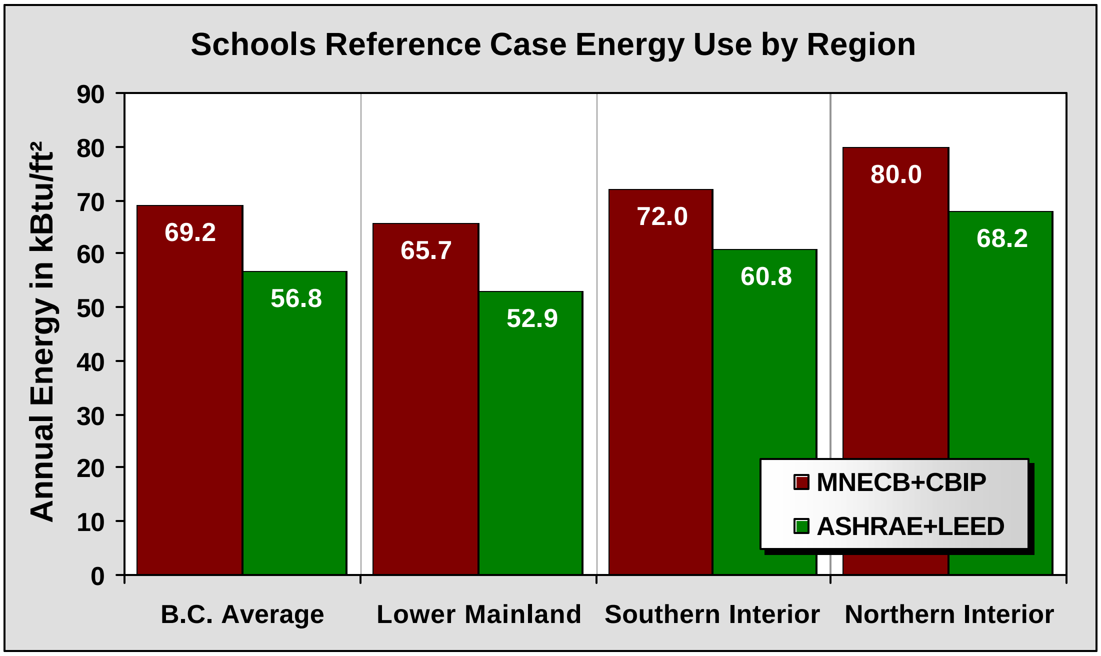
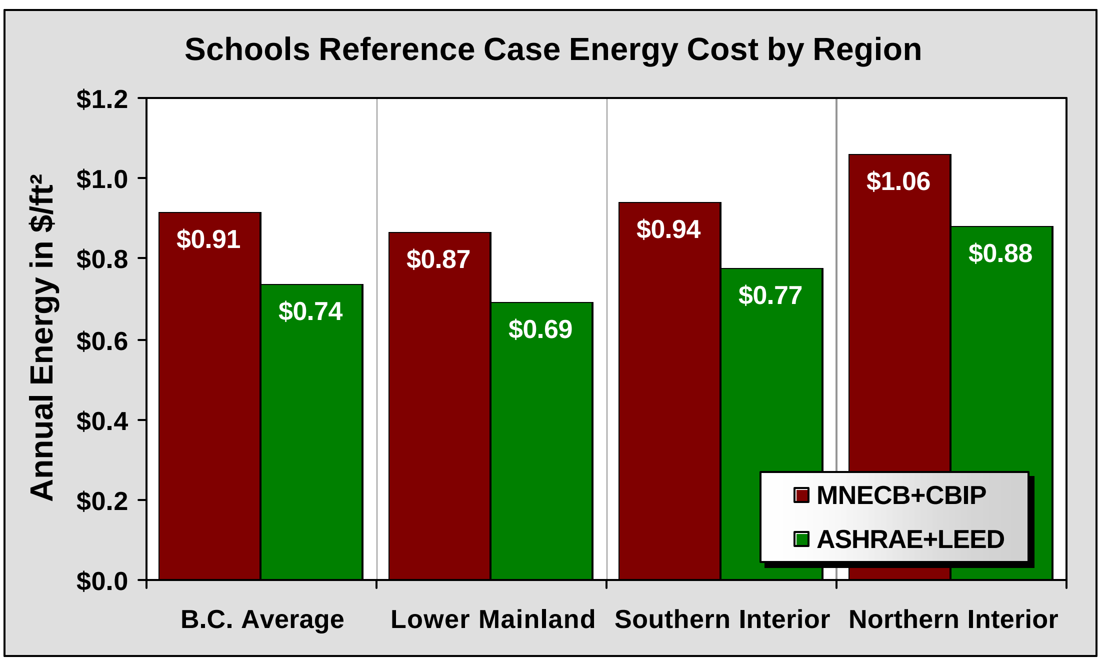


Figure 3. Schools Regional Energy Costs



RESULTS FOR EXTENDED CARE FACILITIES

Table 1. LEED-BC Equivalency Table of Energy Credits: Applied to the Extended Care Segment

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-BC Savings Bins		LEED-BC vs LEED-GBC Difference		ECB vs CO_2 Basis Difference
	$/ft²	kg/m²	ECB	CO_2	ECB	CO_2	
0%	*1.16*	*106.0*	*24.0%*	*22.0%*	*24.0% pt*	*22.0% pt*	*2.0% pt*
20%	0.93	84.8	39.2%	37.6%	19.2% pt	17.6% pt	1.6% pt
30%	0.82	74.2	46.8%	45.4%	16.8% pt	15.4% pt	1.4% pt
40%	0.70	63.6	54.4%	53.2%	14.4% pt	13.2% pt	1.2% pt
50%	0.58	53.0	62.0%	61.0%	12.0% pt	11.0% pt	1.0% pt
60%	0.47	42.4	69.6%	68.8%	9.6% pt	8.8% pt	0.8% pt

