FINAL REPORT

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

prepared for

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EXECUTIVE SUMMARY

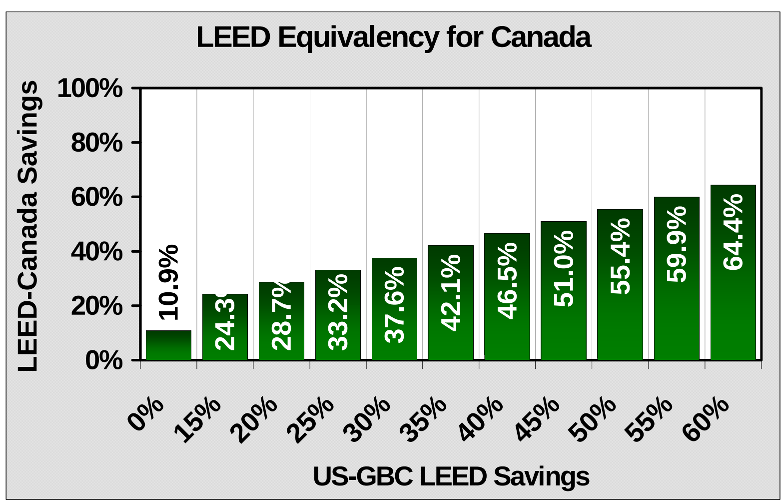
In an effort to apply the U.S. Leadership in Energy and Environmental Design (LEED™) rating system to buildings in Canada, Natural Resources Canada has commissioned this study to determine how ASHRAE/IESNA Standard 90.1-1999 (ASHRAE 90.1-1999) compares to the Commercial Building Incentive Program's (CBIP's) 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 represent the vast majority of new commercial building stock across Canada. 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 seven cities across Canada that represent the major population centres and weather regions across the country.

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 provides the overall result from this analysis process. This chart shows how MNECB+CBIP compares to ASHRAE+ LEED using energy costs applied to energy use to calculate the savings (i.e., following the "energy cost budget" method). 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™ 2.1 system (USGBC LEED).

Figure 1. Comparison of Equivalent Savings Levels



The MNECB+CBIP standard is nearly 11% 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, an equivalent adaptation of LEED for Canada (LEED-Canada) would require nearly 11% savings over respective MNECB+CBIP reference cases to satisfy LEED's EA Prerequisite 2. LEED-Canada, however, is likely to revise EA Prerequisite 2 to require projects to satisfy the minimum 25% CBIP savings target. Since this is calculated based on energy use (not cost) and includes plug loads, the more stringent qualification requirement for LEED-Canada's EA Prerequisite 2 would be equivalent to achieving about 18.0% energy cost savings, or 16.2% savings on energy consumption. This is based on applying LEED's methodology for calculating the percent savings by excluding non-regulated plug loads, which are included for CBIP, and assuming MNECB default plug loads by building type.

After this point, the equivalent EA Credit 1 point awards correspond to the respective 5% differential point savings levels provided by LEED™. For instance, to receive at least 2 points (assuming the same scoring system as LEED™ 2.1), new designs would have to save nearly 29% for LEED-Canada. Notice that qualification for a single EA Credit 1 point at 24.3% cost savings appears lower than the minimum LEED-Canada EA Prerequisite 2 level. However, this is suitable since the 25% CBIP savings target is based on *energy use* while the minimum equivalency for EA Credit 1 is based on *energy cost*.

Assuming LEED-Canada would follow an equivalent scoring system as LEED™ 2.1 from the United States, we generated the following LEED-Canada EA Equivalency Table. This table provides a point awards system for energy savings for LEED-Canada that would be equivalent to the USGBC system.

LEED-Canada EA Equivalency Table

Percent Savings		Points
LEED-Canada	LEED 2.1	
*< 10.9%**	*0%*	*U.S. LEED 2.1 Prereq 2*
CBIP (~25.4% Energy Use)	*~18.0%*	*LEED-Canada Prereq 2*
24.3%	15%	1
28.7%	20%	2
33.2%	25%	3
37.6%	30%	4
42.1%	35%	5
46.5%	40%	6
51.0%	45%	7
55.4%	50%	8
59.9%	55%	9
64.4%	60%	10

**Based on energy cost for regulated end-uses*

As previously indicated and shown by the table, the first point would be awarded when 24.3% savings is reached. At the highest energy savings level, the maximum 10 points would be realized if savings exceed MNECB+CBIP by 64.4%. In contrast, the highest level for LEED™ 2.1 occurs above 60% savings—a difference of over five percentage points with the equivalent LEED-Canada savings level.

INTRODUCTION AND BACKGROUND

The LEED-Canada Steering Committee is seeking to establish a Canada-wide equivalency that represents the difference in energy consumption between (1) reference modelling following the CBIP[1] application of the Model National Energy Code for Commercial Buildings (MNECB+CBIP) requirements in Canada, and (2) reference modelling following the LEED[2] application of the ASHRAE/IESNA[3] Standard 90.1-1999 (ASHRAE+LEED). Similar to a study carried out for LEED-BC[4], the equivalency will be determined by applying this comparison to a representative selection of building types and climatic regions across Canada. The equivalency will be used to first show compliance, and then to adjust the table of point awards for Energy & Atmosphere (EA) 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 study had the primary goal of ensuring that LEED-Canada EA 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.2.1 Reference Guide. The LEED-Canada point awards could then be determined from energy modelling following the MNECB/CBIP simulation requirements rather than ASHRAE 90.1-1999.

As with the preceding LEED-BC effort, the LEED-Canada committee originally 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. However, since it proved problematic to apply generally acceptable factors, we were requested to not evaluate the implications of applying CO_2 emission factors in determining equivalency.

This report discusses the methodology followed for applying the equivalency analysis to the Canadian new commercial building stock and presents the results.

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

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

[3] 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.

[4] The LEED-BC study (Hepting and Ehret, March 2002, "Verification of LEED-BC v1.0 Energy Credit 1 Point Awards for Building Energy Conservation in British Columbia") developed an equivalency between MNECB and ASHRAE/IESNA Standard 90.1-1999 for the Province of British Columbia.

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, generally representing major population centres. 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 served 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 and costs 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 generally more stringent for ASHRAE 90.1-1999 than MNECB+CBIP, for the most typical configurations across the commercial sector. However, MNECB+CBIP is generally more stringent for buildings heated with electricity. Regionally, Quebec tends to have noticeably more stringent MNECB+CBIP shell requirements while Regina's are noticeably less stringent than for most other regions.

- *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 about 45% of the new commercial building stock, ASHRAE 90.1-1999 allowances amount 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[5]. In addition, ASHRAE includes provisions for controlling boilers and chillers that increase these 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 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 the Reference case must use one of three different HVAC system types, 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.

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

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/baseboards (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[6] 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, which typically have high proportions of outside air. Multi-unit residential and hotels may also be affected, depending on the configuration.

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 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 Canada’s adaptation of LEED (LEED-Canada) 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 which corresponds to the equipment

[6] 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. From an official interpretation provided by ASHRAE, the application of heat reclaim only applies in situations where the air is heated to over 60°F, as indicated by one of the exceptions to this provision.

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 the "Calculations" starting on page 140 of the *LEED™ Reference Guide 2.1,* 2nd ed., May 2003). This may be significant, as it will require inexperienced users of EE4 to do post-simulation processing before submitting calculations to LEED-Canada.

APPROACH

In determining the equivalency between MNECB+CBIP and ASHRAE 90.1-1999, we made use of 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, focusing on regional distinctions for major population centres.

Overview

For the purposes of this policy-level study, the prototype building models required relatively little updating to reflect current construction trends in Canada. 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.

We examined the building types called out in the original scope for this study since they capture the large majority of commercial floor area 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 locations, as required by the scope of work:

- British Columbia Coastal regions, using Vancouver weather data (MNECB Region A, ASHRAE T.B-18);
- Alberta south/central region, using Calgary weather data (MNECB Region A, ASHRAE Table B-22);
- Prairies, using Regina weather data (MNECB Region A, ASHRAE Table B-23);
- Eastern Ontario, using Toronto weather data (MNECB Region A, ASHRAE Table B-20);
- South eastern Quebec, using Montreal weather data (MNECB Region A, ASHRAE Table B-20);
- Maritimes, using Halifax weather data (MNECB Region A, ASHRAE Table B-20);
- Territories, using Yellowknife weather data (MNECB Region B, ASHRAE Table B-25);

These weather regions provide for a relatively wide degree of representative weather variations across Canada. Additionally, the specific typical year weather sites within the above regions (from a maximum of 44 available) represent the major population centres in Canada, except for Yellowknife.

The final step in establishing a Canada-wide equivalency between MNECB+ CBIP and ASHRAE 90.1-1999 involved aggregating the various models together as a representation of the entire commercial 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 Natural Resources Canada’s 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-Canada equivalency analysis workbook configured for each building type.

Within this workbook, we applied regional electricity and natural gas or fuel oil rates to the energy performance results. The electricity rates were obtained from tariffs listed on the web sites for each of the respective local electric utilities. NRCan provided most natural gas and fuel oil prices from a draft Commercial Energy Efficiency Alliance (CEEA) source. Montreal natural gas rates were not available from NRCan, so we collected those from the local utility’s web site. We used regional, average blended rates by building type 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."[7] 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.

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

1) The allocation floor area between regions was based on population for each of the major metropolitan areas, represented by the respective weather sites. Commercial and Institutional Building Energy Use Survey (CIBEUS) provides data for building stock by region, but some regions are significantly better represented than others. Applying the regional factors from CIBEUS proves inappropriate and hence, population was used as the proxy for representing the relative market share between the locations.

2) The relative proportion of the building stock floor area within each region was based on figures provided by NRCan through its Commercial and Institutional Building Energy Use Survey 2000 web site. Unfortunately, the CIBEUS data is visibly void in data for certain regions (i.e., British Columbia, in particular) and for certain building types (multi-unit residential sector is completely missing). Hence, we had to leverage the missing data with information from the LEED-BC study and past BC Hydro studies[8]. Appendix D provides the market penetration factors by building type for each region. 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 country.

3) The percent of fossil heated versus electrically heated floor area within the building stock was typically based on figures provided by the CIBEUS data, with the exception of British Columbia. For this region, more accurate data obtained from the LEED-BC study was applied[9]. In general, the proportion of electric heat seems somewhat high, particularly for Quebec and the Maritimes. Because CIBEUS basically lists the frequency of electric heat versus the actual heating load served, we tended to adjust down the electric

[7] The table of Commercial Sector Average Energy Costs by State in the Energy & Atmosphere section of the *LEED v.2.1 Reference Guide* (p. 143) provides average unit rates by fuel type.
[8] 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.
[9] Ibid.

heating market factors slightly based on our professional opinion and anecdotal feedback from other professionals[10].

4) The estimated allocation of appropriate HVAC systems for the different fuel types was based on professional judgments 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 in some regions. 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 drew upon professional experience in the commercial sector to estimate the HVAC allocation factors. We also referenced some limited information cited in the LEED-BC study. 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 frequent occurrence of this system type in new designs. Some regions—Vancouver in particular—were allocated significantly higher market shares than for other regions where distributed heat pumps are relatively rare.

   - 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 end result from the above process resulted in the "baseline equivalency" between MNECB+CBIP and ASHRAE+LEED. That is, it resulted in the minimum

[10] From communication with CBIP representatives, other design professionals and sources cited in the LEED-BC study.

level of energy performance and relative savings required for LEED-Canada to be equivalent to the U.S. LEED system at the minimum prerequisite of zero percent savings. From this point, we could calculate the level of savings for LEED-Canada that would be equivalent to the U.S. system at any savings level (e.g., 15%, 20%, … 60%). Essentially, this is done by (1) calculating the performance level under the U.S. system (e.g., at whatever desired savings percentage), and then (2) comparing it to the corresponding LEED-Canada minimum equivalent performance level. This procedure results in the following formula that may be used to calculate any equivalent savings level for LEED-Canada:

$$\text{LEED-Canada}_{\%\$} = 1 - (1 - \text{LEED-US}_{\%\$}) \times (1 - 10.9\%)$$

where,

$\text{LEED-Canada}_{\%\$}$ - the percent energy cost savings level for LEED-Canada, following the MNECB+CBIP approach, but with the energy cost for plug loads removed

$\text{LEED-US}_{\%\$}$ - the percent energy cost savings level for the U.S. LEED system, following LEED+ASHRAE

RESULTS

This section provides results for the equivalency analysis applied to the overall commercial market within Canada. 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 Canadian adaptation of LEED. Table 1 provides the LEED-Canada savings levels that correspond to equivalent levels of savings following the U.S. LEED system.

Table 1. LEED-Canada Equivalency Table of Energy Credits

LEED-US Savings Bins	Min. Proposed Qualifying		Equivalent LEED-Canada Savings		LEED-Canada vs US-GBC LEED		ECB vs Energy Difference
	$/ft²	kBtu/ft²	ECB	Energy	ECB	Energy	
0% (0 pts)	*1.41*	*87.2*	*10.9%*	*8.8%*	*10.9% pt*	*8.8% pt*	*2.060% pt*
15% (1 pts)	1.20	74.1	24.3%	22.5%	9.3% pt	7.5% pt	1.751% pt
20% (2 pts)	1.13	69.8	28.7%	27.1%	8.7% pt	7.1% pt	1.648% pt
25% (3 pts)	1.06	65.4	33.2%	31.6%	8.2% pt	6.6% pt	1.545% pt
30% (4 pts)	0.99	61.1	37.6%	36.2%	7.6% pt	6.2% pt	1.442% pt
35% (5 pts)	0.92	56.7	42.1%	40.7%	7.1% pt	5.7% pt	1.339% pt
40% (6 pts)	0.85	52.3	46.5%	45.3%	6.5% pt	5.3% pt	1.236% pt
45% (7 pts)	0.78	48.0	51.0%	49.9%	6.0% pt	4.9% pt	1.133% pt
50% (8 pts)	0.70	43.6	55.4%	54.4%	5.4% pt	4.4% pt	1.030% pt
55% (9 pts)	0.63	39.3	59.9%	59.0%	4.9% pt	4.0% pt	0.927% pt
60% (10 pts)	0.56	34.9	64.4%	63.5%	4.4% pt	3.5% pt	0.824% pt

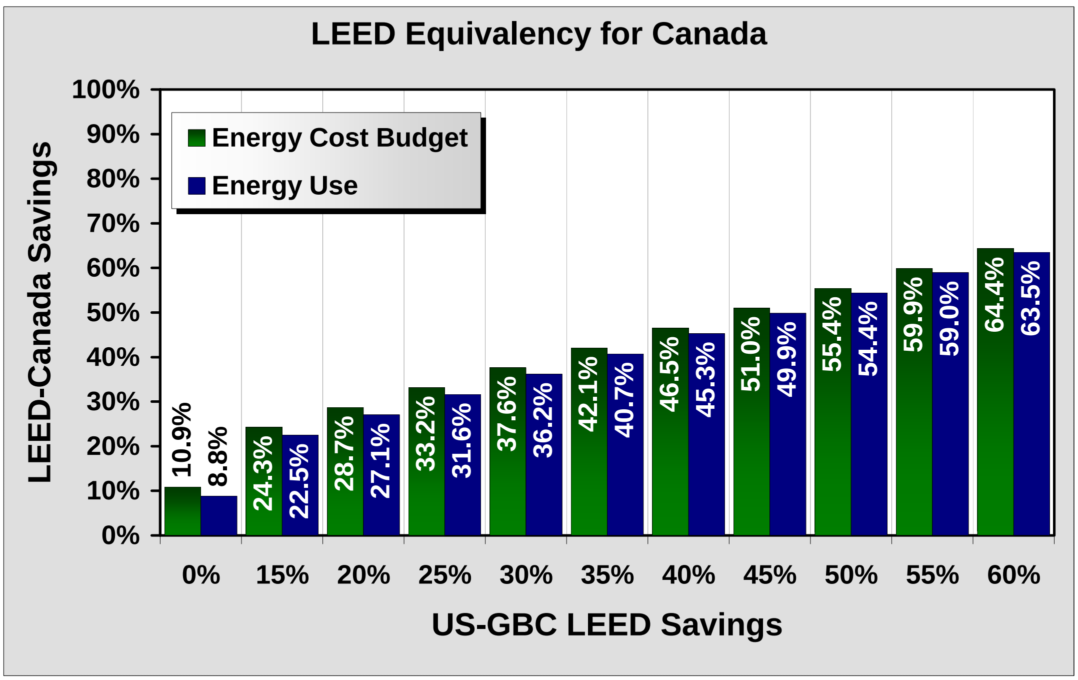
Table 1 illustrates the overall energy cost budget (ECB) differences between ASHRAE+LEED and MNECB+CBIP. This table also shows the relative performance in energy consumption without energy rates applied. It demonstrates that the different bases for comparison used by LEED and CBIP exhibit some slight, but noticeable differences between each other, when *applied on a sector-wide basis across Canada.*

As both Table 1 and Figure 2 (below) show, a new LEED-Canada design would need to achieve nearly 11% savings above the MNECB+CBIP standard to just comply with LEED EA Prerequisite 2. LEED-Canada, however, is likely to revise EA Prerequisite 2 to require projects to satisfy the minimum 25% CBIP savings target[11]. This is calculated based on energy use (not cost) and includes plug

[11] If this provision were adopted, the ASHRAE-90.1 prescriptive compliance approach to EA Prerequisite 2 would no longer apply.

loads. Without plug loads, this minimum increases to 25.4% on average, although it varies depending on the level of plug loads. This more stringent qualification requirement for LEED-Canada's EA Prerequisite 2 would be equivalent to achieving about 18.0% energy cost savings, or 16.2% savings on energy consumption. Hence, this indicates that the Canadian adaptation of LEED has a more stringent prerequisite than that of the U.S. version—by about 7% points. Stated another way, any prospective LEED-Canada project that follows the LEED+ASHRAE method of compliance would need to demonstrate a minimum of about 18% in energy cost savings. Otherwise, the project could not qualify for the Canadian adaptation of LEED. Note that the actual equivalent threshold would vary based on the particulars of a given project, as influenced by the regional shell requirements, energy rates, disparity in fuel type usage and level of plug loads.

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



Disregarding the minimum equivalency for EA Prerequisite 2, LEED-Canada projects would obtain their first EA Credit 1 point if they achieved 24.3% savings. This is equivalent to achieving 15% savings using a corresponding ASHRAE+LEED Budget case as the comparison. However, with requiring CBIP qualification for EA Prerequisite 2, awarding an EA Credit 1 point below the 25.4% may not be desired. The first point level above the Prerequisite minimum is at 2 points, for which 20% savings for the USGBC LEED is equivalent to 28.7% for LEED-Canada.