Figure 1. Equivalency for LEED-BC (MNECB+CBIP) Versus U.S. LEED (ASHRAE+LEED): Applied to Extended Care

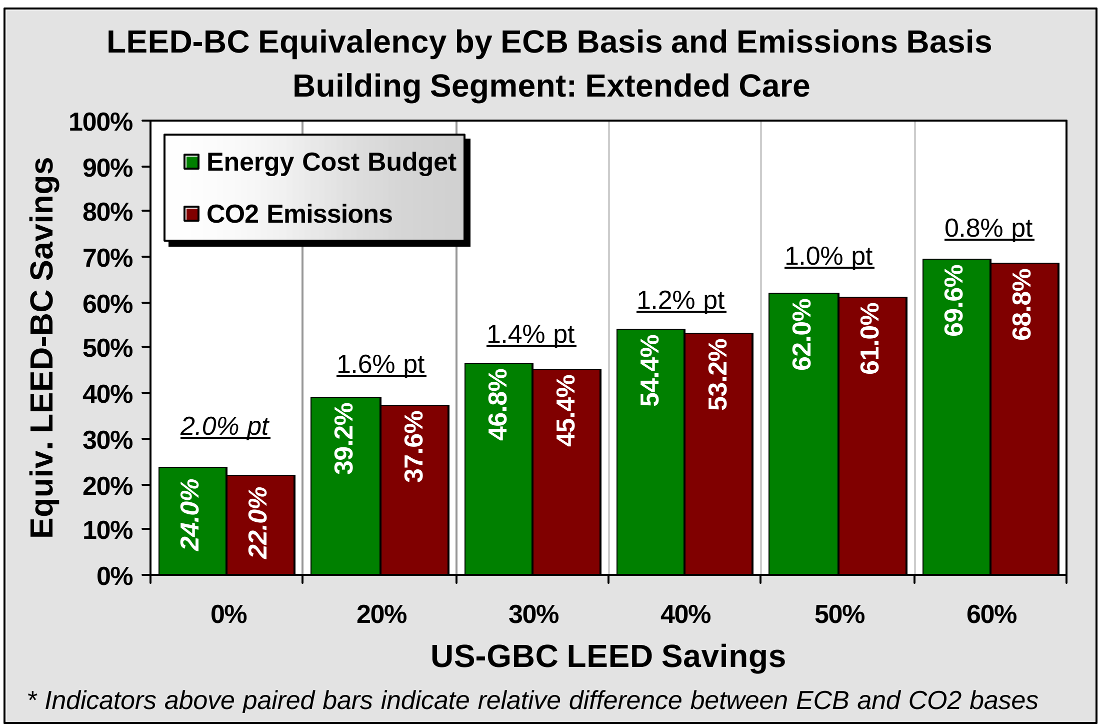


Figure 2. Extended Care Regional Reference Energy Use

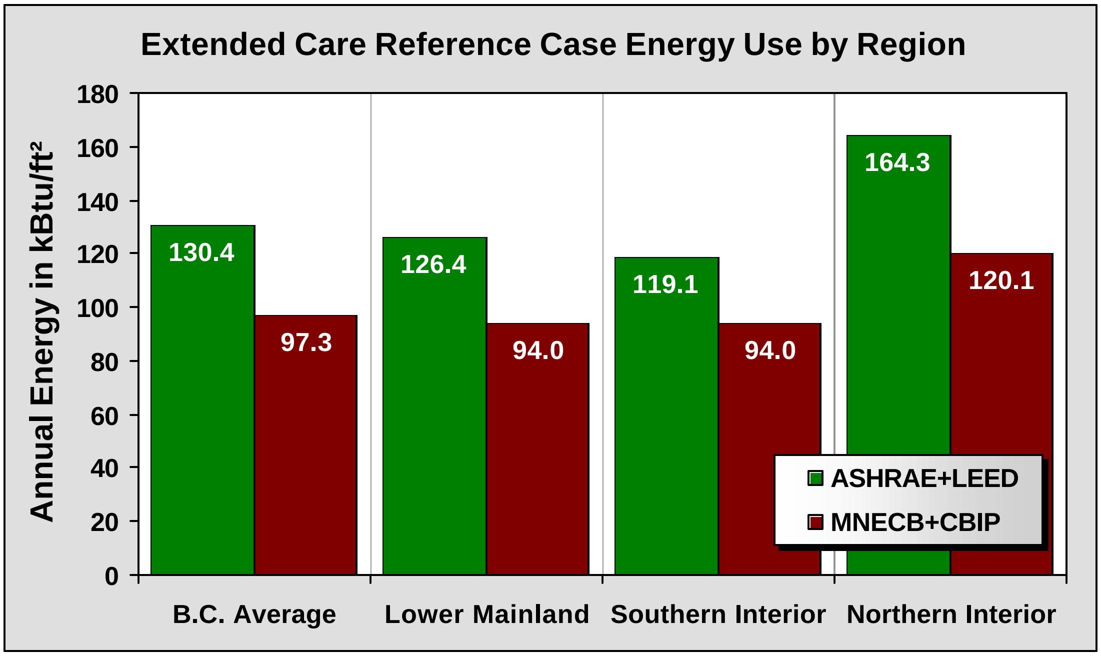
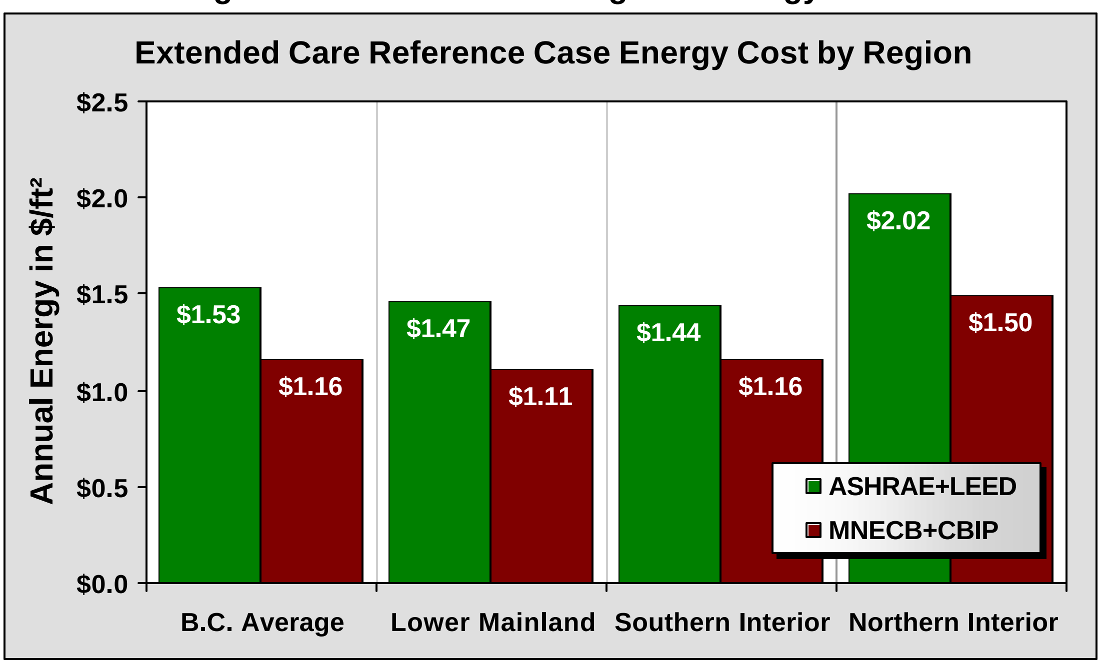


Figure 3. Extended Care Regional Energy Costs



RESULTS FOR HOTEL/MOTEL

Table 1. LEED-BC Equivalency Table of Energy Credits: Applied to the Hotel/Motel Segment

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-BC Savings Bins		LEED-BC vs LEED-GBC Difference		ECB vs CO_2 Basis Difference
	$/ft²	kg/m²	ECB	CO_2	ECB	CO_2	
0%	*0.96*	*97.3*	*10.7%*	*10.2%*	*10.7% pt*	*10.2% pt*	*0.5% pt*
20%	0.77	77.8	28.5%	28.1%	8.5% pt	8.1% pt	0.4% pt
30%	0.68	68.1	37.5%	37.1%	7.5% pt	7.1% pt	0.3% pt
40%	0.58	58.4	46.4%	46.1%	6.4% pt	6.1% pt	0.3% pt
50%	0.48	48.6	55.3%	55.1%	5.3% pt	5.1% pt	0.2% pt
60%	0.39	38.9	64.3%	64.1%	4.3% pt	4.1% pt	0.2% pt

Figure 1. Equivalency for LEED-BC (MNECB+CBIP) Versus U.S. LEED (ASHRAE+LEED): Applied to Hotel/Motel

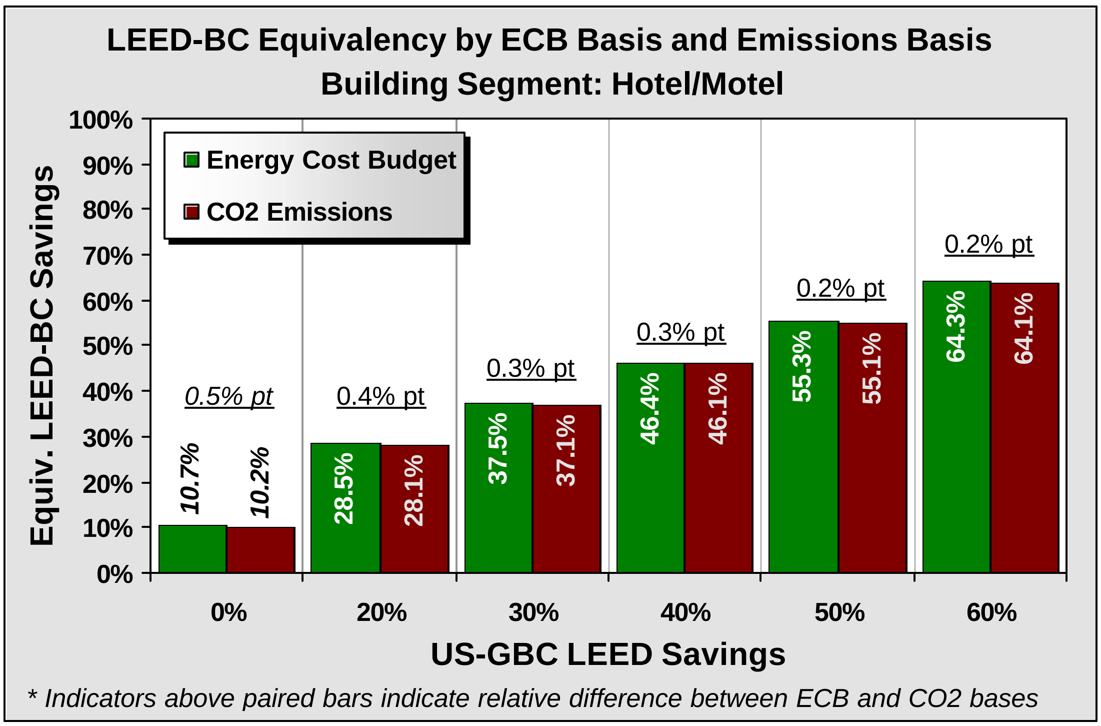