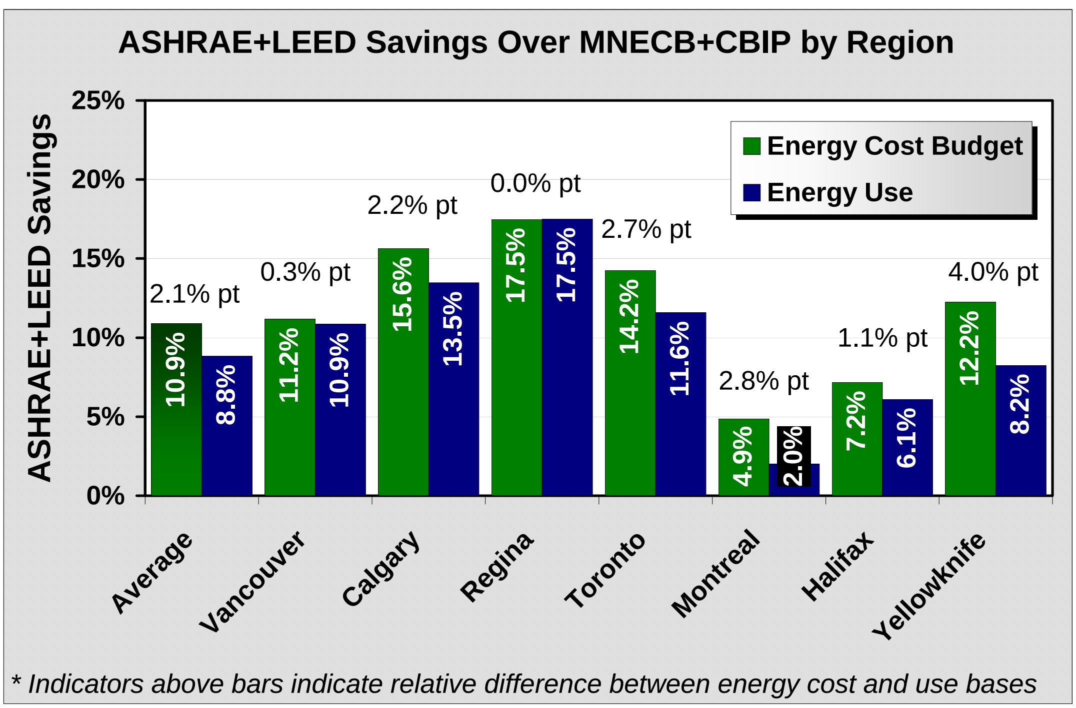
Achieving the maximum 10 points corresponds to saving at least 64.4% following the MNECB+CBIP Standard. This is equivalent to saving over 60% in energy costs following the ASHRAE+LEED ECB approach.

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.

Regional Results

The following graph provides more detailed results on a regional basis for the seven regions evaluated as part of this study. For each location, 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, Montreal exhibits the lowest relative difference between the standards at only about 5% difference. The highest regional difference between MNECB+CBIP and ASHRAE+LEED is observed for Regina, at nearly 18% difference.

Figure 3. Regional Equivalency Comparisons



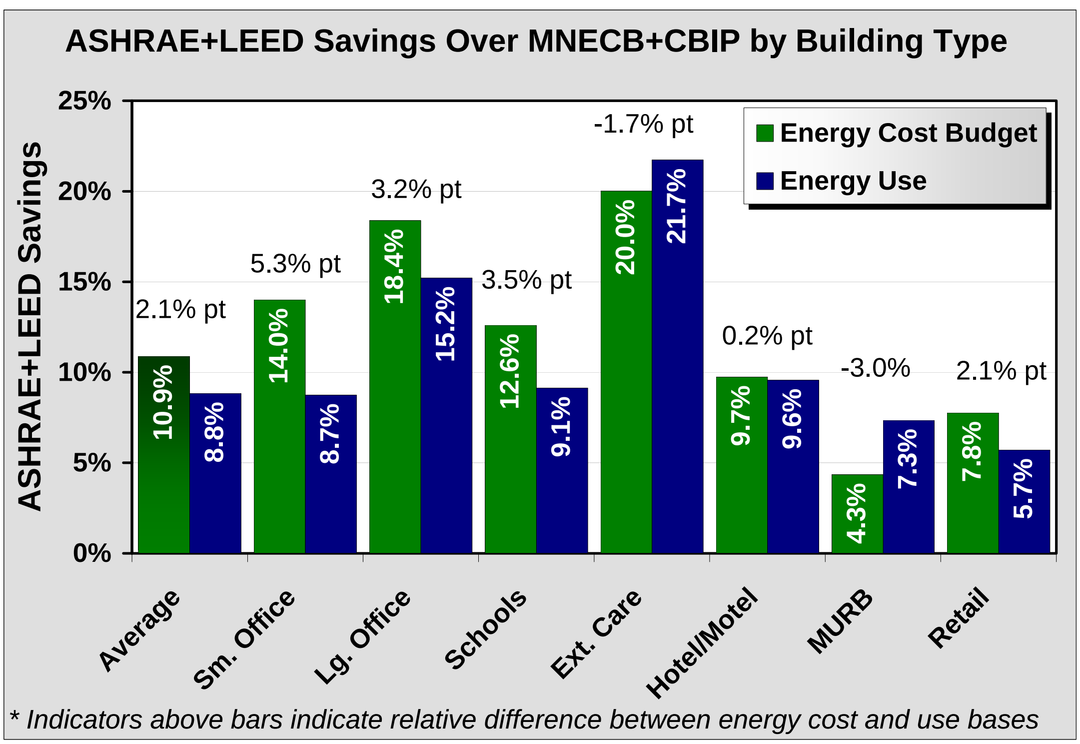
The numbers above the bars represent the percentage point differences between the energy cost budget and energy use equivalencies. This is provided to approximate the differences between CBIP's approach to basing savings on site energy use versus LEED's energy cost basis. There is some difference between the two methods by region—most notably in Toronto, Montreal and Yellowknife where the difference is about 3–4 percentage points. In contrast, Vancouver and Regina exhibit little difference between energy cost and use. The overall average difference is noticeable at above 2 percentage points, partly because Toronto and Montreal account for over two-thirds of the total market share (at 40% and 29%, respectively).

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

Building Type Results

Figure 4 provides more detailed results for each building type averaged across all seven 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 in basing saving on energy costs versus energy consumption is much wider by building type than it was for the different regions or the overall commercial sector average. This difference is highest for the small office building type at 5.3 percentage points and lowest for the hotel/motel building type at 0.2 percentage points. While these results point out the differences among the

Figure 4. Building Segment Equivalency Comparisons



building types and regions, it is important to note that LEED v.2.1 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 about 20–22% 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 overall difference between MNECB+CBIP and ASHRAE+LEED was observed in the strip mall retail building type, at about 1–2% *more stringent for CBIP than for LEED*. Note that the strip mall and big box retail were combined in the summary results as a representation for the overall retail segment; the appendices, however, provide detailed results for each building type.

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

CONCLUSIONS

This energy performance analysis of the commercial sector in Canada indicates that the Energy Performance (EA Credit 1) requirements of the U.S. LEED Rating System is nearly 11% more stringent than Canada's MNECB+CBIP energy performance requirements. The following point awards table would apply for the LEED-Canada Applications Guide, assuming the minimum CBIP savings requirement is adopted for EA Prerequisite 2. To be consistent with LEED v.2.1, we developed an overall commercial sector average and did not differentiate among different building types when developing the point awards table for LEED-Canada.

Table 2 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 that is used regardless of the building type or weather region. As indicated previously, overall building type differences between MNECB+ CBIP and ASHRAE+LEED may be significant. While potentially unwieldy, if an energy credit point award system were defined for each of the building segments represented in this study, the point award levels would vary considerably (Table 3). At a minimum 1-point award level, the equivalent ECB savings level ranges from 14% savings for multi-unit residential buildings to 28% savings for extended care. At the highest level, the maximum of 10 points is

EA Credit 1 Table* Applied to Entire Canadian New Commercial Sector

MNECB+ CBIP Savings	LEED-Canada Point Awards	Equivalent U.S. LEED Savings
29.3%	2	20%
33.7%	3	25%
38.1%	4	30%
42.6%	5	35%
47.0%	6	40%
51.4%	7	45%
55.8%	8	50%
60.2%	9	55%
64.7%	10	60%

**Assumes CBIP for EA Prerequisite 2*

Table 3. Energy Credit 1 Point Awards by Building Type

Building Segment	MNECB+CBIP Savings by LEED-Canada Point Award Category (ECB Basis)				
	2	4	6	8	10
Small Office	31%	40%	48%	57%	66%
Large Office	35%	43%	51%	59%	67%
Schools	30%	39%	48%	56%	65%
Extended Care	36%	44%	52%	60%	68%
Hotel/Motel	28%	37%	46%	55%	64%
Multi-unit Residential	23%	33%	43%	52%	62%
Retail, Average	26%	35%	44%	54%	63%

awarded at a minimum of nearly 62% savings for multi-unit residential buildings to maximum of 68% savings for extended care.

The differences among regions are significantly less than the differences among building types. There are, however, some noticeable discrepancies. If an energy credit point award system were defined for regions that corresponded to the seven locations used in this study, the point award level would vary as indicated in Table 4. At a minimum 1-point award level, the equivalent ECB savings level ranges from 14% savings for Montreal to 26% savings for Regina. At the highest level, the maximum of 10 points is awarded at a minimum of about 62% savings for Montreal to a maximum of 67% savings for Regina and Calgary.

Table 4. Energy Credit 1 Point Awards by Location

Regional City	MNECB+CBIP Savings by LEED-Canada Point Award Category (ECB Basis)				
	2	4	6	8	10
Vancouver	29%	38%	47%	56%	64%
Calgary	33%	41%	49%	58%	66%
Regina	34%	42%	50%	59%	67%
Toronto	31%	40%	49%	57%	66%
Montreal	24%	33%	43%	52%	62%
Halifax	26%	35%	44%	54%	63%
Yellowknife	30%	39%	47%	56%	65%

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[12] 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.

[12] DOE2 is an energy performance building simulation software program available from the U.S. Department of Energy.

APPENDIX A

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

Energy Code Comparisons and Analysis Approach Notes

LEED-Canada 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 ASHRAE 90.1-1999 Appendix B for the applicable weather region.	R-value substitution as appropriate to achieved overall "assembly" R-value. Set baseline for new projects at appropriate prescribed level based on estimated mix of wall types.	Vancouver: MNECB Region A, BC | ASHRAE T. B-18; Calgary: MNECB Region A, AB | ASHRAE T. B-22; Regina: MNECB Region A, SK | ASHRAE T. B-23; Toronto: MNECB Region A, ON | ASHRAE T. B-20; Montreal: MNECB Region A, QC | ASHRAE T. B-20; Halifax: MNECB Region A, NS | ASHRAE T. B-20; Yellowknife: MNECB Region A, NWT | ASHRAE T. B-25;
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 ASHRAE 90.1-1999 Appendix B for the applicable weather region.	R-value substitution as appropriate to achieved overall "assembly" R-value. Set baseline for new projects at appropriate prescribed level based on estimated mix of roof types, as applicable.	Vancouver: MNECB Region A, BC | ASHRAE T. B-18; Calgary: MNECB Region A, AB | ASHRAE T. B-22; Regina: MNECB Region A, SK | ASHRAE T. B-23; Toronto: MNECB Region A, ON | ASHRAE T. B-20; Montreal: MNECB Region A, QC | ASHRAE T. B-20; Halifax: MNECB Region A, NS | ASHRAE T. B-20; Yellowknife: MNECB Region A, NWT | ASHRAE T. B-25;
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 ASHRAE 90.1-1999 Appendix B for the applicable weather region.	R-value substitution as appropriate to achieved overall "assembly" R-value. 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. Vancouver: MNECB Region A, BC | ASHRAE T. B-18; Calgary: MNECB Region A, AB | ASHRAE T. B-22; Regina: MNECB Region A, SK | ASHRAE T. B-23; Toronto: MNECB Region A, ON | ASHRAE T. B-20; Montreal: MNECB Region A, QC | ASHRAE T. B-20; Halifax: MNECB Region A, NS | ASHRAE T. B-20; Yellowknife: MNECB Region A, NWT | ASHRAE T. B-25;
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 overall glazing substitution as appropriate.	An interpretation to ASHRAE indicates that the U-value and shading coefficient must be selected corresponding to the percent glazing instead of setting the "fenestration U-factor [to] be the minimum required for the climate, and the solar heat gain coefficient [to] be the maximum allowed for the climate and orientation." (11.4.2.(c)). *This clarification was not provided until after the LEED-BC equivalency study began.*

LEED-Canada 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
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 corresponding to the percent glazing from the envelope table for the applicable weather region. (*Modification from founding LEED-BC study - see note for Glazing Percent.*)	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. An 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 U_o 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.
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 corresponding to the percent glazing from the envelope table for the applicable weather region. (*Modification from founding LEED-BC study - see note for Glazing Percent.*)	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 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.

LEED-Canada 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
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, applying 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 are maintained and 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.

LEED-Canada 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
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.		
	Fossil (Natural Gas, Fuel Oil)	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 and over 150 tons (LEED exception), 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 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 - 1.40 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.

LEED-Canada 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
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) Adjustments for high static filtering systems, heat recovery devices, process devices	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 typically higher than the corresponding Proposed designs, and ASHRAE's limits tend to be higher than seen in new designs. 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.	Set at typical design levels, compliant with ASHRAE 62 (*Modification from founding LEED-BC study due to subsequent changes with CBIP*).	Most new designs designate outdoor air levels which are higher than the minimum MNECB mandatory defaults and comply with maximum ASHRAE 62-1999 standards. The typical approach for designating outdoor air in EE4 frequently use to involve maintaining the defaults, but has since changed per CBIP rulings to using higher design levels, compliant with ASHRAE. 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 typically increased above 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.

LEED-Canada 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
Heat Reclaim	Percent outside air	No exhaust air heat reclaim.	Exhaust air heat reclaim at 50% effectiveness if outside air is >70% of supply air, over 5000 cfm supply and provide over 60ºF heat to cooled spaces.	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.
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 - required for all weather regions if cooling capacity > 5.4T, except Montreal where economizer control is required if cooling capacity > 11.3T	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 the NRCan prototypes.
Humidification	Humidification RH, if any	Same as Proposed	Same as Proposed (assumed, but cannot find this explicitly called out)		Humidification is prevalent in prototype models for very few building types and weather locations (e.g., extended care)
HEATING PLANT					
Boiler	Gas/Oil 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.

LEED-Canada 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
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.
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 or fuel oil 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.	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.

Bldg Characteristic	Proposed Design *Relative Influence*	MNECB+CBIP Reference	ASHRAE+LEED ECB Reference	ASHRAE Modelling Analysis Approach	Discussion/Issues
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.
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 screw chillers with COP of 4.9 if capacity 300T - 600T; Two or more equally sized centrifugal chillers with COP of 6.1 if capacity > 600T, with no chiller > 800T. Note that if <150T, LEED exception effectively provides for using DX cooling.	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 beyond scope. Thus, we stayed with the MNECB part-load curves used in the NRCan templates, except for a screw chiller PLC from DOE2 documentation. 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 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 default centrifugal part-load curve default, regardless of the chiller size.

LEED-Canada 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
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 are captured in the newly generated projects (as necessary).
Chilled water reset	If hydronic cooling applies	No reset	Outdoor air reset unless variable flow pumping applies.	Increase cooling efficiency by 5%, 8%, 14%, 11%, 12%, 6%, and 21% for Vancouver, Calgary, Regina, Toronto, Montreal, Halifax and Yellowknife, respectively; from sensitivity analysis performed using DOE2 eca133 on cases with hydronic cooling on large office ECB prototypes.	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 may have water-source heat pumps if the Proposed case has distributed heat pumps, whereas MNECB would have a chiller in the reference case. LEED also varies from MNECB if the Proposed case has an air-cooled chiller or has a capacity <150T, in which case, the reference case has DX cooling.
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.	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 vast majority 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		
	Fossil (Natural Gas, Fuel Oil)	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

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

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/Oil Heat Source	Mass	Metal	Steel	Other	R_o	Allocation of construction types is based on professional experience in the commercial sector, including limited interviews with other design professionals, and is not statistically proven nor supported by market research. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada, except for the North where wood frame construction is more apparent. 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.
Vancouver	12.6	7.0	50%	0%	50%	0%	8.1	
			8.1	8.8	8.1	11.2		
Calgary	17.2	10.3	50%	0%	50%	0%	13.4	
			11.1	17.5	15.6	11.2		
Regina	21.0	11.8	50%	0%	50%	0%	13.4	
			11.1	17.5	15.6	15.6		
Toronto	17.2	10.3	50%	0%	50%	0%	10.8	
			9.6	8.8	11.9	11.2		
Montreal	17.2	17.2	50%	0%	50%	0%	10.8	
			9.6	8.8	11.9	11.2		
Halifax	21.0	11.8	50%	0%	50%	0%	10.8	
			9.6	8.8	11.9	11.2		
Yellowknife	21.0	17.2	40%	0%	30%	30%	16.2	
			14.1	17.5	15.6	19.6		
Roof Overall R-Value	Electric Heat Source	Gas/Oil 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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada.
Vancouver	13.8	12.1	15.9					
Calgary	19.6	12.1	15.9					
Regina	22.7	13.8	15.9					
Toronto	19.6	12.1	15.9					
Montreal	19.6	19.6	15.9					
Halifax	21.0	13.8	15.9					
Yellowknife	28.4	19.6	20.8					

Small Office: Key Building Characteristics

Exposed Floor R-Value	Electric Heat Source	Gas/Oil Heat Source	Mass	Steel	Other	R_o
Vancouver	15.0	13.5	90%	0%	10%	10.4
			9.3	19.2	19.6	
Calgary	20.2	13.5	90%	0%	10%	13.4
			11.5	26.3	30.3	
Regina	23.3	15.0	90%	0%	10%	15.2
			13.5	26.3	30.3	
Toronto	20.2	13.5	90%	0%	10%	13.4
			11.5	19.2	30.3	
Montreal	20.2	20.2	90%	0%	10%	13.4
			11.5	19.2	30.3	
Halifax	21.8	15.0	90%	0%	10%	13.4
			11.5	19.2	30.3	
Yellowknife	34.5	22.1	60%	0%	40%	21.5
			15.6	31.3	30.3	

Allocation of construction types is based on professional experience in the commercial sector and is not statistically proven nor supported by market research. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada, except for the North where wood frame construction is more apparent. Account for some Type II (MNECB) and Other (ASHRAE) floors for more rural building stock. Note that floor losses are relatively insignificant.

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.

GLAZING

Glazing Percent	Electric Heat Source	Gas/Oil Heat Source
	40% except Yellowknife at 25%	40% except Yellowknife at 25%

From limited survey information on existing offices, the average percent window area is less than 40%. However, since newer buildings have much higher percentages of glazing (particularly LEED projects), estimate new construction percent at the MNECB maximum based on professional observation and estimates. Exception for North, where percentages are lower based on professional experience and interviews.