Figure 2. Hotel/Motel Regional Reference Energy Use

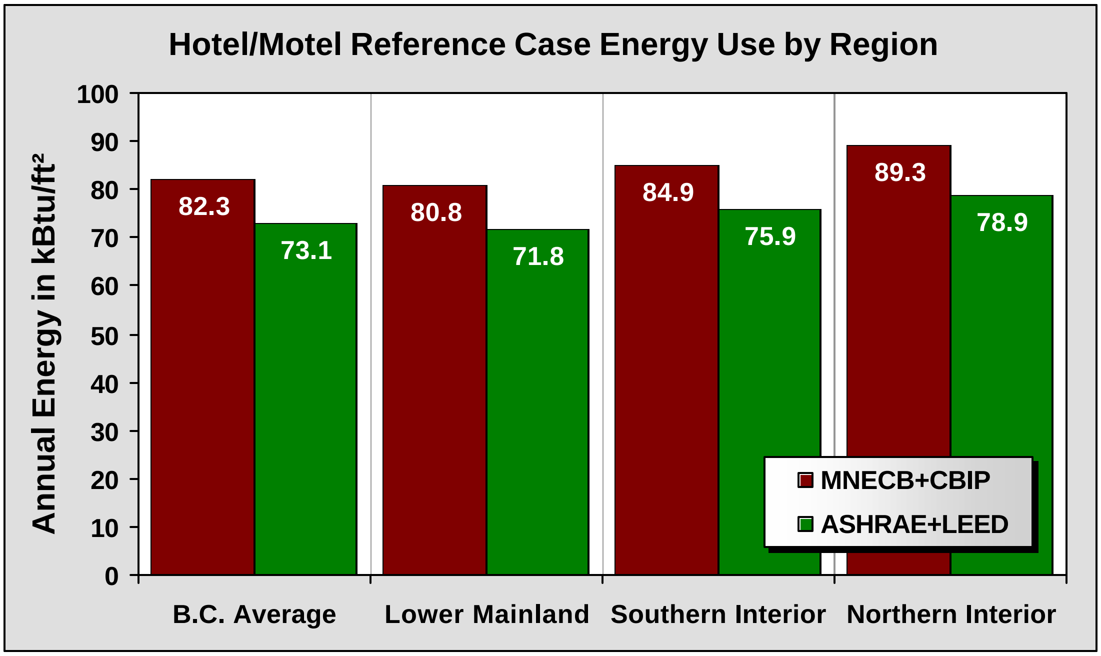
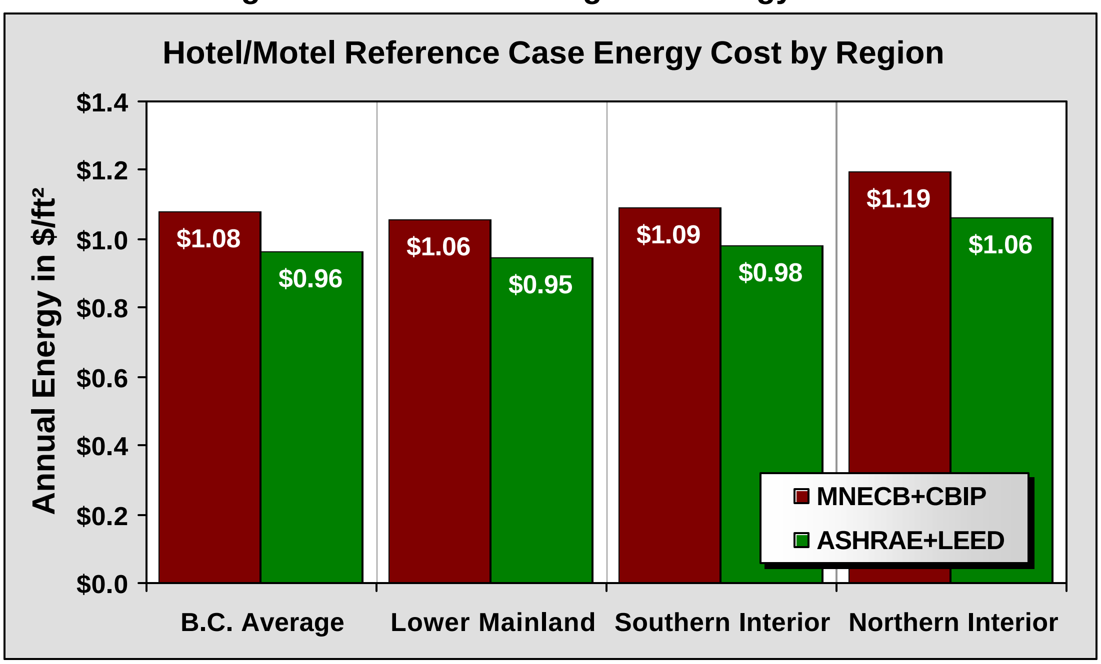


Figure 3. Hotel/Motel Regional Energy Costs



RESULTS FOR MULTI-UNIT RESIDENTIAL BUILDINGS

Table 1. LEED-BC Equivalency Table of Energy Credits: Applied to the Multi-Unit Residential Segment

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-BC Savings Bins		LEED-BC vs LEED-GBC Difference		ECB vs CO_2 Basis Difference
	$/ft²	kg/m²	ECB	CO_2	ECB	CO_2	
0%	*0.53*	*44.7*	*8.9%*	*6.4%*	*8.9% pt*	*6.4% pt*	*2.5% pt*
20%	0.43	35.8	27.1%	25.1%	7.1% pt	5.1% pt	2.0% pt
30%	0.37	31.3	36.2%	34.5%	6.2% pt	4.5% pt	1.8% pt
40%	0.32	26.8	45.3%	43.8%	5.3% pt	3.8% pt	1.5% pt
50%	0.27	22.3	54.4%	53.2%	4.4% pt	3.2% pt	1.3% pt
60%	0.21	17.9	63.6%	62.6%	3.6% pt	2.6% pt	1.0% pt