Window U-value	Electric Heat Source	Gas/Oil Heat Source	Oper-able	Fixed	U_o
Vancouver	0.57	0.57	10%	90%	0.58
			0.67	0.57	
Calgary	0.38	0.57	10%	90%	0.58
			0.67	0.57	
Regina	0.32	0.57	10%	90%	0.46
			0.47	0.46	
Toronto	0.38	0.57	10%	90%	0.58
			0.67	0.57	
Montreal	0.37	0.49	10%	90%	0.58
			0.67	0.57	
Halifax	0.33	0.57	10%	90%	0.58
			0.67	0.57	
Yellowknife	0.22	0.38	10%	90%	0.43
			0.44	0.43	

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.

Small Office: Key Building Characteristics

Window Shading Coefficient			ASHRAE differentiates between North-facing windows separately from all other windows.
Vancouver	0.74	0.57 (all orientations)	
Calgary		0.57 (all orientations) / 0.74 (North)	
Regina		not required, set same as CBIP	
Toronto		0.57 (all orientations) / 0.74 (North)	
Montreal		0.57 (all orientations) / 0.74 (North)	
Halifax		0.57 (all orientations) / 0.74 (North)	
Yellowknife		not required, set same as CBIP	
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) HP (System 6) - N/A* 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. System 6 (HP) references System 3 per LEED EMP exception for hydronically cooled system under 150 tons.
Principle Heating Fuel Type	1) Gas (L02g??r) 2) Electric (L02e??r)	a) Gas for System 4 (L02g??rB) b) & 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.

Small Office: Key Building Characteristics

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	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	0.13 cfm/ft²	Same as MNECB+CBIP	Based on ASHRAE 62-1999 "simple system requirements" for general office space, or 20 cfm/person at design occupancy of 154 people/ft²
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	
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.
Vancouver		81.5%	
Calgary		82.0%	
Regina		82.0%	
Toronto		81.5%	
Montreal		81.5%	
Halifax		81.5%	
Yellowknife		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.

Small Office: Key Building Characteristics

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.
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	
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/Oil Heat Source	Mass	Metal	Steel	Other	R_o	Allocation of construction types is based on professional experience in the commercial sector and is not statistically proven nor supported by market research. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada. 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.
Vancouver	12.6	7.0	25%	0%	75%	0%	8.1	
			8.1	8.8	8.1	11.2		
Calgary	17.2	10.3	25%	0%	75%	0%	14.5	
			11.1	17.5	15.6	11.2		
Regina	21.0	11.8	25%	0%	75%	0%	14.5	
			11.1	17.5	15.6	15.6		
Toronto	17.2	10.3	25%	0%	75%	0%	11.3	
			9.6	8.8	11.9	11.2		
Montreal	17.2	17.2	25%	0%	75%	0%	11.3	
			9.6	8.8	11.9	11.2		
Halifax	21.0	11.8	25%	0%	75%	0%	11.3	
			9.6	8.8	11.9	11.2		
Yellowknife	21.0	17.2	25%	0%	75%	0%	15.2	
			14.1	17.5	15.6	19.6		
Roof Overall R-Value	Electric Heat Source	Gas/Oil Heat Source	Insulation Entirely above Deck					For this building type, all roof types as 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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada.
Vancouver	13.8	12.1	15.9					
Calgary	19.6	12.1	15.9					
Regina	22.7	13.8	15.9					
Toronto	19.6	12.1	15.9					
Montreal	19.6	19.6	15.9					
Halifax	21.0	13.8	15.9					
Yellowknife	28.4	19.6	20.8					

Large Office: Key Building Characteristics

Exposed Floor R-Value	Electric Heat Source	Gas/Oil Heat Source	Mass	Steel	Other	R_o
Vancouver	13.8	12.1	100%	0%	0%	9.3
			9.3	19.2	19.6	
Calgary	19.6	12.1	100%	0%	0%	11.5
			11.5	26.3	30.3	
Regina	22.7	13.8	100%	0%	0%	13.5
			13.5	26.3	30.3	
Toronto	19.6	12.1	100%	0%	0%	11.5
			11.5	19.2	30.3	
Montreal	19.6	19.6	100%	0%	0%	11.5
			11.5	19.2	30.3	
Halifax	21.0	13.8	100%	0%	0%	11.5
			11.5	19.2	30.3	
Yellowknife	28.4	19.6	100%	0%	0%	15.6
			15.6	31.3	30.3	

Allocation of construction types is based on professional experience in the commercial sector and is not statistically proven nor supported by market research. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada. 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.

GLAZING

Glazing Percent

Electric Heat Source	Gas/Oil Heat Source
40% except Yellowknife at 35%	50% except Yellowknife at 35%

From survey information on existing offices, the average percent window area is about 40%. However, since newer buildings have higher percentages of glazing, estimate new construction percent at the MNECB maximum based on professional observation and estimates. Exception for Yellowknife, where percentages are lower based on professional experience and interviews.

Window U-value	Electric Heat Source	Gas/Oil Heat Source	Oper-able	Fixed	U_o
Vancouver	0.57	0.57	10%	90%	0.46
			0.47	0.46	
Calgary	0.38	0.57	10%	90%	0.46
			0.47	0.46	
Regina	0.32	0.57	10%	90%	0.35
			0.39	0.35	
Toronto	0.38	0.57	10%	90%	0.46
			0.47	0.46	
Montreal	0.37	0.49	10%	90%	0.46
			0.47	0.46	
Halifax	0.33	0.57	10%	90%	0.46
			0.47	0.46	
Yellowknife	0.22	0.38	10%	90%	0.43
			0.44	0.43	

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.

Large Office: Key Building Characteristics

Window Shading Coefficient			ASHRAE differentiates between North-facing windows separately from all other windows.
Vancouver	0.74	0.42 (all orientations) / 0.57 (North)	
Calgary		0.42 (all orientations) / 0.74 (North)	
Regina		not required, set same as CBIP	
Toronto		0.42 (all orientations) / 0.74 (North)	
Montreal		0.42 (all orientations) / 0.74 (North)	
Halifax		0.42 (all orientations) / 0.74 (North)	
Yellowknife		not required, set same as CBIP	
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	0.13 cfm/ft²	Same as MNECB+CBIP	Based on ASHRAE 62-1999 "simple system requirements" for general office space, or 20 cfm/person at design occupancy of 154 people/ft²
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.
Vancouver		81.5%	
Calgary		82.0%	
Regina		82.0%	
Toronto		81.5%	
Montreal		81.5%	
Halifax		81.5%	
Yellowknife		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	

Large Office: Key Building Characteristics

COOLING			
Central Cooling Efficiency	Centrifugal chiller at 5.2 COP; no CHW reset	Use 2 screw or centrifugal chillers, depending on region; effectively increase COP by 5% - 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.
Vancouver		2 screw chillers at COP of 4.9 + 5% = 5.1	
Calgary		2 screw chillers at COP of 4.9 + 8% = 5.3	
Regina		2 centrifugal chillers at COP of 6.1 + 14% = 7.0	
Toronto		2 centrifugal chillers at COP of 6.1 + 11% = 6.8	
Montreal		2 centrifugal chillers at COP of 6.1 + 12% = 6.8	
Halifax		2 screw chillers at COP of 4.9 + 6% = 5.2	
Yellowknife		2 centrifugal chillers at COP of 6.1 + 21% = 7.4	
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.
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.

Item	MNECB+CBIP		ASHRAE+LEED ECB					Discussion/Issues
EXTERIOR SURFACES								
Wall Overall R-Value	Electric Heat Source	Gas/Oil 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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada. 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 a relatively even mix of constructions is apparent.
Vancouver	12.6	7.0	33%	0%	33%	33%	9.1	
			8.1	8.8	8.1	11.2		
Calgary	17.2	10.3	33%	0%	33%	33%	12.7	
			11.1	17.5	15.6	11.2		
Regina	21.0	11.8	33%	0%	33%	33%	14.1	
			11.1	17.5	15.6	15.6		
Toronto	17.2	10.3	33%	0%	33%	33%	10.9	
			9.6	8.8	11.9	11.2		
Montreal	17.2	17.2	33%	0%	33%	33%	10.9	
			9.6	8.8	11.9	11.2		
Halifax	21.0	11.8	33%	0%	33%	33%	10.9	
			9.6	8.8	11.9	11.2		
Yellowknife	21.0	17.2	33%	0%	33%	33%	16.4	
			14.1	17.5	15.6	19.6		
Roof Overall R-Value	Electric Heat Source	Gas/Oil 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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada.
Vancouver	13.8	12.1	15.9					
Calgary	19.6	12.1	15.9					
Regina	22.7	13.8	15.9					
Toronto	19.6	12.1	15.9					
Montreal	19.6	19.6	15.9					
Halifax	21.0	13.8	15.9					
Yellowknife	28.4	19.6	20.8					
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.

School: Key Building Characteristics

GLAZING						
Glazing Percent	16%		16%			From survey information and guidelines on schools, including communication with design professionals, the average percent window area is about 16%. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada.
Window U-value	Electric Heat Source	Gas/Oil Heat Source	Oper-able	Fixed	U_o	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.
Vancouver	0.57	0.57	25% / 0.67	75% / 0.57	0.60	
Calgary	0.40	0.57	25% / 0.67	75% / 0.57	0.60	
Regina	0.32	0.57	25% / 0.47	75% / 0.46	0.46	
Toronto	0.40	0.57	25% / 0.67	75% / 0.57	0.60	
Montreal	0.37	0.49	25% / 0.67	75% / 0.57	0.60	
Halifax	0.36	0.57	25% / 0.67	75% / 0.57	0.60	
Yellowknife	0.23	0.40	25% / 0.44	75% / 0.43	0.43	
Window Shading Coefficient						ASHRAE differentiates between North-facing windows separately from all other windows.
Vancouver	0.74		0.57 (all orientations)			
Calgary	0.74		0.57 (all orientations) / 0.74 (North)			
Regina	0.74		not required, set same as CBIP			
Toronto	0.74		0.57 (all orientations) / 0.74 (North)			
Montreal	0.74		0.57 (all orientations) / 0.74 (North)			
Halifax	0.74		0.57 (all orientations) / 0.74 (North)			
Yellowknife	0.74		not required, set same as CBIP			
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			

School: Key Building Characteristics

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 DX cooling, air-cooled chillers or have capacities <150T. 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 Calgary, Regina, Toronto and Montreal; DX in Vancouver, Halifax, and Yellowknife	Air	Cooling approach for hydronic versus DX estimated from investigating NRCan regional "current practice" DOE2 prototypes.. Note that method of cooling is not as important as the relative differences in the cooling efficiencies. Although water-cooled chiller plants are not uncommon, it appears to be more typical to have DX cooling or 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 DX Cooling: 3.0"/45% fan efficiency for supply and 0.6"/25% 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.
Outside Air	0.35 cfm/ft²	Same as MNECB+CBIP	Based on ASHRAE 62-1999 "simple system requirements" for classrooms, which is equivalent to the 17 cfm/person default for MNECB school building type at design occupancy of 49 people/ft²

School: Key Building Characteristics

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 (Fossil)	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.
Vancouver		81.5%	
Calgary		82.0%	
Regina		82.0%	
Toronto		81.5%	
Montreal		81.5%	
Halifax		81.5%	
Yellowknife		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 roughly 20% of Coastal regions, but 80% or more of other regions (gyms are often not cooled). NRCan templates are not set up to allow for easy removal of this level of cooling. Instead, reduced resulting cooling end-use according to current practice indicators from NRCan data, as such: 20% for Vancouver, Halifax; 80% for Montreal, Yellowknife; 100% for Calgary, Regina, Toronto. This is appropriate since air systems are typically sized to deliver supply air based on the assumption that mechanical cooling would be present and hence, fan energy is not affected.*			
Central Cooling Efficiency	Calgary, Regina, Toronto, Montreal: centrifugal chiller at 5.2 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 quite common for schools with near full cooling (DX otherwise). 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-Canada 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/Oil Heat Source	Mass	Metal	Steel	Other	R_o	Allocation of construction types is based on professional experience in the commercial sector and is not statistically proven nor supported by market research. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada, except for the North where wood frame construction is more apparent. From founding CBIP surveys, roughly 60% of exposed shell is allocated to residential-type space. 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.
Vancouver	12.6	7.0	40%	0%	40%	20%	11.2	
			9.91	8.8	12.6	11.2		
Calgary	17.2	10.3	40%	0%	40%	20%	14.3	
			11.9	17.5	15.6	16.3		
Regina	21.0	11.8	40%	0%	40%	20%	15.0	
			12.9	17.5	15.6	18.0		
Toronto	17.2	10.3	40%	0%	40%	20%	12.6	
			10.5	14.1	14.1	13.9		
Montreal	17.2	17.2	40%	0%	40%	20%	12.6	
			10.5	14.1	14.1	13.9		
Halifax	21.0	11.8	40%	0%	40%	20%	12.6	
			10.5	14.1	14.1	13.9		
Yellowknife	21.0	17.2	33%	0%	33%	33%	17.8	
			14.1	17.5	19.6	19.6		
Roof Overall R-Value	Electric Heat Source	Gas/Oil 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), with more attics 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. While it is not statistically proven nor supported by market research, NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada.
Vancouver	13.8	12.1	75%		25%		19.3	
			15.9		29.4			
Calgary	22.7	13.8	50%		50%		27.9	
			18.8		37			
Regina	19.6	19.6	50%		50%		26.5	
			15.9		37			
Toronto	28.4	19.6	70%		30%		21.3	
			15.9		34			
Montreal	15.0	13.5	70%		30%		21.3	
			15.9		34			
Halifax	20.2	13.5	70%		30%		21.3	
			15.9		34			
Yellowknife	23.3	15.0	50%		50%		28.9	
			20.8		37			
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.

Extended Care Facility: Key Building Characteristics

GLAZING						
Glazing Percent	24%		24%			Average specified in NRCan archetypes and appears reasonable based on experience and survey data.
Window U-value	Electric Heat Source	Gas/Oil 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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada. Input is corrected for DOE2's adjustment for air films to produce the specified overall U-value.
Vancouver	0.57	0.57	25% 0.67	75% 0.57	0.60	
Calgary	0.38	0.57	25% 0.67	75% 0.57	0.60	
Regina	0.32	0.57	25% 0.47	75% 0.46	0.46	
Toronto	0.38	0.57	25% 0.67	75% 0.57	0.60	
Montreal	0.37	0.49	25% 0.67	75% 0.57	0.60	
Halifax	0.33	0.57	25% 0.67	75% 0.57	0.60	
Yellowknife	0.22	0.38	25% 0.44	75% 0.43	0.43	
Window Shading Coefficient						ASHRAE differentiates between North-facing windows separately from all other windows.
Vancouver			0.57 (all orientations) / 0.74 (North)			
Calgary			0.57 (all orientations) / 0.74 (North)			
Regina			not required, set same as CBIP			
Toronto	0.74		0.57 (all orientations) / 0.74 (North)			
Montreal			0.57 (all orientations) / 0.74 (North)			
Halifax			0.57 (all orientations) / 0.74 (North)			
Yellowknife			not required, set same as CBIP			
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			

Extended Care Facility: Key Building Characteristics

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. Coastal regions without 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.
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 (45% overall)	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 different regions, but approximate averages provided, which are supported by feedback from CBIP reviewers.
Economizer	Enthalpy	Temperature for VAV and PSZ	

Extended Care Facility: Key Building Characteristics

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.
Vancouver		81.5%	
Calgary		82.0%	
Regina		82.0%	
Toronto		81.5%	
Montreal		81.5%	
Halifax		81.5%	
Yellowknife		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.
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 ft² (11,500 m²), 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. *Note that NRCan models corrected for erroneous configuration of not having make-up air units first, as required by DOE2.*

Item	MNECB+CBIP		ASHRAE+LEED ECB					Discussion/Issues
EXTERIOR SURFACES								
Wall Overall R-Value	Electric Heat Source	Gas/Oil Heat Source	Mass	Metal	Steel	Other	R_o	Allocation of construction types is based on professional experience in the commercial sector and is not statistically proven nor supported by market research. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada, except for the North where wood frame construction is more apparent. Larger high-rise hotels typically have lighter construction.
Vancouver	12.6	7.0	30%	0%	60%	10%	12.5	
			10.4	8.8	13.7	11.2		
Calgary	17.2	10.3	40%	0%	50%	10%	14.4	
			12.2	17.5	15.6	17.5		
Regina	21.0	11.8	40%	0%	50%	10%	15.0	
			13.3	17.5	15.6	18.6		
Toronto	17.2	10.3	30%	0%	60%	10%	13.5	
			10.7	15.4	14.7	14.5		
Montreal	17.2	17.2	30%	0%	60%	10%	13.5	
			10.7	15.4	14.7	14.5		
Halifax	21.0	11.8	40%	0%	50%	10%	13.1	
			10.7	15.4	14.7	14.5		
Yellowknife	21.0	17.2	30%	0%	50%	20%	18.4	
			14.1	17.5	20.6	19.6		
Roof Overall R-Value	Electric Heat Source	Gas/Oil 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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada.
Vancouver	13.8	12.1	15.9					
Calgary	19.6	12.1	15.9					
Regina	22.7	13.8	19.6					
Toronto	19.6	12.1	15.9					
Montreal	19.6	19.6	15.9					
Halifax	21.0	13.8	15.9					
Yellowknife	28.4	19.6	20.8					
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.

Motel/Hotel: Key Building Characteristics

GLAZING						
Glazing Percent	35%		35%			From 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 50%), 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/Oil 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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada. Input is corrected for DOE2's adjustment for air films to produce the specified overall U-value.
Vancouver	0.57	0.57	25% 0.67	75% 0.57	0.60	
Calgary	0.38	0.57	25% 0.67	75% 0.57	0.60	
Regina	0.32	0.57	25% 0.47	75% 0.46	0.46	
Toronto	0.38	0.57	25% 0.67	75% 0.57	0.60	
Montreal	0.37	0.49	25% 0.67	75% 0.57	0.60	
Halifax	0.33	0.57	25% 0.67	75% 0.57	0.60	
Yellowknife	0.22	0.38	25% 0.44	75% 0.43	0.43	
Window Shading Coefficient						ASHRAE differentiates between North-facing windows separately from all other windows.
Vancouver			0.57 (all orientations) / 0.57 (North)			
Calgary			0.57 (all orientations) / 0.74 (North)			
Regina			not required, set same as CBIP			
Toronto	0.74		0.57 (all orientations) / 0.74 (North)			
Montreal			0.57 (all orientations) / 0.74 (North)			
Halifax			0.57 (all orientations) / 0.74 (North)			
Yellowknife			not required, set same as CBIP			
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			

Motel/Hotel: Key Building Characteristics

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 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.
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	From CBIP models for Technical Guidelines; exceeds MNECB minimum defaults for hotel/motel building type.