Figure 1. Equivalency for LEED-BC (MNECB+CBIP) Versus U.S. LEED (ASHRAE+LEED): Applied to Multi-Unit Residential

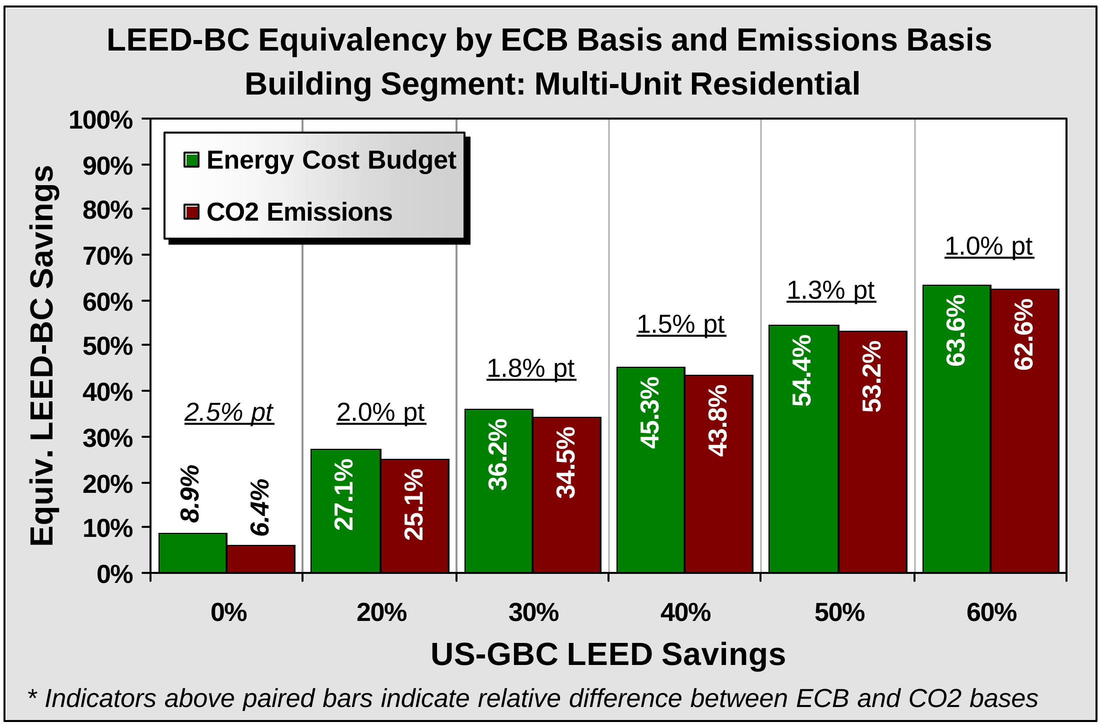


Figure 2. Multi-Unit Residential Regional Reference Energy Use

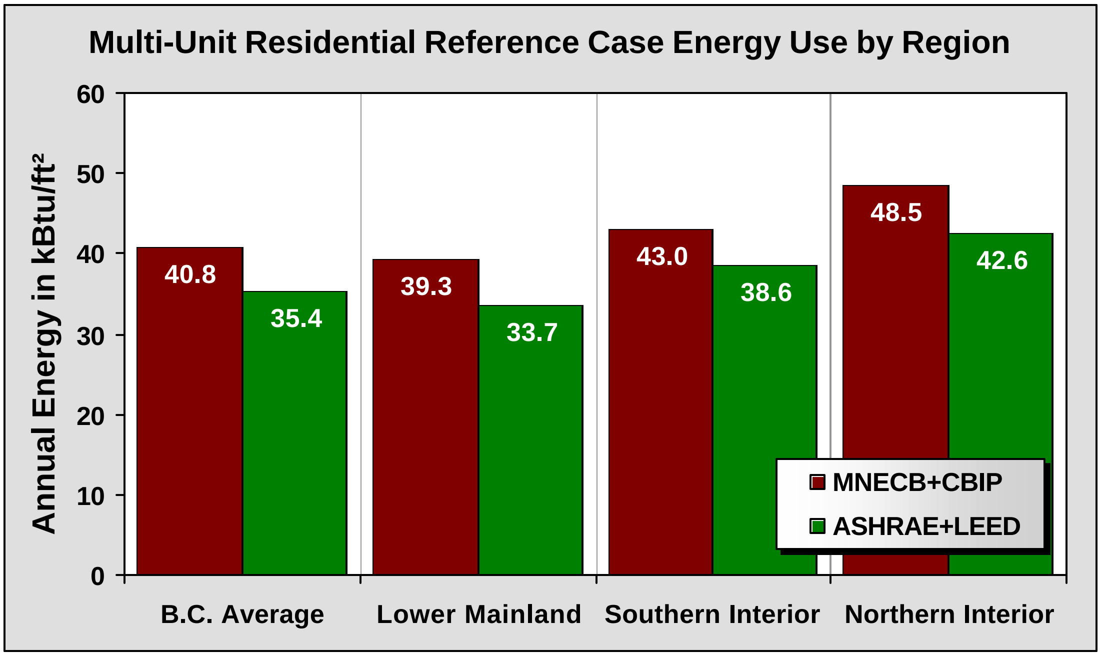
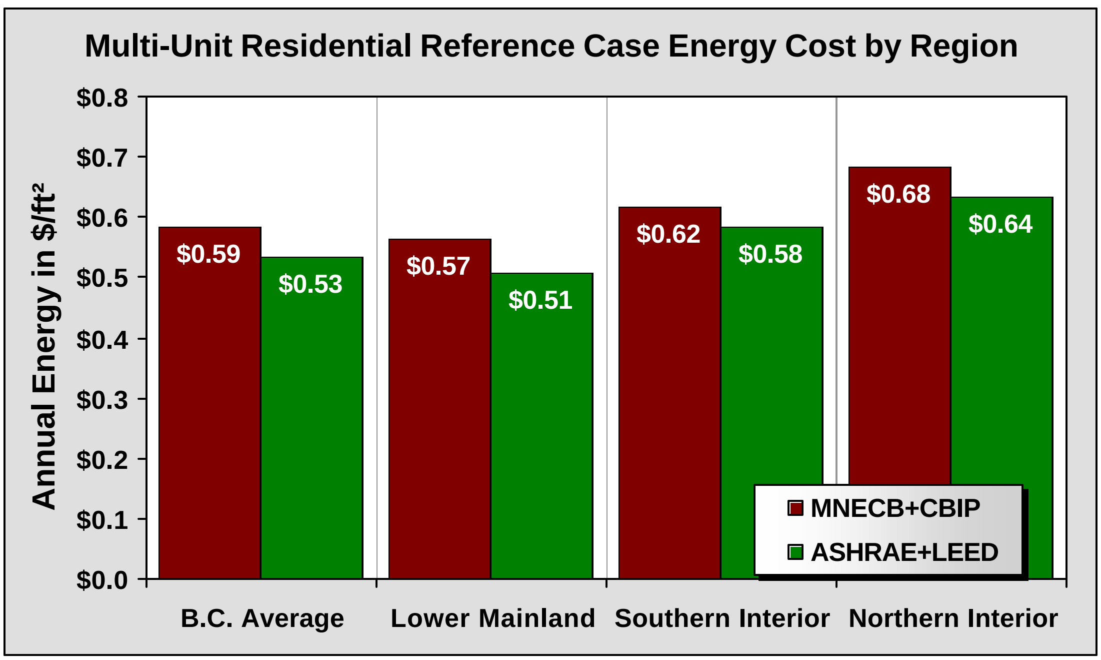