Motel/Hotel: Key Building Characteristics

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.
Vancouver		81.5%	
Calgary		82.0%	
Regina		82.0%	
Toronto		81.5%	
Montreal		81.5%	
Halifax		81.5%	
Yellowknife		82.0%	
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	

Motel/Hotel: Key Building Characteristics

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) DX cooling with COP at 2.5	a) All <150T; DX cooling with 2.9 COP (LEED exception to ASHRAE) 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. Chiller size based on observed peak load from NRCan models, which indicated *sizing* under 150T, requiring DX cooling. DX cooling in these cases simulated with an air-cooled chiller with no chilled water pumping energy. **Refer to associated LEED-Canada 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.
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)	

Motel/Hotel: Key Building Characteristics

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 the modelling approaches.

Item	MNECB+CBIP		ASHRAE+LEED ECB					Discussion/Issues
EXTERIOR SURFACES								
Wall Overall R-Value	Electric Heat Source	Gas/Oil 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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada, except for the North where wood frame construction is more apparent. General observation is that concentrated urban areas have higher concentrations of curtain wall construction than other areas. To be conservative, all areas are considered as residential type for selection of ASHRAE characteristics.
Vancouver	12.6	7.0	25%	0%	50%	25%	13.4	
			11.1	8.8	15.6	11.2		
Calgary	17.2	10.3	30%	0%	40%	30%	15.9	
			12.5	17.5	15.6	19.6		
Regina	21.0	11.8	30%	0%	40%	30%	16.4	
			14.1	17.5	15.6	19.6		
Toronto	17.2	10.3	25%	0%	50%	25%	14.5	
			11.1	17.5	15.6	15.6		
Montreal	17.2	17.2	25%	0%	50%	25%	14.5	
			11.1	17.5	15.6	15.6		
Halifax	21.0	11.8	30%	0%	40%	30%	14.3	
			11.1	17.5	15.6	15.6		
Yellowknife	21.0	17.2	33%	0%	33%	33%	18.6	
			14.1	17.5	22.2	19.6		
Roof Overall R-Value	Electric Heat Source	Gas/Oil 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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada. In some cases, steel joist with metal decking and built-up roofing. Some cases are wood joists with plywood and build-up roofing. To be conservative, all areas are considered as residential type for selection of ASHRAE characteristics.
Vancouver	13.8	12.1	15.9					
Calgary	19.6	12.1	15.9					
Regina	22.7	13.8	20.8					
Toronto	19.6	12.1	15.9					
Montreal	19.6	19.6	15.9					
Halifax	21.0	13.8	15.9					
Yellowknife	28.4	19.6	20.8					

MURB: Key Building Characteristics

Exposed Floor R-Value	Electric Heat Source	Gas/Oil Heat Source	Mass	Steel	Other		R_o
Vancouver	16.8	15.5	75%	0%	25%		16.2
			11.5	26.3	30.3		
Calgary	21.1	15.5	75%	0%	25%		19.3
			15.6	26.3	30.3		
Regina	24.1	16.8	75%	0%	25%		19.3
			15.6	31.3	30.3		
Toronto	21.1	15.5	75%	0%	25%		17.7
			13.5	26.3	30.3		
Montreal	21.1	21.1	75%	0%	25%		17.7
			13.5	26.3	30.3		
Halifax	22.9	16.8	75%	0%	25%		17.7
			13.5	26.3	30.3		
Yellowknife	34.5	22.1	60%	0%	40%		23.9
			19.6	31.3	30.3		

Allocation of construction types is based on professional experience in the commercial sector and is not statistically proven nor supported by market research. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada, with more wood construction in the North. 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.

To be conservative, all areas are considered as residential type for selection of ASHRAE characteristics.

GLAZING

Glazing Percent	Electric Heat Source	Gas/Oil Heat Source
	40% except Yellowknife at 30%	45% except Yellowknife at 30%

From a BC Hydro MURB study on construction in the 90s, average for new high-rises at about 50%, but low-rise lower based on City of Vancouver feedback. Trend across Canada supported based on feedback from NRCan representatives and MURB charrettes.

Window U-value	Electric Heat Source	Gas/Oil Heat Source	Oper-able	Fixed	U_o
Vancouver	0.57	0.57	35%	65%	0.46
			0.47	0.46	
Calgary	0.38	0.57	35%	65%	0.46
			0.47	0.46	
Regina	0.32	0.57	35%	65%	0.36
			0.39	0.35	
Toronto	0.38	0.57	35%	65%	0.46
			0.47	0.46	
Montreal	0.37	0.49	35%	65%	0.46
			0.47	0.46	
Halifax	0.33	0.57	35%	65%	0.46
			0.47	0.46	
Yellowknife	0.22	0.38	35%	65%	0.43
			0.44	0.43	

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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada.

Input is corrected for DOE2's adjustment for air films to produce the specified overall U-value.

MURB: Key Building Characteristics

Window Shading Coefficient			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.
Vancouver	0.74	0.42 (all orientations) / 0.57 (North)	
Calgary		0.42 (all orientations) / 0.74 (North)	
Regina		not required, set same as CBIP	
Toronto		0.42 (all orientations) / 0.74 (North)	
Montreal		0.42 (all orientations) / 0.74 (North)	
Halifax		0.42 (all orientations) / 0.74 (North)	
Yellowknife		not required, set same as CBIP	
SPACE CONDITIONS			
Schedules	MNECB Schedule A	Same as MNECB+CBIP	Schedules already established from founding efforts for NRCan's CBIP Technical Guidelines
Lighting	0.84 W/ft²	1.0 W/ft²	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.
Equipment density	0.46 W/ft²	0.46 W/ft²	
HVAC SYSTEM TYPE			
Air Handling	1) FPFC 2) PTAC with baseboards serving suites with common areas served by PSZ 3) PTAC serving suites with common areas served by PSZ	*a) FPFC (System 7) - N/A since LEED provision for an air condensing cooling source at <150T would equate to type c below* 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)	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.
Principle Heating Fuel Type	1) Gas (R01g??1) 2) Gas (R01g??3) 3) Electric (R01e??3a)	b) Gas for System 6 (R01g??2B) a) & 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	Air	Note that method of cooling is not as important as the relative differences in the cooling efficiencies.

MURB: Key Building Characteristics

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	From CBIP models for Technical Guidelines; exceeds MNECB minimum defaults for building type.
Heat Reclaim	N/A	50% effectiveness applied to 10% of outdoor air (<u>5% overall</u>)	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 survey data, a MURB would have to be > 65,000 sf to warrant heat reclaim. From BC Hydro data, ~70% of the building stock met this condition. However, it is rare that the largest exhaust source would exceed 75% of ventilation delivery (6.3.6.1.(h)) and cooling is not always present; estimate only 10% of new buildings would be applicable.
HVAC CONTROL			
Heating and Cooling Setpoints	Occupied: 71.6°/75.2°; Setback: 64.4°/99°	Same as MNECB+CBIP	
Economizer	N/A	N/A	
HEATING PLANT			
Central Heating Efficiency	One 80% efficient boiler; no HW reset	80% efficient boiler(s), plus 1.5% - 2.0% pts. for reset, as indicated below. Gas furnace 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.
Vancouver		81.5%	
Calgary		82.0%	
Regina		82.0%	
Toronto		81.5%	
Montreal		81.5%	
Halifax		81.5%	
Yellowknife		82.0%	
Hot Water Temperature	30°F drop; 140°F supply	50°F drop; 180°F supply	

MURB: Key Building Characteristics

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), 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 150 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.
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 30' 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	b) 12 EER for distributed HP system a), 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.

MURB: Key Building Characteristics

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/Oil Heat Source	Mass	Metal	Steel	Other	R_o	Allocation of construction types is based on professional experience in the commercial sector and is not statistically proven nor supported by market research. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada, except for the North where wood frame construction is more apparent.
Vancouver	12.6	7.0	50%	0%	30%	20%	8.7	
			8.1	8.8	8.1	11.2		
Calgary	17.2	10.3	50%	0%	30%	20%	12.5	
			11.1	17.5	15.6	11.2		
Regina	21.0	11.8	50%	0%	30%	20%	13.4	
			11.1	17.5	15.6	15.6		
Toronto	17.2	10.3	50%	0%	30%	20%	10.6	
			9.6	8.8	11.9	11.2		
Montreal	17.2	17.2	50%	0%	30%	20%	10.6	
			9.6	8.8	11.9	11.2		
Halifax	21.0	11.8	50%	0%	30%	20%	10.6	
			9.6	8.8	11.9	11.2		
Yellowknife	21.0	17.2	33%	0%	33%	33%	16.4	
			14.1	17.5	15.6	19.6		
Roof Overall R-Value	Electric Heat Source	Gas/Oil 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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada
Vancouver	13.8	12.1	15.9					
Calgary	19.6	12.1	15.9					
Regina	22.7	13.8	15.9					
Toronto	19.6	12.1	15.9					
Montreal	19.6	19.6	15.9					
Halifax	21.0	13.8	15.9					
Yellowknife	28.4	19.6	20.8					
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.

Strip Mall: Key Building Characteristics

	Electric Heat Source	Gas/Oil Heat Source	Oper-able	Fixed	U_o	Notes
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/Oil 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.
Vancouver	0.56	0.56	0% 0.67	100% 0.57	0.57	
Calgary	0.37	0.56	0% 0.67	100% 0.57	0.57	
Regina	0.32	0.56	0% 0.47	100% 0.46	0.46	
Toronto	0.37	0.56	0% 0.67	100% 0.57	0.57	
Montreal	0.37	0.49	0% 0.67	100% 0.57	0.57	
Halifax	0.32	0.56	0% 0.67	100% 0.57	0.57	
Yellowknife	0.21	0.37	0% 0.44	100% 0.43	0.43	
Window Shading Coefficient						ASHRAE differentiates between North-facing windows separately from all other windows.
Vancouver	0.74		0.57 (all orientations)			
Calgary	0.74		0.57 (all orientations) / 0.74 (North)			
Regina	0.74		not required, set same as CBIP			
Toronto	0.74		0.57 (all orientations) / 0.74 (North)			
Montreal	0.74		0.57 (all orientations) / 0.74 (North)			
Halifax	0.74		0.57 (all orientations) / 0.74 (North)			
Yellowknife	0.74		not required, set same as CBIP			
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			

Strip Mall: Key Building Characteristics

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	0.25 cfm/ft²	Same as MNECB+CBIP	Based on ASHRAE 62-1999 "simple system requirements" for retail "sales floor," which is fairly indicative for a representative mix of street and storage retail space requirements.
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 applied to half of building, except N/A for Montreal	Economizers for ASHRAE would not apply to small stores, particularly in Montreal because of higher ASHRAE requirement.
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.

Strip Mall: Key Building Characteristics

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/Oil Heat Source	Mass	Metal	Steel	Other	R_o	Allocation of construction types is based on professional experience in the commercial sector and is not statistically proven nor supported by market research. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada.
Vancouver	12.6	7.0	70%	0%	25%	5%	8.3	
			8.1	8.8	8.1	11.2		
Calgary	17.2	10.3	70%	0%	25%	5%	12.2	
			11.1	17.5	15.6	11.2		
Regina	21.0	11.8	70%	0%	25%	5%	12.5	
			11.1	17.5	15.6	15.6		
Toronto	17.2	10.3	70%	0%	25%	5%	10.3	
			9.6	8.8	11.9	11.2		
Montreal	17.2	17.2	70%	0%	25%	5%	10.3	
			9.6	8.8	11.9	11.2		
Halifax	21.0	11.8	70%	0%	25%	5%	10.3	
			9.6	8.8	11.9	11.2		
Yellowknife	21.0	17.2	70%	0%	25%	5%	14.7	
			14.1	17.5	15.6	19.6		
Roof Overall R-Value	Electric Heat Source	Gas/Oil 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. NRCan representatives and other design professionals have indicated that construction characteristics are fairly similar across Canada
Vancouver	13.8	12.1	15.9					
Calgary	19.6	12.1	15.9					
Regina	22.7	13.8	15.9					
Toronto	19.6	12.1	15.9					
Montreal	19.6	19.6	15.9					
Halifax	21.0	13.8	15.9					
Yellowknife	28.4	19.6	20.8					
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.

Big Box Retail: Key Building Characteristics

GLAZING						
Glazing Percent	10%		10%			Average specified in NRCan archetypes and appears reasonable based on our experience.
Window U-value	Electric Heat Source	Gas/Oil 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.
Vancouver	0.56	0.56	0% 0.67	100% 0.57	0.57	
Calgary	0.37	0.56	0% 0.67	100% 0.57	0.57	
Regina	0.32	0.56	0% 0.47	100% 0.46	0.46	
Toronto	0.37	0.56	0% 0.67	100% 0.57	0.57	
Montreal	0.37	0.49	0% 0.67	100% 0.57	0.57	
Halifax	0.32	0.56	0% 0.67	100% 0.57	0.57	
Yellowknife	0.21	0.37	0% 0.44	100% 0.43	0.43	
Window Shading Coefficient						ASHRAE differentiates between North-facing windows separately from all other windows.
Vancouver			0.57 (all orientations)			
Calgary			0.57 (all orientations) / 0.74 (North)			
Regina			not required, set same as CBIP			
Toronto	0.74		0.57 (all orientations) / 0.74 (North)			
Montreal			0.57 (all orientations) / 0.74 (North)			
Halifax			0.57 (all orientations) / 0.74 (North)			
Yellowknife			not required, set same as CBIP			
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			

Big Box Retail: Key Building Characteristics

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	0.25 cfm/ft²	Same as MNECB+CBIP	Based on ASHRAE 62-1999 "simple system requirements" for retail "sales floor," which is fairly indicative for a representative mix of street and storage retail space requirements.
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	ASHRAE economizer may not apply for cases with several smaller package units, particularly for Montreal; however, apply economizer to be conservative.
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.

Big Box Retail: Key Building Characteristics

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

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

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 show the relative performance differences when using energy consumption instead of energy rates as the basis for establishing equivalency. They demonstrate how the different bases for comparison (i.e., ECB vs. energy use) vary between each other.

- Table 2 provides a regional comparison of the ASHRAE+LEED ECB average versus the corresponding MNECB+CBIP references. Normalized energy use and cost is shown, with comparative percent differences.

- Figure 2 compares the Budget and Reference cases' energy use for the indicated building type across Canada for the seven identified regional cities.

- Finally, Figure 3 shows the results from applying average blended energy rates to the energy use to determine the regional energy costs.

RESULTS FOR SMALL OFFICE

Table 1. LEED-Canada Equivalency Table of Energy Credits: Applied to the Small Office Segment

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-Canada Savings Bins		LEED-Canada vs LEED-GBC		ECB vs Energy Basis Diff.
	$/ft²	kBtu/ft²	ECB	Energy	ECB	Energy	
0%	*1.14*	*56.7*	*14.0%*	*8.7%*	*14.0% pt*	*8.7% pt*	*5.3% pt*
20%	0.91	45.3	31.2%	27.0%	11.2% pt	7.0% pt	4.2% pt
30%	0.80	39.7	39.8%	36.1%	9.8% pt	6.1% pt	3.7% pt
40%	0.68	34.0	48.4%	45.2%	8.4% pt	5.2% pt	3.2% pt
50%	0.57	28.3	57.0%	54.4%	7.0% pt	4.4% pt	2.6% pt
60%	0.45	22.7	65.6%	63.5%	5.6% pt	3.5% pt	2.1% pt

Figure 1. Equivalency for LEED-Canada Versus US-GBC LEED

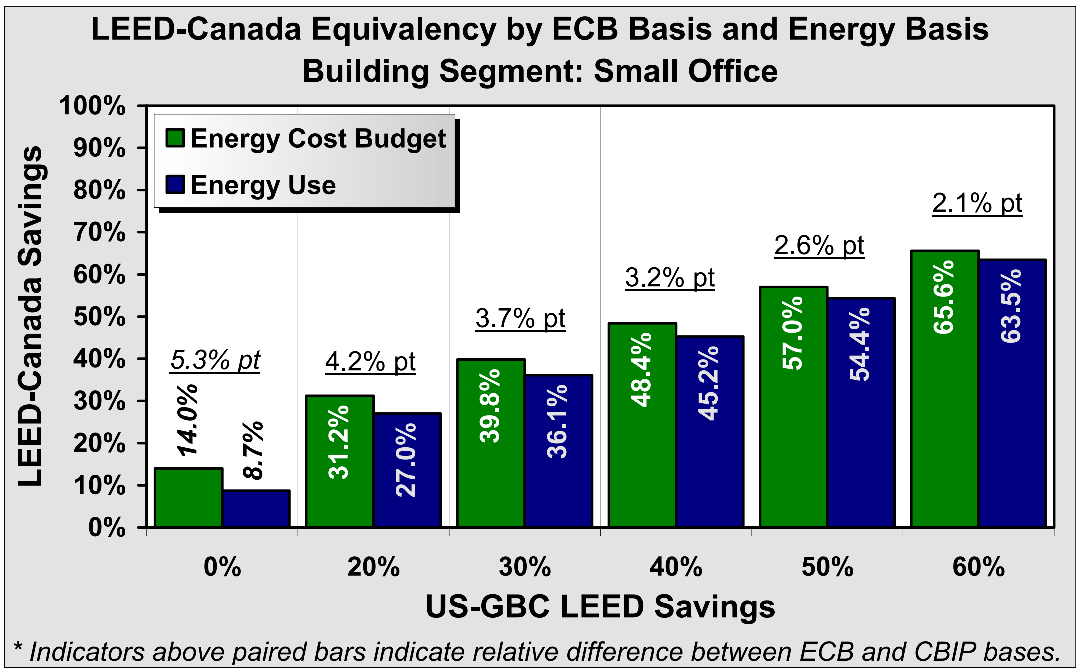


Table 2. Comparison of MNECB+CBIP Reference Versus ASHRAE+LEED ECB Cases: Applied to Small Offices

Region	Energy (kBtu/ft²)			Energy Cost ($/ft²)		
	CBIP	ASHRAE	Diff.	CBIP	ASHRAE	Diff.
Average	*62.1*	*56.7*	*8.7%*	*$1.32*	*$1.14*	***14.0%***
Vancouver	49.9	45.1	9.6%	$0.73	$0.65	**12.0%**
Calgary	70.1	60.9	13.2%	$1.01	$0.82	**18.3%**
Regina	79.2	65.8	16.9%	$1.28	$1.04	**18.7%**
Toronto	66.2	57.8	12.8%	$1.57	$1.27	**19.1%**
Montreal	61.1	60.7	0.6%	$1.37	$1.29	**6.3%**
Halifax	54.5	51.2	6.1%	$1.68	$1.54	**8.4%**
Yellowknife	82.1	74.6	9.2%	$2.86	$2.36	**17.7%**