Figure 3. Multi-Unit Residential Regional Energy Costs



RESULTS FOR BIG BOX RETAIL

Table 1. LEED-BC Equivalency Table of Energy Credits: Applied to the Big Box Retail Segment

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-BC Savings Bins		LEED-BC vs LEED-GBC Difference		ECB vs CO_2 Basis Difference
	$/ft²	kg/m²	ECB	CO_2	ECB	CO_2	
0%	*1.09*	*96.5*	*6.9%*	*8.3%*	*6.9% pt*	*8.3% pt*	*-1.4% pt*
20%	0.88	77.2	25.5%	26.6%	5.5% pt	6.6% pt	-1.1% pt
30%	0.77	67.5	34.8%	35.8%	4.8% pt	5.8% pt	-1.0% pt
40%	0.66	57.9	44.1%	45.0%	4.1% pt	5.0% pt	-0.8% pt
50%	0.55	48.2	53.4%	54.1%	3.4% pt	4.1% pt	-0.7% pt
60%	0.44	38.6	62.8%	63.3%	2.8% pt	3.3% pt	-0.5% pt

Figure 1. Equivalency for LEED-BC (MNECB+CBIP) Versus U.S. LEED (ASHRAE+LEED): Applied to Big Box Retail

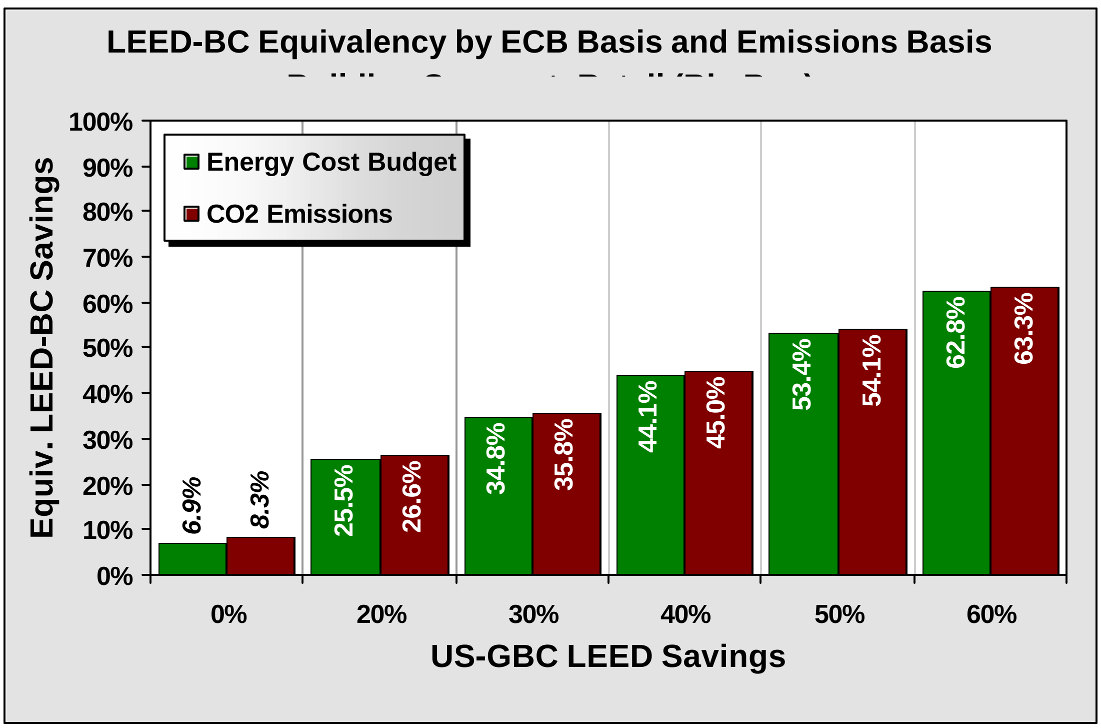


Figure 2. Big Box Retail Regional Reference Energy Use

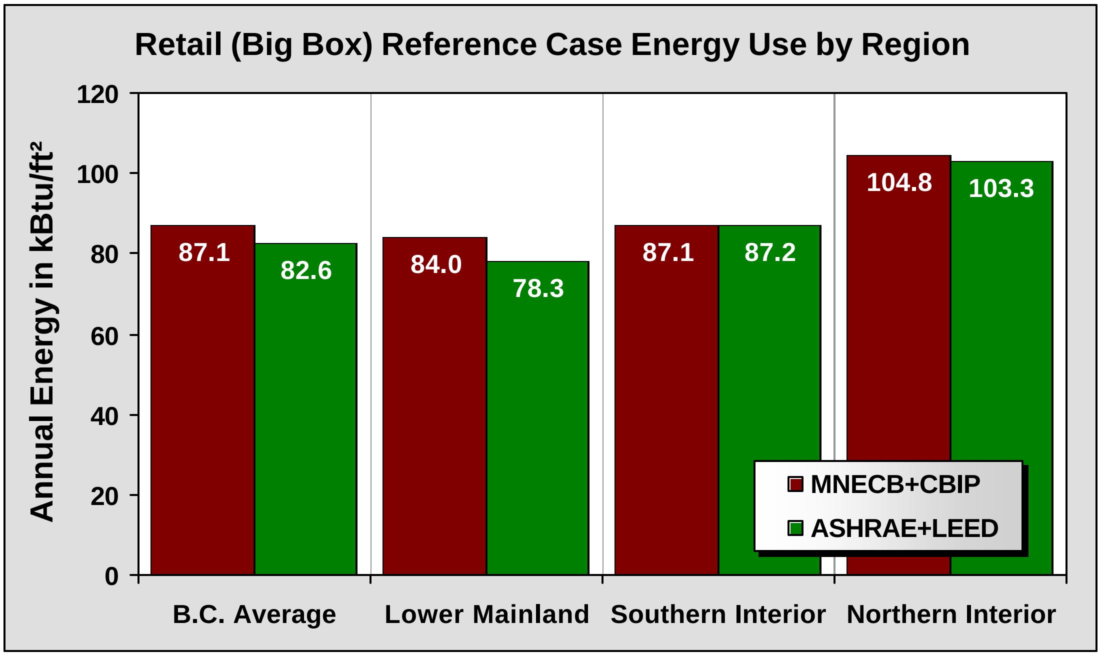
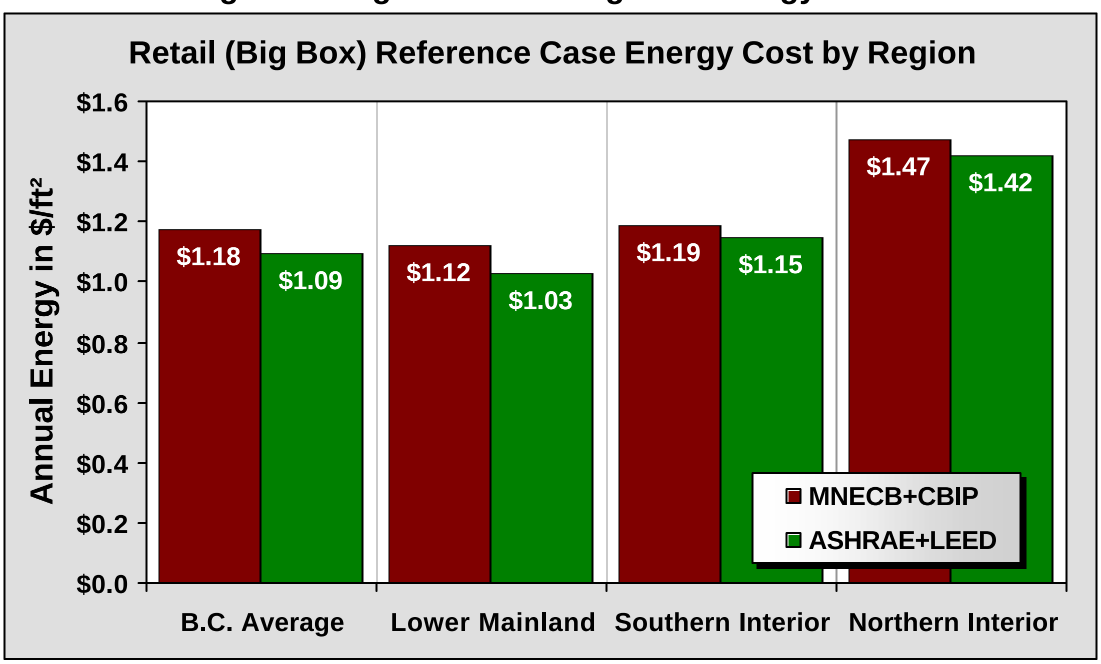


Figure 3. Big Box Retail Regional Energy Costs



RESULTS FOR STRIP MALL RETAIL

Table 1. LEED-BC Equivalency Table of Energy Credits: Applied to the Strip Mall Retail Segment