Figure 2. Regional Reference Energy Use

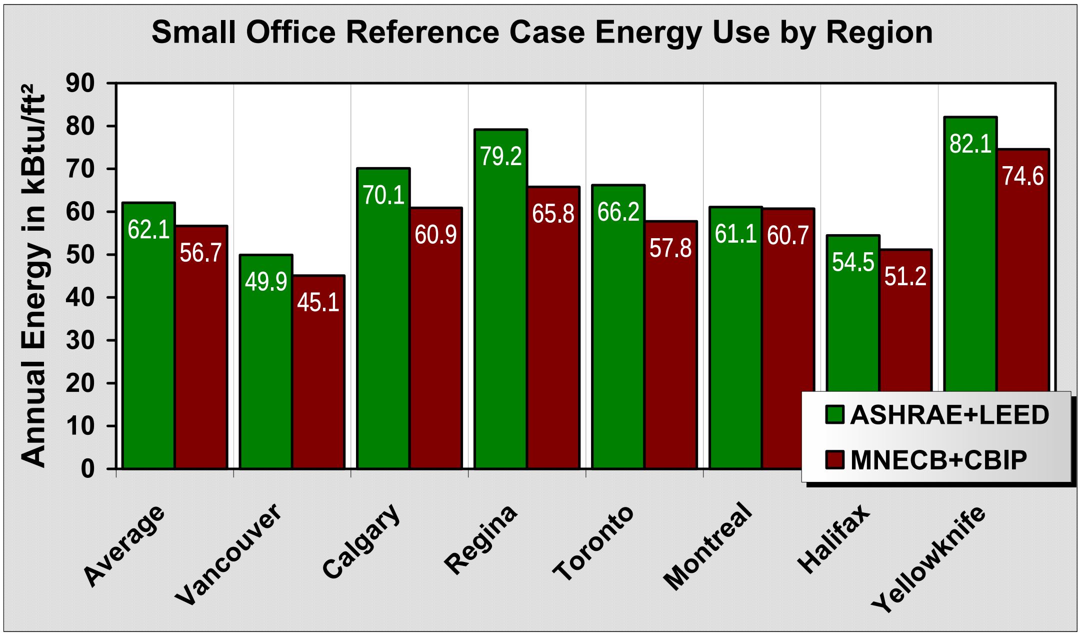
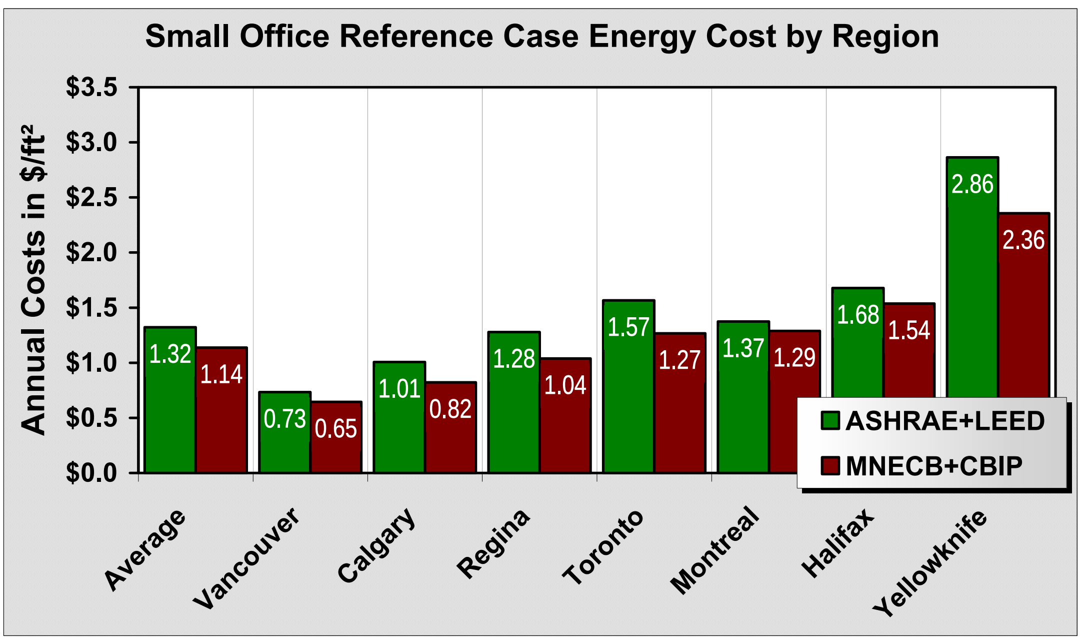


Figure 3. Regional Energy Costs



RESULTS FOR LARGE OFFICE

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

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-Canada Savings Bins		LEED-Canada vs LEED-GBC		ECB vs Energy Basis Diff.
	$/ft²	kBtu/ft²	ECB	Energy	ECB	Energy	
0%	*0.97*	*51.5*	*18.4%*	*15.2%*	*18.4% pt*	*15.2% pt*	*3.2% pt*
20%	0.77	41.2	34.7%	32.2%	14.7% pt	12.2% pt	2.5% pt
30%	0.68	36.0	42.9%	40.6%	12.9% pt	10.6% pt	2.2% pt
40%	0.58	30.9	51.0%	49.1%	11.0% pt	9.1% pt	1.9% pt
50%	0.48	25.7	59.2%	57.6%	9.2% pt	7.6% pt	1.6% pt
60%	0.39	20.6	67.4%	66.1%	7.4% pt	6.1% pt	1.3% pt

Figure 1. Equivalency for LEED-Canada Versus US-GBC LEED

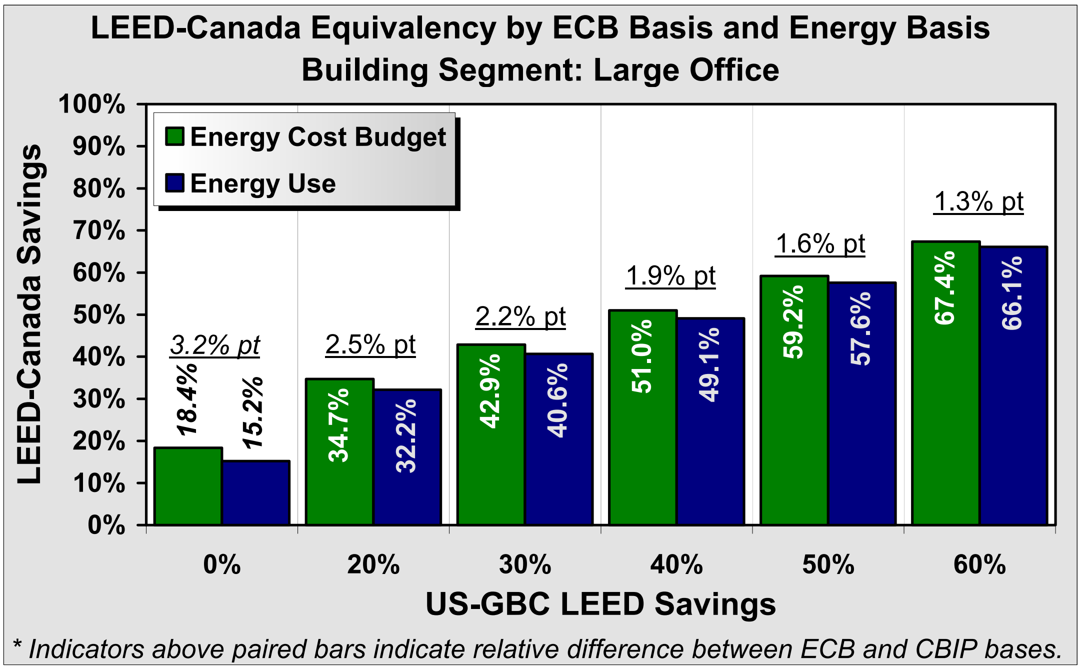


Table 2. Comparison of MNECB+CBIP Reference Versus ASHRAE+LEED ECB Cases: Applied to Large Offices

Region	Energy (kBtu/ft²)			Energy Cost ($/ft²)		
	CBIP	ASHRAE	Diff.	CBIP	ASHRAE	Diff.
Average	*60.7*	*51.5*	*15.2%*	*$1.18*	*$0.97*	***18.4%***
Vancouver	48.3	40.6	15.8%	$0.69	$0.59	**14.8%**
Calgary	68.1	53.5	21.4%	$0.97	$0.73	**24.4%**
Regina	76.2	55.5	27.2%	$1.27	$0.95	**25.3%**
Toronto	64.4	51.8	19.5%	$1.34	$1.04	**22.7%**
Montreal	60.4	56.7	6.0%	$1.25	$1.10	**11.9%**
Halifax	55.9	48.2	13.7%	$1.66	$1.41	**15.2%**
Yellowknife	85.8	76.4	10.9%	$3.01	$2.40	**20.3%**

Figure 2. Regional Reference Energy Use

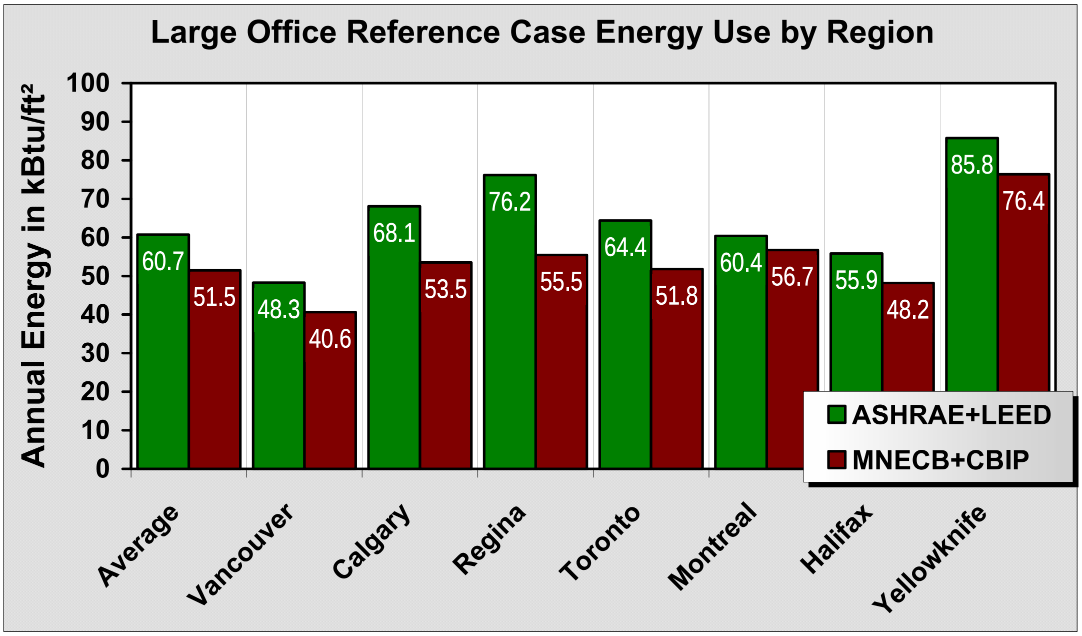
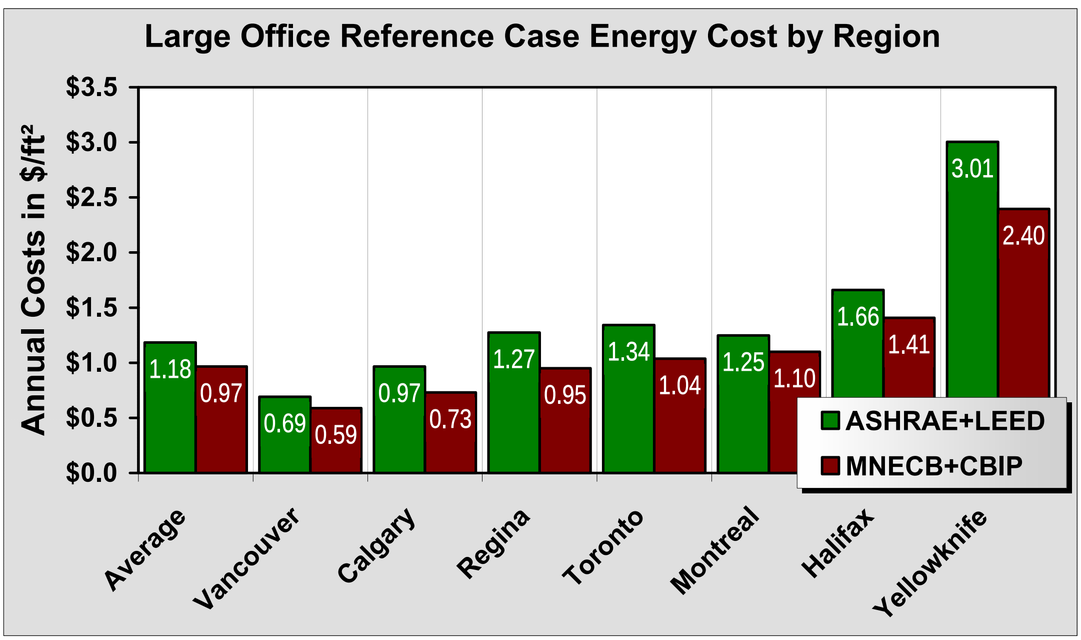


Figure 3. Regional Energy Costs



RESULTS FOR SCHOOLS

Table 1. LEED-Canada Equivalency Table of Energy Credits: Applied to the School Segment

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-Canada Savings Bins		LEED-Canada vs LEED-GBC		ECB vs Energy Basis Diff.
	$/ft²	kBtu/ft²	ECB	Energy	ECB	Energy	
0%	*1.48*	*98.7*	*12.6%*	*9.1%*	*12.6% pt*	*9.1% pt*	*3.5% pt*
20%	1.18	79.0	30.1%	27.3%	10.1% pt	7.3% pt	2.8% pt
30%	1.03	69.1	38.8%	36.4%	8.8% pt	6.4% pt	2.4% pt
40%	0.89	59.2	47.6%	45.5%	7.6% pt	5.5% pt	2.1% pt
50%	0.74	49.3	56.3%	54.6%	6.3% pt	4.6% pt	1.7% pt
60%	0.59	39.5	65.0%	63.7%	5.0% pt	3.7% pt	1.4% pt

Figure 1. Equivalency for LEED-Canada Versus US-GBC LEED

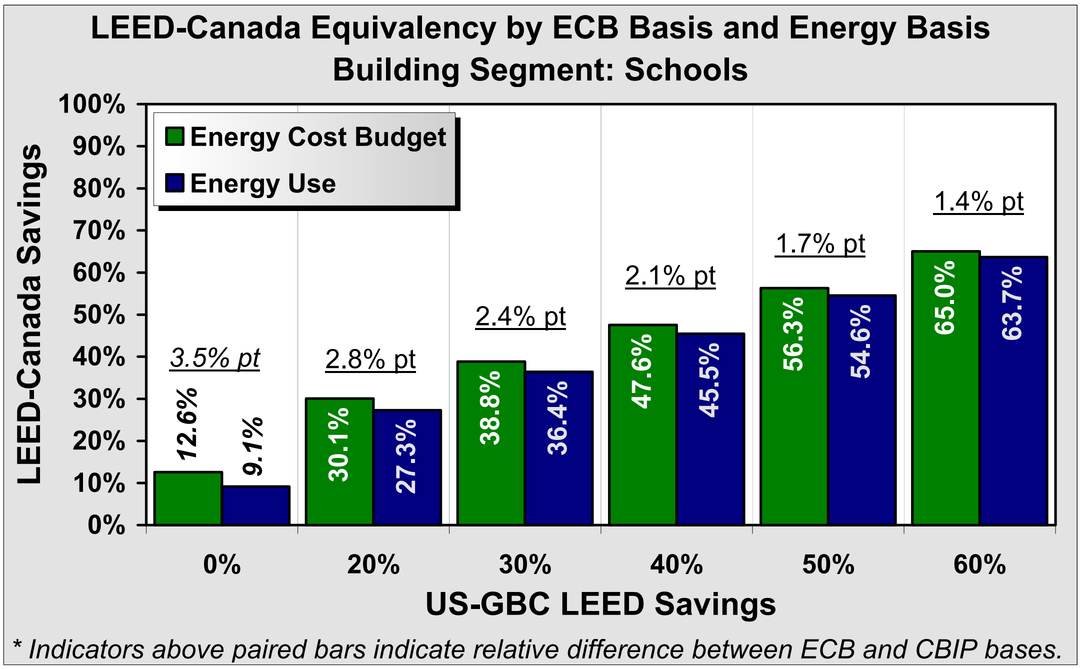


Table 2. Comparison of MNECB+CBIP Reference Versus ASHRAE+LEED ECB Cases: Applied to Schools

Region	Energy (kBtu/ft²)			Energy Cost ($/ft²)		
	CBIP	ASHRAE	Diff.	CBIP	ASHRAE	Diff.
Average	*108.6*	*98.7*	*9.1%*	*$1.69*	*$1.48*	***12.6%***
Vancouver	82.3	72.1	12.5%	$1.02	$0.88	**13.9%**
Calgary	119.2	105.2	11.7%	$1.55	$1.30	**16.1%**
Regina	136.3	120.4	11.7%	$1.82	$1.54	**15.5%**
Toronto	111.7	99.6	10.8%	$1.88	$1.59	**15.2%**
Montreal	115.5	110.0	4.8%	$1.76	$1.62	**7.8%**
Halifax	101.7	94.2	7.4%	$2.46	$2.24	**9.2%**
Yellowknife	173.9	160.0	8.0%	$4.68	$4.01	**14.4%**

Figure 2. Regional Reference Energy Use

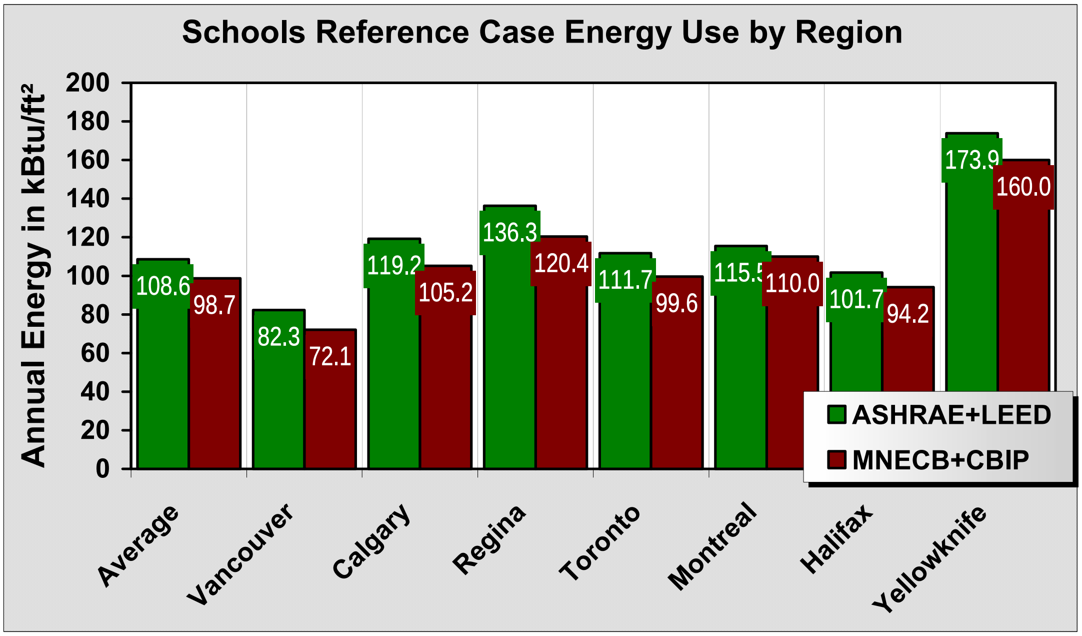
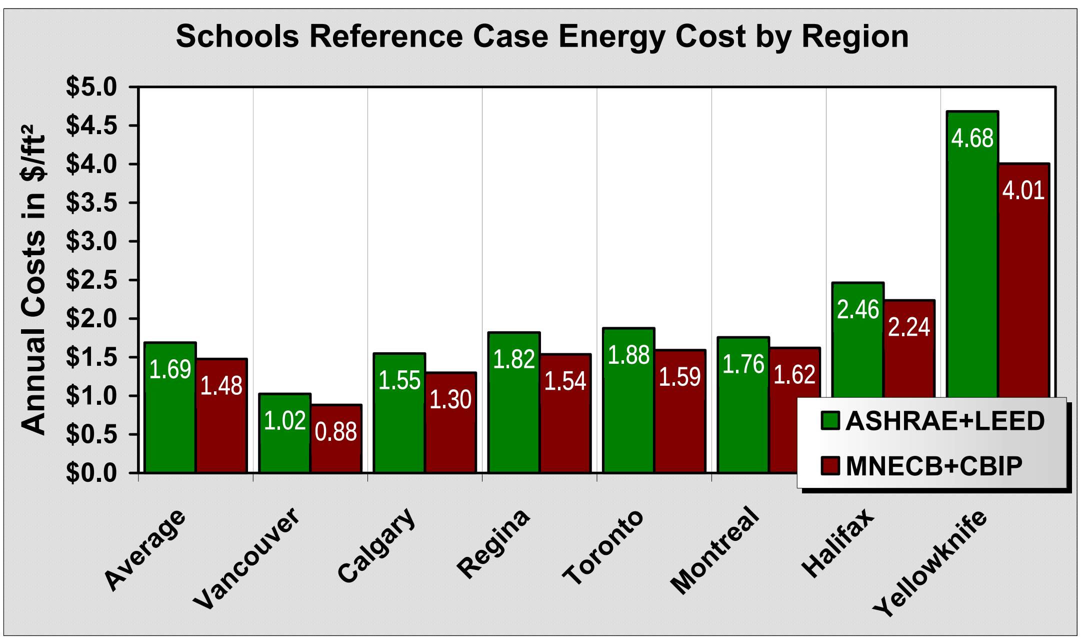


Figure 3. Regional Energy Costs



RESULTS FOR EXTENDED CARE

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

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-Canada Savings Bins		LEED-Canada vs LEED-GBC		ECB vs Energy Basis Diff.
	$/ft²	kBtu/ft²	ECB	Energy	ECB	Energy	
0%	*1.69*	*113.1*	*20.0%*	*21.7%*	*20.0% pt*	*21.7% pt*	*-1.7% pt*
20%	1.35	90.5	36.0%	37.4%	16.0% pt	17.4% pt	-1.4% pt
30%	1.18	79.2	44.0%	45.2%	14.0% pt	15.2% pt	-1.2% pt
40%	1.02	67.9	52.0%	53.0%	12.0% pt	13.0% pt	-1.0% pt
50%	0.85	56.5	60.0%	60.9%	10.0% pt	10.9% pt	-0.9% pt
60%	0.68	45.2	68.0%	68.7%	8.0% pt	8.7% pt	-0.7% pt

Figure 1. Equivalency for LEED-Canada Versus US-GBC LEED

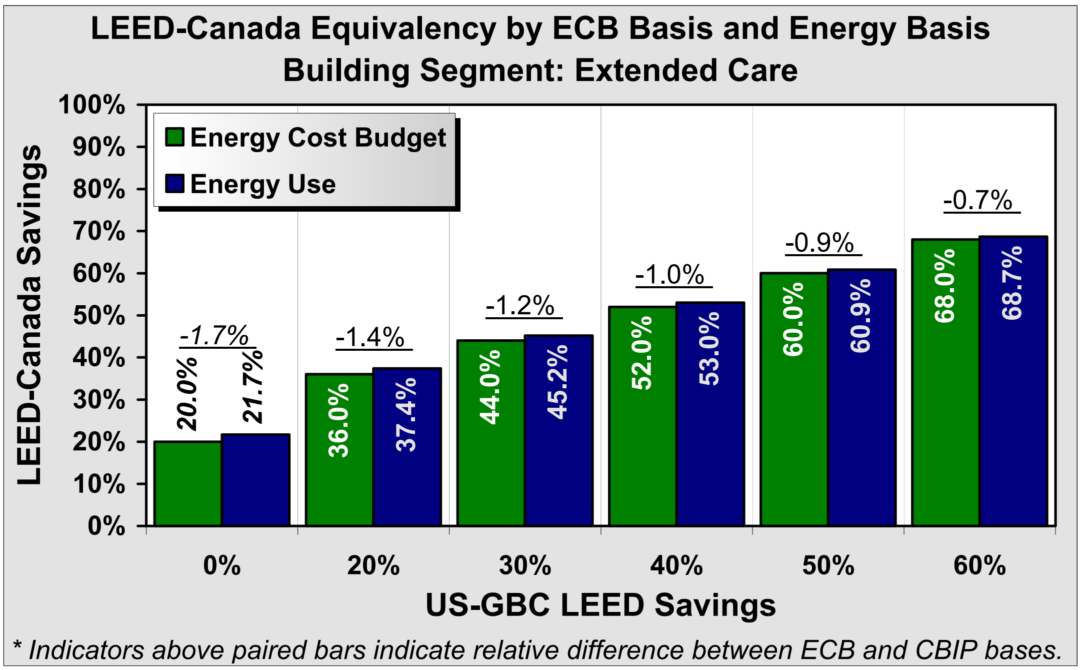


Table 2. Comparison of MNECB+CBIP Reference Versus ASHRAE+LEED ECB Cases: Applied to Extended Care

Region	Energy (kBtu/ft²)			Energy Cost ($/ft²)		
	CBIP	ASHRAE	Diff.	CBIP	ASHRAE	Diff.
Average	*144.5*	*113.1*	*21.7%*	*$2.12*	*$1.69*	***20.0%***
Vancouver	112.8	88.0	22.0%	$1.33	$1.06	**20.5%**
Calgary	161.9	119.7	26.0%	$1.93	$1.47	**23.9%**
Regina	183.4	129.6	29.3%	$2.24	$1.64	**26.7%**
Toronto	147.6	114.6	22.4%	$2.27	$1.80	**20.7%**
Montreal	151.9	123.0	19.0%	$2.28	$1.87	**17.7%**
Halifax	136.5	108.5	20.5%	$3.13	$2.54	**18.9%**
Yellowknife	248.7	180.2	27.5%	$6.01	$4.56	**24.2%**

Figure 2. Regional Reference Energy Use

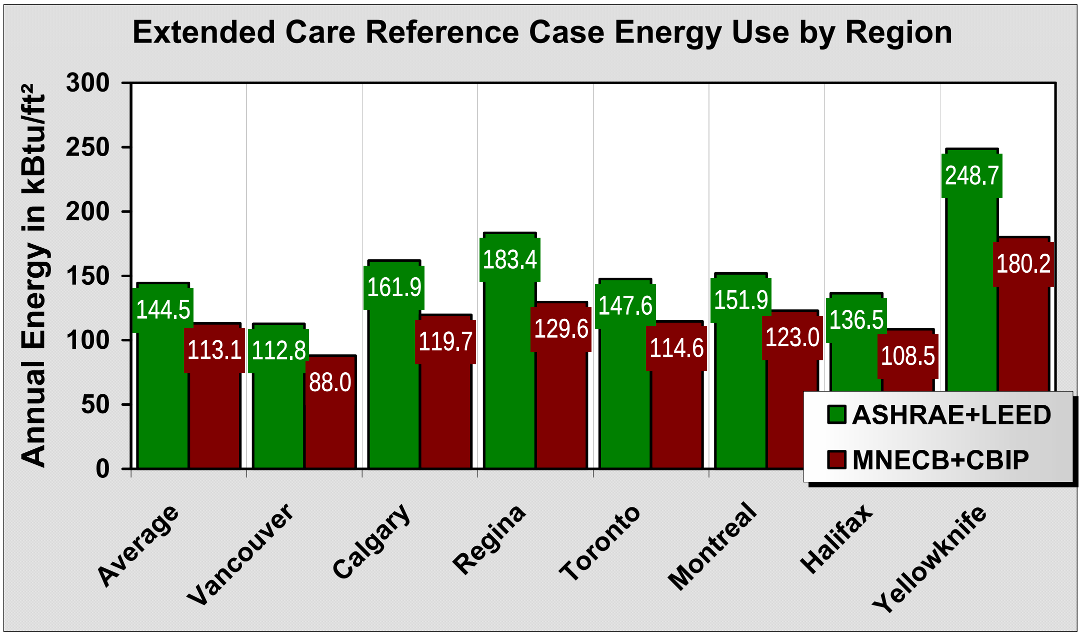
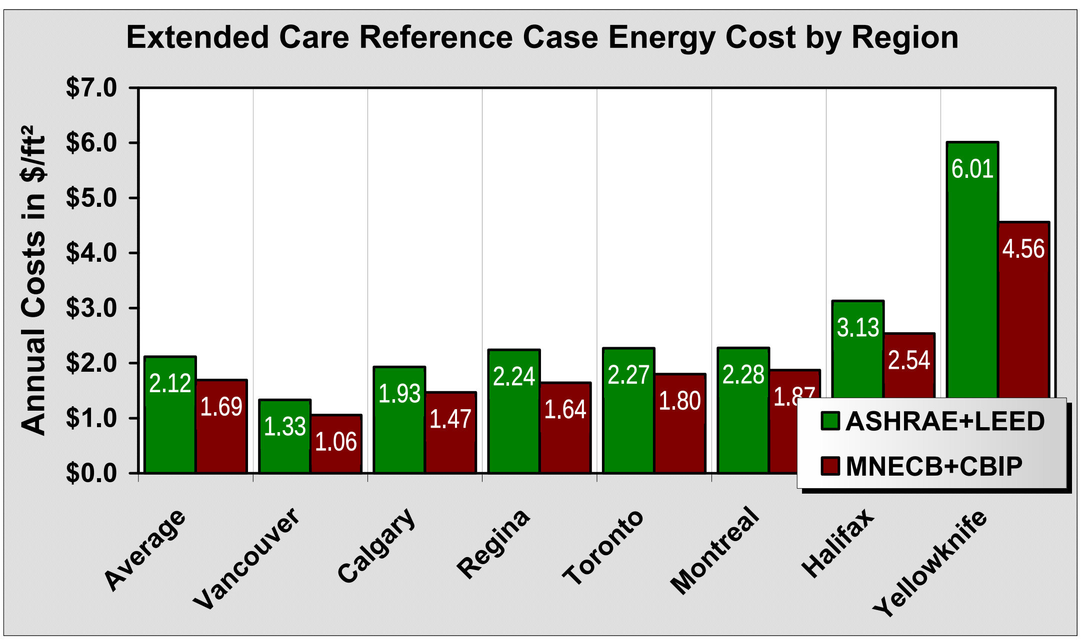


Figure 3. Regional Energy Costs

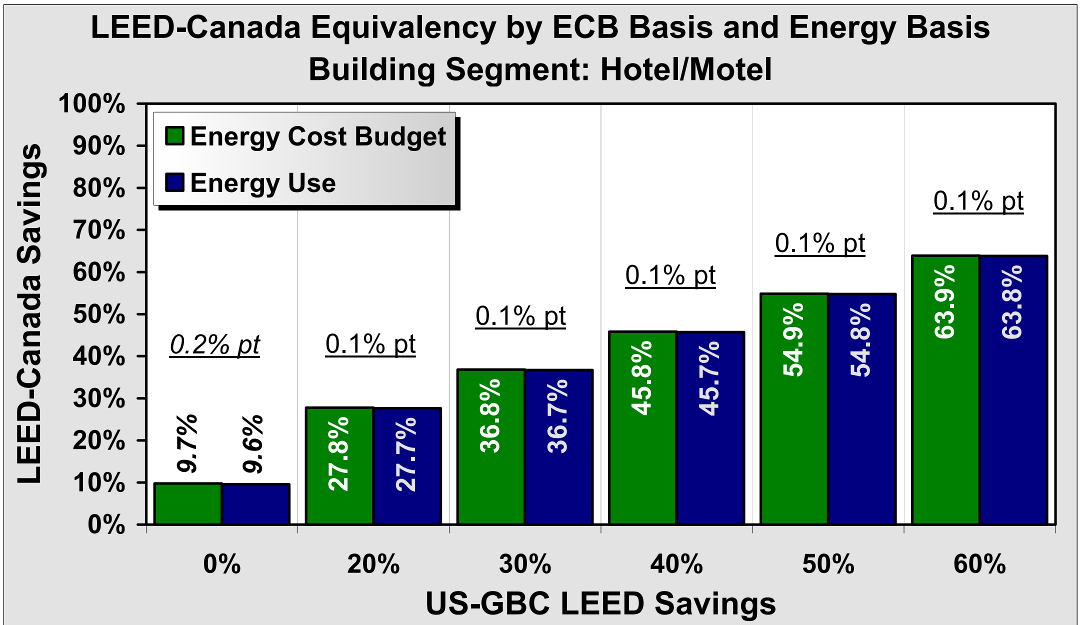


RESULTS FOR HOTEL/MOTEL

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

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-Canada Savings Bins		LEED-Canada vs LEED-GBC		ECB vs Energy Basis Diff.
	$/ft²	kBtu/ft²	ECB	Energy	ECB	Energy	
0%	*1.60*	*94.7*	*9.7%*	*9.6%*	*9.7% pt*	*9.6% pt*	*0.2% pt*
20%	1.28	75.7	27.8%	27.7%	7.8% pt	7.7% pt	0.1% pt
30%	1.12	66.3	36.8%	36.7%	6.8% pt	6.7% pt	0.1% pt
40%	0.96	56.8	45.8%	45.7%	5.8% pt	5.7% pt	0.1% pt
50%	0.80	47.3	54.9%	54.8%	4.9% pt	4.8% pt	0.1% pt
60%	0.64	37.9	63.9%	63.8%	3.9% pt	3.8% pt	0.1% pt

Figure 1. Equivalency for LEED-Canada Versus US-GBC LEED



** Indicators above paired bars indicate relative difference between ECB and CBIP bases.*

Table 2. Comparison of MNECB+CBIP Reference Versus ASHRAE+LEED ECB Cases: Applied to Hotel/Motel

Region	Energy (kBtu/ft²)			Energy Cost ($/ft²)		
	CBIP	ASHRAE	Diff.	CBIP	ASHRAE	Diff.
Average	*104.7*	*94.7*	*9.6%*	*$1.78*	*$1.60*	***9.7%***
Vancouver	90.6	79.9	11.8%	$1.14	$1.00	**11.9%**
Calgary	115.5	99.0	14.3%	$1.76	$1.50	**15.0%**
Regina	129.1	105.6	18.2%	$1.93	$1.62	**16.2%**
Toronto	109.0	96.6	11.4%	$2.01	$1.78	**11.6%**
Montreal	103.4	99.3	4.0%	$1.73	$1.65	**4.6%**
Halifax	94.9	88.8	6.4%	$2.40	$2.24	**6.4%**
Yellowknife	144.2	125.3	13.1%	$5.63	$4.89	**13.1%**

Figure 2. Regional Reference Energy Use

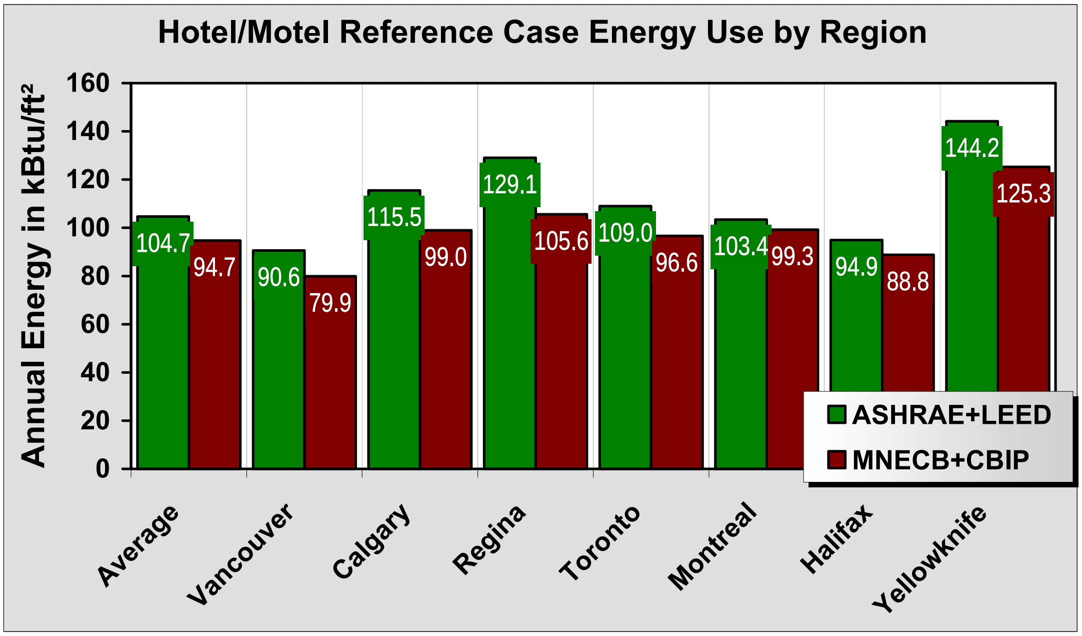
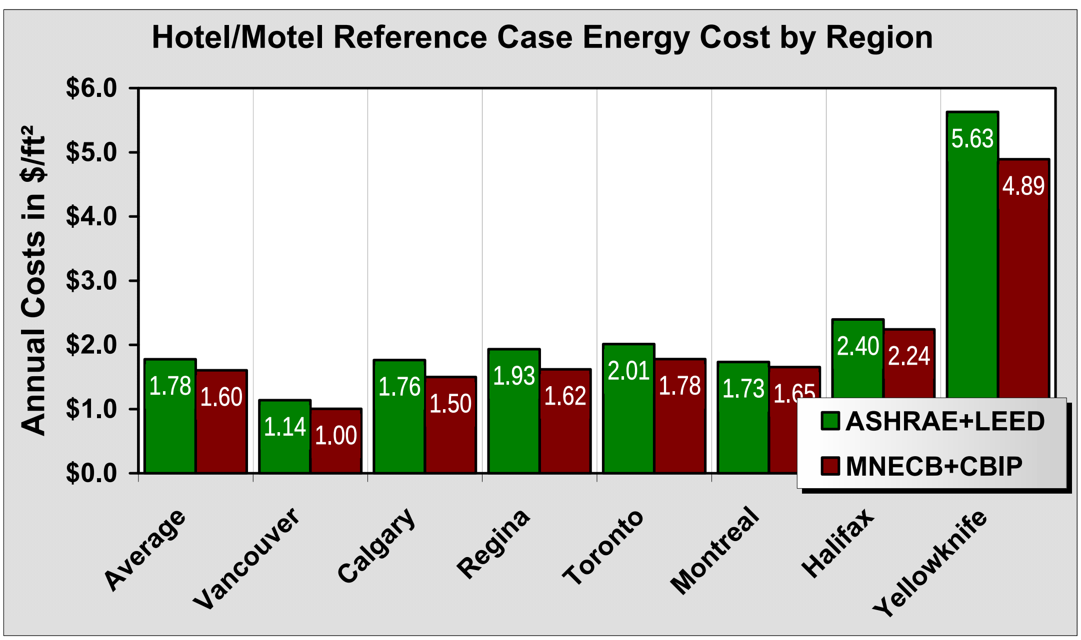