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-BC Savings Bins		LEED-BC vs LEED-GBC Difference		ECB vs CO_2 Basis Difference
	$/ft²	kg/m²	ECB	CO_2	ECB	CO_2	
0%	*1.40*	*111.1*	*7.5%*	*7.3%*	*7.5% pt*	*7.3% pt*	*0.2% pt*
20%	1.12	88.9	26.0%	25.9%	6.0% pt	5.9% pt	0.1% pt
30%	0.98	77.8	35.2%	35.1%	5.2% pt	5.1% pt	0.1% pt
40%	0.84	66.7	44.5%	44.4%	4.5% pt	4.4% pt	0.1% pt
50%	0.70	55.6	53.7%	53.7%	3.7% pt	3.7% pt	0.1% pt
60%	0.56	44.5	63.0%	62.9%	3.0% pt	2.9% pt	0.1% pt

Figure 1. Equivalency for LEED-BC (MNECB+CBIP) Versus U.S. LEED (ASHRAE+LEED): Applied to Strip Mall Retail

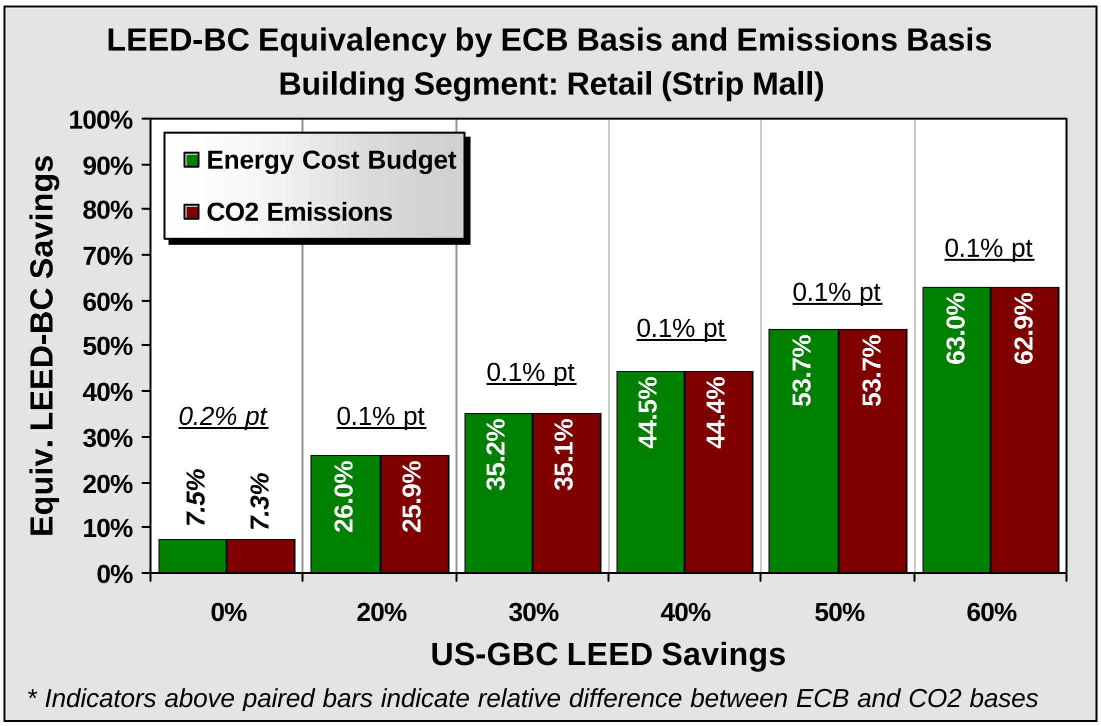


Figure 2. Strip Mall Retail Regional Reference Energy Use

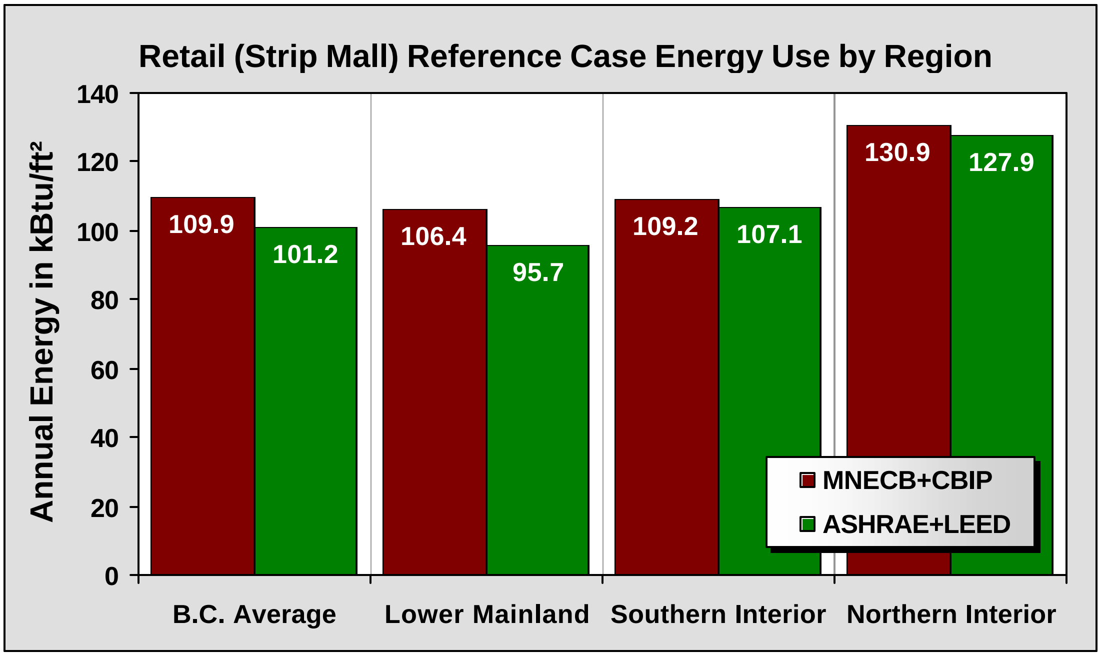


Figure 3. Strip Mall Retail Regional Energy Costs