Figure 3. Regional Energy Costs

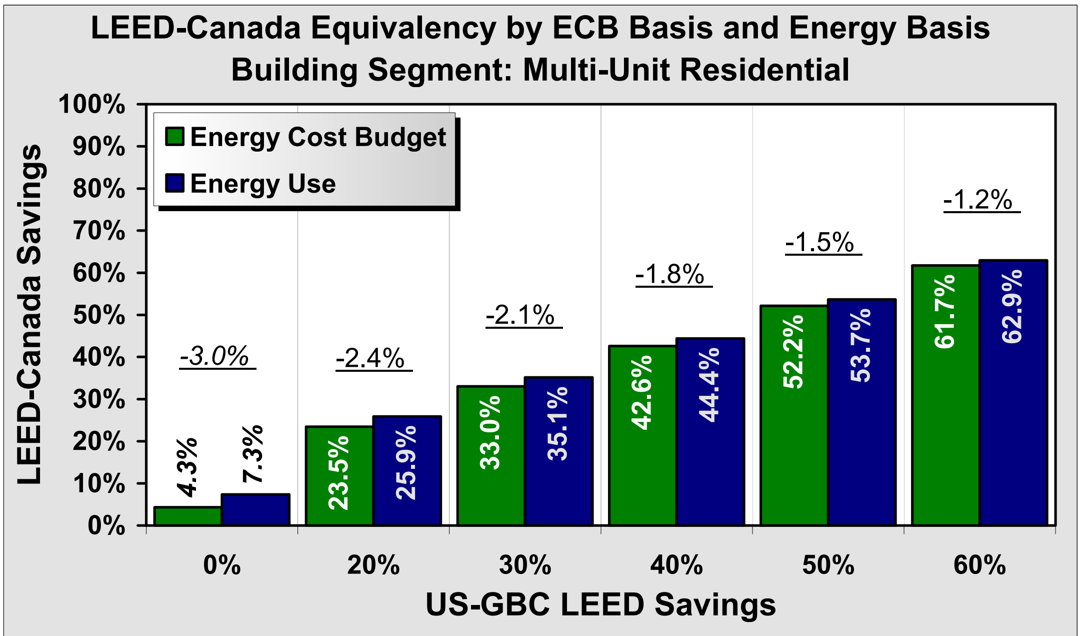


RESULTS FOR MULTI-UNIT RESIDENTIAL

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

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-Canada Savings Bins		LEED-Canada vs LEED-GBC		ECB vs Energy Basis Diff.
	$/ft²	kBtu/ft²	ECB	Energy	ECB	Energy	
0%	*0.69*	*44.1*	*4.3%*	*7.3%*	*4.3% pt*	*7.3% pt*	*-3.0% pt*
20%	0.55	35.3	23.5%	25.9%	3.5% pt	5.9% pt	-2.4% pt
30%	0.48	30.9	33.0%	35.1%	3.0% pt	5.1% pt	-2.1% pt
40%	0.41	26.5	42.6%	44.4%	2.6% pt	4.4% pt	-1.8% pt
50%	0.34	22.0	52.2%	53.7%	2.2% pt	3.7% pt	-1.5% pt
60%	0.28	17.6	61.7%	62.9%	1.7% pt	2.9% pt	-1.2% pt

Figure 1. Equivalency for LEED-Canada Versus US-GBC LEED



** Indicators above paired bars indicate relative difference between ECB and CBIP bases.*

Table 2. Comparison of MNECB+CBIP Reference Versus ASHRAE+LEED ECB Cases: Applied to Multi-Unit Residential

Region	Energy (kBtu/ft²)			Energy Cost ($/ft²)		
	CBIP	ASHRAE	Diff.	CBIP	ASHRAE	Diff.
Average	*47.6*	*44.1*	*7.3%*	*$0.72*	*$0.69*	***4.3%***
Vancouver	37.6	33.1	11.9%	$0.54	$0.49	**8.9%**
Calgary	55.0	48.5	11.9%	$0.71	$0.66	**7.8%**
Regina	65.7	41.9	36.2%	$0.88	$0.68	**22.6%**
Toronto	52.9	47.8	9.6%	$0.82	$0.77	**6.2%**
Montreal	44.0	44.8	-1.9%	$0.66	$0.67	**-2.5%**
Halifax	37.8	38.0	-0.5%	$0.85	$0.86	**-1.9%**
Yellowknife	60.9	58.4	4.0%	$1.60	$1.64	**-2.2%**

Figure 2. Regional Reference Energy Use

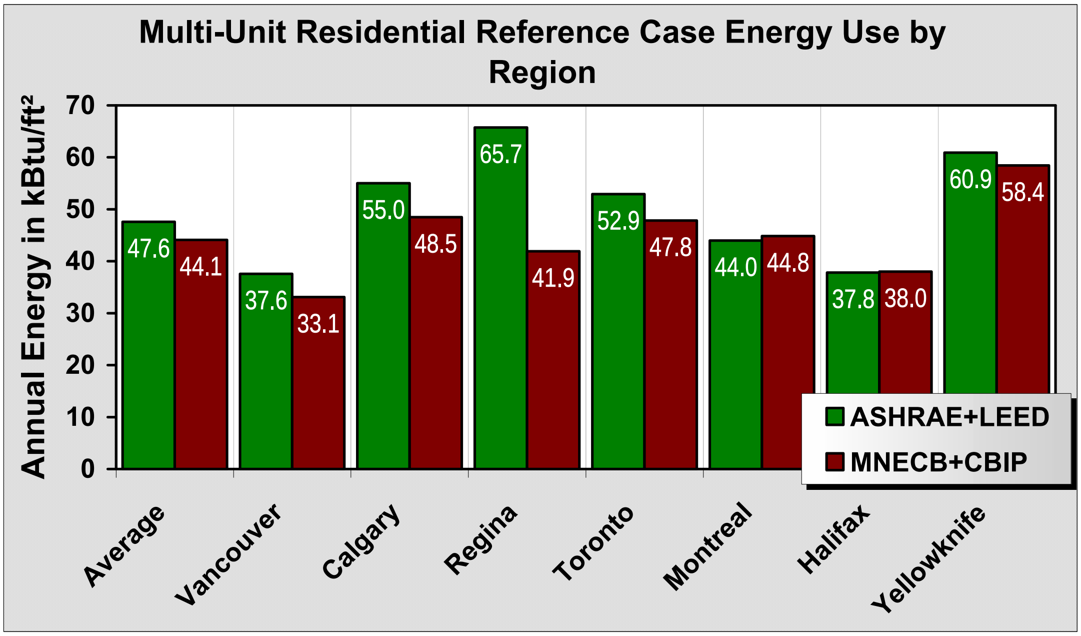
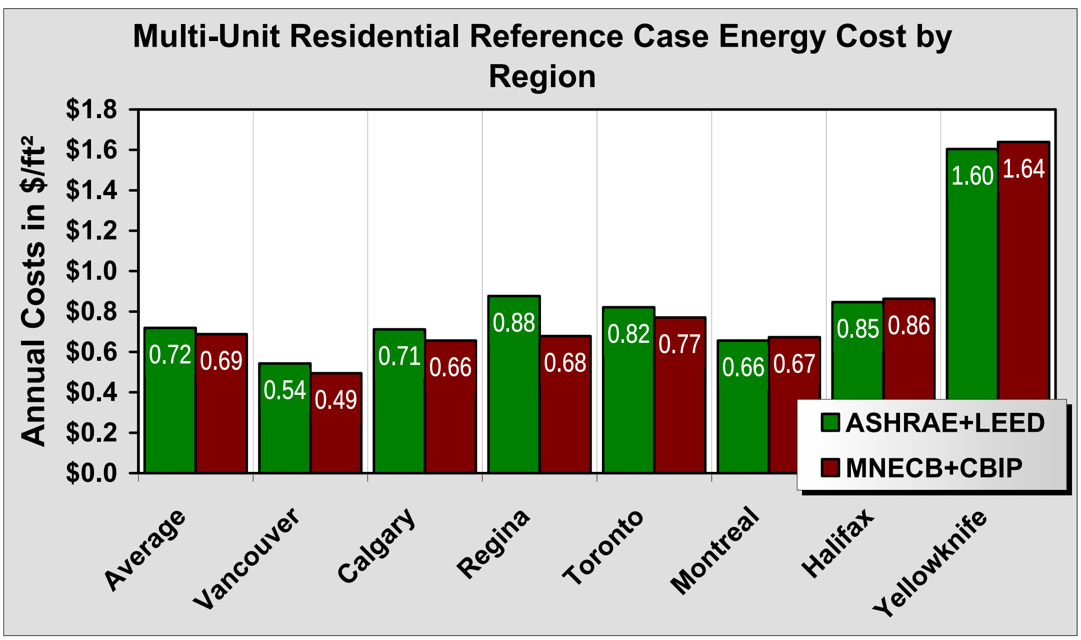


Figure 3. Regional Energy Costs

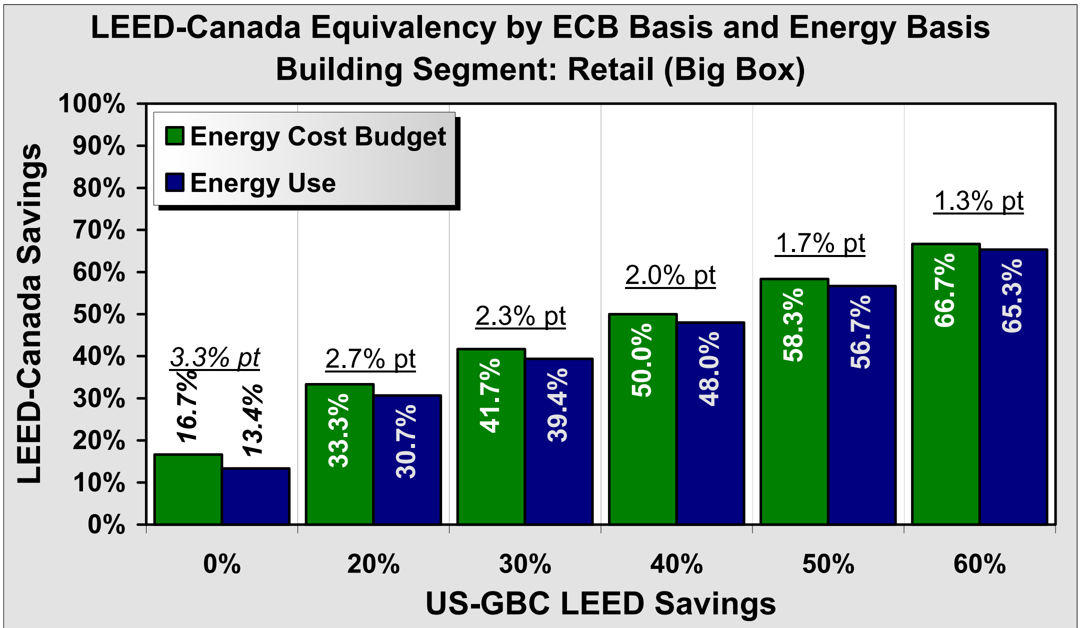


RESULTS FOR BIG BOX RETAIL

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

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-Canada Savings Bins		LEED-Canada vs LEED-GBC		ECB vs Energy Basis Diff.
	$/ft²	kBtu/ft²	ECB	Energy	ECB	Energy	
0%	*1.74*	*112.6*	*16.7%*	*13.4%*	*16.7% pt*	*13.4% pt*	*3.3% pt*
20%	1.39	90.0	33.3%	30.7%	13.3% pt	10.7% pt	2.7% pt
30%	1.22	78.8	41.7%	39.4%	11.7% pt	9.4% pt	2.3% pt
40%	1.04	67.5	50.0%	48.0%	10.0% pt	8.0% pt	2.0% pt
50%	0.87	56.3	58.3%	56.7%	8.3% pt	6.7% pt	1.7% pt
60%	0.69	45.0	66.7%	65.3%	6.7% pt	5.3% pt	1.3% pt

Figure 1. Equivalency for LEED-Canada Versus US-GBC LEED



** Indicators above paired bars indicate relative difference between ECB and CBIP bases.*

Table 2. Comparison of MNECB+CBIP Reference Versus ASHRAE+LEED ECB Cases: Applied to Big Box Retail

Region	Energy (kBtu/ft²)			Energy Cost ($/ft²)		
	CBIP	ASHRAE	Diff.	CBIP	ASHRAE	Diff.
Average	*129.9*	*112.6*	*13.4%*	*$2.08*	*$1.74*	***16.7%***
Vancouver	91.8	85.0	7.5%	$1.18	$1.07	**8.7%**
Calgary	156.2	125.4	19.7%	$2.05	$1.57	**23.3%**
Regina	177.4	141.6	20.2%	$2.53	$1.95	**23.0%**
Toronto	141.9	116.7	17.8%	$2.24	$1.77	**20.9%**
Montreal	126.6	118.2	6.6%	$2.26	$1.99	**11.8%**
Halifax	117.6	104.6	11.0%	$3.11	$2.70	**13.2%**
Yellowknife	204.1	185.9	8.9%	$5.93	$4.93	**16.8%**

Figure 2. Regional Reference Energy Use

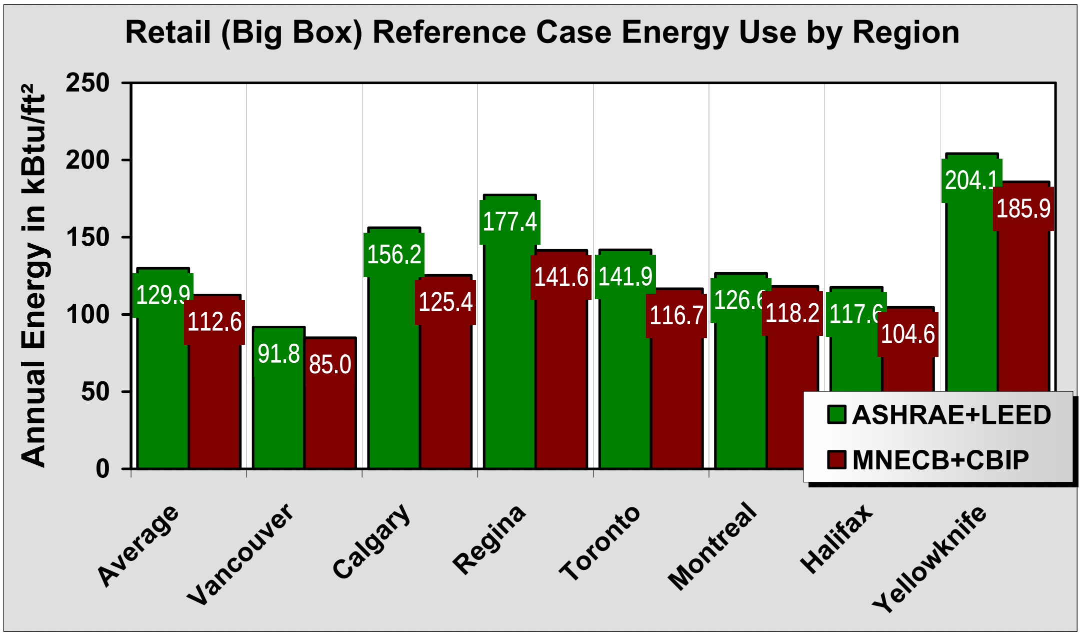
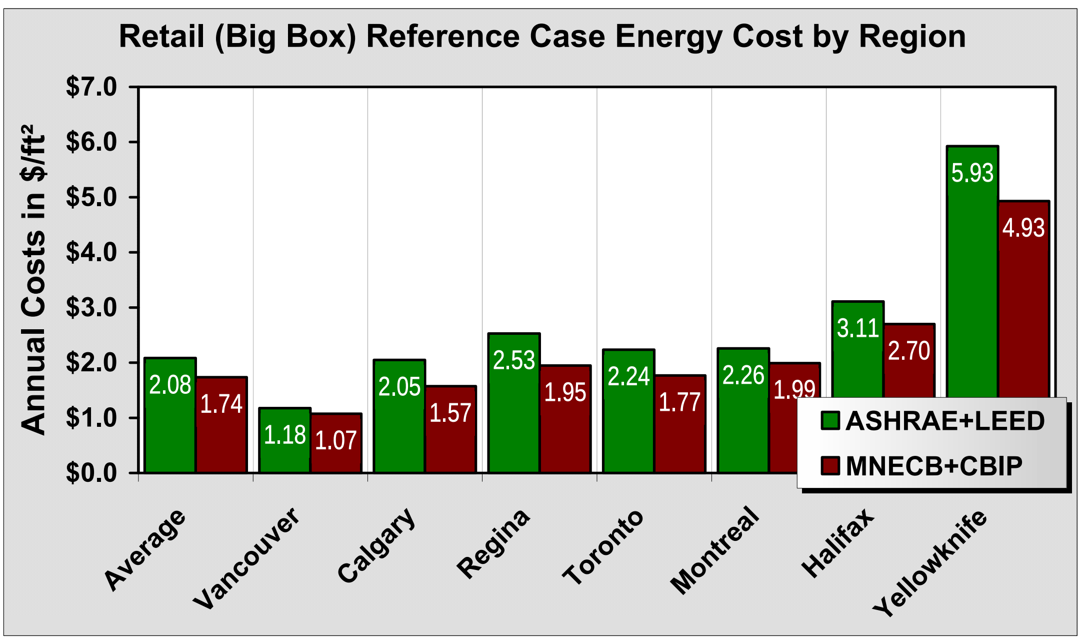


Figure 3. Regional Energy Costs



RESULTS FOR STRIP MALL RETAIL

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

LEED-US Savings Bins	Min. Proposed Qualifying Level		Equivalent LEED-Canada Savings Bins		LEED-Canada vs LEED-GBC		ECB vs Energy Basis Diff.
	$/ft²	kBtu/ft²	ECB	Energy	ECB	Energy	
0%	*2.28*	*145.8*	*-1.2%*	*-1.9%*	*-1.2% pt*	*-1.9% pt*	*0.8% pt*
20%	1.82	116.6	19.1%	18.4%	-0.9% pt	-1.6% pt	0.6% pt
30%	1.59	102.1	29.2%	28.6%	-0.8% pt	-1.4% pt	0.6% pt
40%	1.37	87.5	39.3%	38.8%	-0.7% pt	-1.2% pt	0.5% pt
50%	1.14	72.9	49.4%	49.0%	-0.6% pt	-1.0% pt	0.4% pt
60%	0.91	58.3	59.5%	59.2%	-0.5% pt	-0.8% pt	0.3% pt

Figure 1. Equivalency for LEED-Canada Versus US-GBC LEED

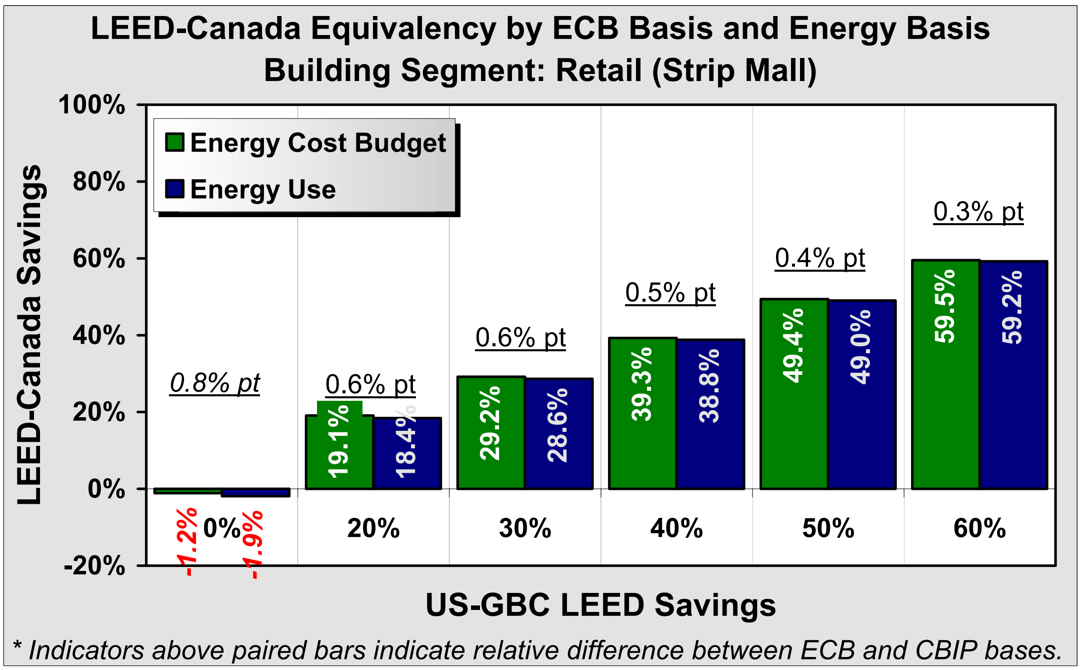


Table 2. Comparison of MNECB+CBIP Reference Versus ASHRAE+LEED ECB Cases: Applied to Strip Mall Retail

Region	Energy (kBtu/ft²)			Energy Cost ($/ft²)		
	CBIP	ASHRAE	Diff.	CBIP	ASHRAE	Diff.
Average	*143.0*	*145.8*	*-1.9%*	*$2.25*	*$2.28*	***-1.2%***
Vancouver	115.6	108.7	5.9%	$1.60	$1.50	**6.0%**
Calgary	171.8	164.6	4.2%	$2.07	$1.97	**5.0%**
Regina	193.9	179.6	7.4%	$2.42	$2.27	**6.5%**
Toronto	154.5	152.1	1.6%	$2.33	$2.27	**2.5%**
Montreal	133.5	152.2	-14.0%	$2.45	$2.69	**-10.0%**
Halifax	128.5	135.5	-5.4%	$3.16	$3.32	**-5.2%**
Yellowknife	226.6	233.8	-3.2%	$5.71	$5.82	**-2.0%**

Figure 2. Regional Reference Energy Use

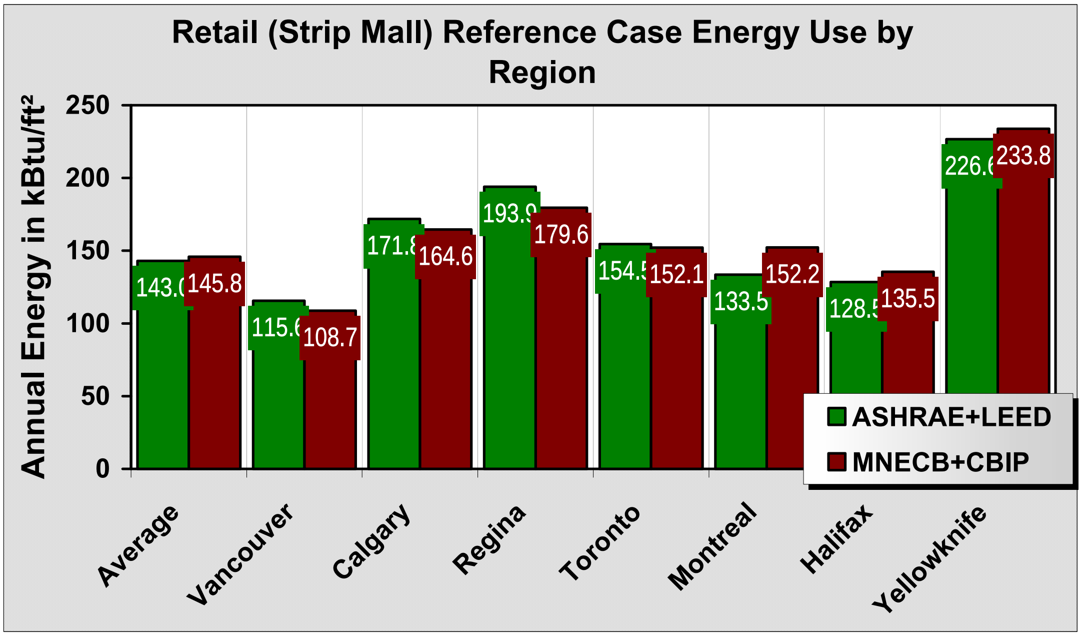
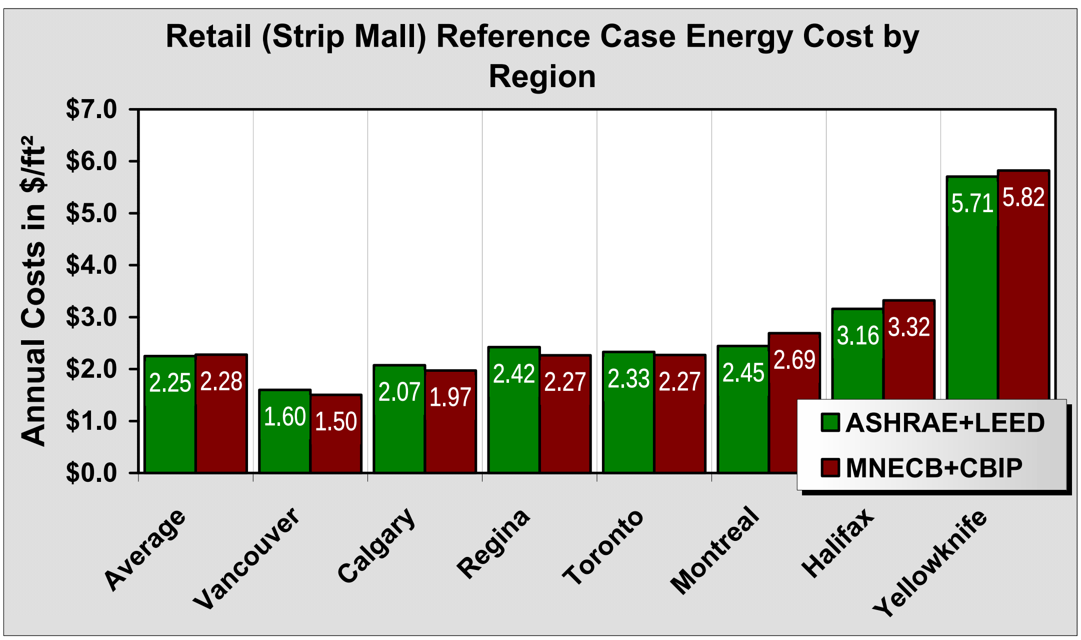


Figure 3. Regional Energy Costs



APPENDIX D

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

New Commercial Market Share Factors

LEED-Canada Equivalency Analysis
Estimated Canadian Market Share Penetration Factors

VANCOUVER	**% of Canada:**	**17.1%**	**Heating Fuel Source**			**DHW Fuel Source**	
Building Type	**Segment Market Penetration (est. new m²)**	**Market Segment Penetration Apportion**	**Electricity**	**Fossil**	**Source / Notes**	**Electricity**	**Fossil**
		VT	e	g		e	g
School	2,372,565	17.1%	12%	88%	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., October 1996.	12%	88%
Large Office	555,093	17.1%	17%	83%		30%	70%
Small Office	4,158,941	17.1%	30%	70%		30%	70%
Retail, Big Box	1,263,843	17.1%	20%	80%		20%	80%
Retail, Strip Mall	1,263,843	17.1%	20%	80%		20%	80%
Extended Care	355,481	17.1%	20%	80%	Electricity and gas breakout from 1988 Marbek study. Regional breakouts an estimate, based on weighted averages of other segments	20%	80%
Hotel/Motel	1,154,304	17.1%	35%	65%		10%	90%
MURB	2,238,100	17.1%	40%	60%		10%	90%
TOTAL:	***13,362,170***	***17.1%***	***26%***	***74%***		***20%***	***80%***

CALGARY	**% of Canada:**	**8.2%**	**Heating Fuel Source**			**DHW Fuel Source**	
Building Type	**Segment Market Penetration (est. new m²)**	**Market Segment Penetration Apportion**	**Electricity**	**Fossil**	**Source / Notes**	**Electricity**	**Fossil**
		CA	e	g		e	g
School	10,707,574	8.2%	1.9%	98%	From CIBEUS Data, informed by LEED-BC information with adjustments to account for data deficiencies and inconsistencies among distributions and representation of data segments. Fuel heating source derived from CIBEUS with equivalent allocation between building types similar to Vancouver.	4.5%	95%
Large Office	1,341,580	8.2%	2.7%	97%		11.3%	89%
Small Office	10,051,558	8.2%	4.7%	95%		11.3%	89%
Retail, Big Box	4,654,527	8.2%	3.2%	97%		7.6%	92%
Retail, Strip Mall	4,654,527	8.2%	3.2%	97%		7.6%	92%
Extended Care	2,795,231	8.2%	3.2%	97%		7.6%	92%
Hotel/Motel	6,702,332	8.2%	5.5%	94%		3.8%	96%
MURB	8,230,324	8.2%	6.3%	94%	Based on BC and professional knowledge and infor	3.8%	96%
TOTAL:	***49,137,653***	***8.2%***	***4%***	***96%***		***7%***	***93%***

LEED-Canada Equivalency Analysis
Estimated Canadian Market Share Penetration Factors

REGINA	% of Canada:	1.7%	Heating Fuel Source			DHW Fuel Source	
Building Type	**Segment Market Penetration (est. new m²)**	**Market Segment Penetration Apportion**	**Electricity**	**Fossil**	**Source / Notes**	**Electricity**	**Fossil**
		RG	e	g		e	g
School	2,169,888	1.7%	1.9%	98%	From CIBEUS Data, informed by LEED-BC information with adjustments to account for data deficiencies and inconsistencies among distributions and representation of data segments. Fuel heating source derived from CIBEUS with equivalent allocation between building types similar to Vancouver.	4.5%	95%
Large Office	271,871	1.7%	2.7%	97%		11.3%	89%
Small Office	2,036,946	1.7%	4.7%	95%		11.3%	89%
Retail, Big Box	943,239	1.7%	3.2%	97%		7.6%	92%
Retail, Strip Mall	943,239	1.7%	3.2%	97%		7.6%	92%
Extended Care	566,453	1.7%	3.2%	97%		7.6%	92%
Hotel/Motel	1,358,226	1.7%	5.5%	94%		3.8%	96%
MURB	1,667,873	1.7%	6.3%	94%	Based on BC and professional knowledge and infor	3.8%	96%
TOTAL:	***9,957,735***	***1.7%***	***4%***	***96%***		***7%***	***93%***

TORONTO	% of Canada:	40.3%	Heating Fuel Source			DHW Fuel Source	
Building Type	**Segment Market Penetration (est. new m²)**	**Market Segment Penetration Apportion**	**Electricity**	**Fossil**	**Source / Notes**	**Electricity**	**Fossil**
		TO	e	g		e	g
School	23,522,762	40.3%	6%	94%	From CIBEUS Data, informed by LEED-BC information with adjustments to account for data deficiencies and inconsistencies among distributions and representation of data segments. Fuel heating source derived from CIBEUS with equivalent allocation between building types similar to Vancouver.	11%	89%
Large Office	4,752,142	40.3%	9%	91%		28%	72%
Small Office	27,533,251	40.3%	16%	84%		28%	72%
Retail, Big Box	13,112,550	40.3%	10%	90%		19%	81%
Retail, Strip Mall	13,112,550	40.3%	10%	90%		19%	81%
Extended Care	4,692,980	40.3%	10%	90%		19%	81%
Hotel/Motel	10,041,200	40.3%	18%	82%		9%	91%
MURB	19,469,062	40.3%	21%	79%	Based on BC and professional knowledge and infor	9%	91%
TOTAL:	***116,236,497***	***40.3%***	***13%***	***87%***		***18%***	***82%***

LEED-Canada Equivalency Analysis
Estimated Canadian Market Share Penetration Factors

MONTREAL	**% of Canada:**	**29.5%**	**Heating Fuel Source**			**DHW Fuel Source**	
Building Type	**Segment Market Penetration (est. new m²)**	**Market Segment Penetration Apportion**	**Electricity**	**Fossil**	**Source / Notes**	**Electricity**	**Fossil**
		MO	e	g		e	g
School	11,761,951	29.5%	20%	80%	From CIBEUS Data, informed by LEED-BC information with adjustments to account for data deficiencies and inconsistencies among distributions and representation of data segments. Fuel heating source derived from CIBEUS with equivalent allocation between building types similar to Vancouver.	19%	81%
Large Office	1,231,171	29.5%	28%	72%		47%	53%
Small Office	7,133,234	29.5%	50%	50%		47%	53%
Retail, Big Box	8,473,262	29.5%	33%	67%		31%	69%
Retail, Strip Mall	8,473,262	29.5%	33%	67%		31%	69%
Extended Care	4,471,107	29.5%	33%	67%		31%	69%
Hotel/Motel	3,263,521	29.5%	58%	42%		16%	84%
MURB	9,015,017	29.5%	66%	34%	Based on BC and professional knowledge and infor	16%	84%
TOTAL:	***53,822,524***	***29.5%***	***39%***	***61%***		***28%***	***72%***

HALIFAX	**% of Canada:**	**3.1%**	**Heating Fuel Source**			**DHW Fuel Source**	
Building Type	**Segment Market Penetration (est. new m²)**	**Market Segment Penetration Apportion**	**Electricity**	**Fossil**	**Source / Notes**	**Electricity**	**Fossil**
		HX	e	g		e	g
School	3,374,379	3.1%	18%	82%	From CIBEUS Data, informed by LEED-BC information with adjustments to account for data deficiencies and inconsistencies among distributions and representation of data segments. Fuel heating source derived from CIBEUS with equivalent allocation between building types similar to Vancouver.	22%	78%
Large Office	103,673	3.1%	25%	75%		55%	45%
Small Office	1,070,227	3.1%	44%	56%		55%	45%
Retail, Big Box	2,344,354	3.1%	29%	71%		36%	64%
Retail, Strip Mall	2,344,354	3.1%	29%	71%		36%	64%
Extended Care	945,481	3.1%	29%	71%		36%	64%
Hotel/Motel	694,230	3.1%	52%	48%		18%	82%
MURB	2,188,330	3.1%	59%	41%	Based on BC and professional knowledge and infor	18%	82%
TOTAL:	***13,065,027***	***3.1%***	***34%***	***66%***		***30%***	***70%***

LEED-Canada Equivalency Analysis
Estimated Canadian Market Share Penetration Factors

YELLOWKNIFE	**% of Canada:**	**0.2%**	**Heating Fuel Source**			**DHW Fuel Source**	
Building Type	**Segment Market Penetration (est. new m²)**	**Market Segment Penetration Apportion**	**Electricity**	**Fossil**	**Source / Notes**	**Electricity**	**Fossil**
		YK	e	g		e	g
School	202,583	0.2%	1.9%	98%	From CIBEUS Data, informed by LEED-BC information with adjustments to account for data deficiencies and inconsistencies among distributions and representation of data segments. Fuel heating source derived from CIBEUS with equivalent allocation between building types similar to Vancouver.	4.5%	95%
Large Office	25,382	0.2%	2.7%	97%		11.3%	89%
Small Office	190,171	0.2%	4.7%	95%		11.3%	89%
Retail, Big Box	88,062	0.2%	3.2%	97%		7.6%	92%
Retail, Strip Mall	88,062	0.2%	3.2%	97%		7.6%	92%
Extended Care	52,885	0.2%	3.2%	97%		7.6%	92%
Hotel/Motel	126,805	0.2%	5.5%	94%		3.8%	96%
MURB	155,714	0.2%	6.3%	94%	Based on BC and professional knowledge and infor	3.8%	96%
TOTAL:	***929,664***	***0.2%***	***4%***	***96%***		***7%***	***93%***