CANADA'S CBIP VERSUS THE UNITED STATES' LEED™: BUILDING ENERGY PERFORMANCE PATH REQUIREMENTS

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ABSTRACT

LEED-Canada is launching a green building rating system based on the U.S. Leadership in Energy and Environmental Design (LEED™) rating system. As part of the system, it assessed the energy performance difference between Canada's Model National Energy Code for Buildings (MNECB) and the ASHRAE/ IESNA Standard 90.1-1999 energy code (ASHRAE) to develop an equivalent localized rating system.

A comprehensive review of the two energy standards and the development of dozens of DOE2 models were conducted to evaluate the differences. The models represented compliant reference cases for both respective standards for prototype building types and HVAC configurations across Canada. A comparison of the overall aggregate difference showed that ASHRAE is nearly 11% more stringent than the MNECB.

This paper provides an overview of the approach followed to determine the relative differences between the codes, as well as summary results from the analysis.

INTRODUCTION

The Canadian Green Building Council is spearheading the development of a Canadian version of the U.S. Leadership in Energy and Environmental Design (LEED™) green building rating system, referred to as "LEED-Canada." LEED-Canada endeavoured to establish a Canada-wide equivalency that reflected the energy performance difference between Canada's Model National Energy Code for Buildings (MNECB) and the ASHRAE/IESNA Standard 90.1-1999 energy code. More specifically, the equivalency was to capture the energy performance differences between (1) reference modelling following Canada's Commercial Building Incentive Program (CBIP) requirements, and (2) reference modelling following the LEED application of the ASHRAE/IESNA Standard 90.1-1999 (ASHRAE+LEED).

CBIP references the Model National Energy Code for Commercial Buildings, but makes some significant distinctions. We applied the CBIP variation to the MNECB (MNECB+CBIP) because it is the compliance standard most widely used by designers concerned with creating an energy efficient design in Canada. More significantly, the CBIP version is more stringent than MNECB.

The equivalency analysis for LEED-Canada built on a previous study carried out for British Columbia, Canada (LEED-BC). In both studies, the equivalency was determined by applying the comparisons between archetype models for the respective energy standards to a representative selection of building types and climatic regions.

The study had the primary goal of ensuring that LEED-Canada's Energy & Atmosphere (EA) Prerequisite 2 and Credit 1 point awards were equal to or more stringent than the application of the energy cost budget method detailed by the ASHRAE/IESNA Standard 90.1-1999, Section 11 (ASHRAE 90.1-1999), and the LEED v.2.1 Reference Guide. In other words, the application of a Canadian energy performance system must prove to be equal to or more stringent than the U.S. version of LEED. LEED-Canada point awards could then be determined from energy modelling following the MNECB+CBIP simulation requirements rather than the requirements for ASHRAE+ LEED.

METHODOLOGY

The energy performance analysis started with appropriately modifying prototype DOE2.1e models from past CBIP initiatives. These models represented typical design practices for new buildings across different regions in Canada, with focus on characteristics and conditions in major population centres. The original CBIP archetype model sets included both proposed building design prototypes and MNECB+CBIP reference case model prototypes.

For the equivalency study, we created models from these existing prototypes that served as equivalent ASHRAE+LEED energy cost budget reference cases. We compared the energy use from these ASHRAE+

LEED reference models to corresponding MNECB+ CBIP reference models to help establish the minimum equivalency between the standards.

Key Differences between the Standards

The energy performance analysis approach for establishing the reference case energy use for MNECB+ CBIP and ASHRAE+LEED is very similar overall. There are, however, several significant differences between the standards. The two most significant differences 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.

Overall, ASHRAE 90.1-1999 is more stringent than MNECB+CBIP. 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 for the MNECB, for the most typical configurations across the commercial sector. However, the MNECB is generally more stringent for buildings heated with electricity. Of the administrative regions included in the study, Quebec tends to have noticeably more stringent MNECB 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 for 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 for 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 for MNECB+CBIP in nearly all categories. 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 the tables for prescriptive envelope values, lighting levels and equipment efficiencies, there are potentially more significant differences embodied in how the ASHRAE budget HVAC system is defined. 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 reference 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 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.

- Exhaust air heat reclaim often is required for ASHRAE 90.1-1999 budget cases when the outside air is above 70% of the supply airflow, whereas MNECB+CBIP does not stipulate heat reclaim in its reference case. This most significantly affects facilities such as extended care homes, which typically have high proportions of outside air.

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, after the simulation, from both the proposed and reference cases before calculating the percent savings.

This nuance with LEED influences the overall approach for establishing the minimum energy performance equivalency. Since equipment levels vary among different building types, the resulting equivalency would not be representative between the two systems. As the proportion of equipment load increases, the saving levels would have to increase correspondingly to appropriately correspond to the equivalent LEED levels. The discrepancy in the two standards' savings calculation would make it slightly easier for buildings with relatively high equipment loads to attain the same savings level as 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 implies that simulators will need to subtract out the proportional plug load's energy cost for LEED-Canada, but still leave it in for CBIP.

Approach

For the purposes of the policy-level study, the prototype CBIP 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.

The following building types were included in the assessment since they capture the large majority of commercial floor area across Canada:

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

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 be 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, the analysis included the following representative locations:

- 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, given the practical constraints on the study scope (i.e., it was not practical to conduct simulations on all 44 available typical weather sites in Canada).

The final step in establishing a Canada-wide equivalency between MNECB+CBIP and ASHRAE+LEED involved aggregating the various models together as a representation of the entire commercial market. Market penetration factors that represent the estimated floor area shares were applied 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.

Analysis Process

A first task involved comparing the overall MNECB+CBIP modelling requirements to those of ASHRAE 90.1-1999. We provided a comparative side-by-side listing, with comments relating to the relative differences, including approach and analysis issues. This exercise helped determine how the standards vary and the relative significance in the differences. This was an important first step in creating adequate prototype ASHRAE budget case models that would provide 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 was 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.).

The next task involved applying the significant characteristics to each specific building prototype. 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 using the DOE2.1e energy performance simulation program. 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, regional electricity and natural gas or fuel oil rates were applied to the energy performance results. 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, it is consistent with LEED guidelines. For this type of policy level analysis, it was impossible to precisely specify full rate tariffs since a host of different structures apply and are continually changing.

We then 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.

2) The relative proportion of the building stock floor area within each region was based on figures provided by Natural Resources Canada (NRCan). Other sources were required to supplement the data since it was visibly void for certain regions and building types.

3) The percent of fossil heated versus electrically heated floor area within the building stock was typically based on figures provided by NRCan (with the exception of British Columbia in which more accurate data was obtained from the founding LEED-BC study). Some adjustments based on professional experience were required in a few cases when data was incomplete.

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. This was necessary since resources on the market penetration for different HVAC systems were not readily available.

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

[% LEED-Canada Energy $ Savings] = 1 – (1 –
[% US LEED Energy $ Savings]) x (1 – 10.9%)

RESULTS

Simulated energy use and costs from the prototype MNECB+CBIP and ASHRAE+LEED models were used to assess the energy performance differences between the standards. Applying estimated market penetration factors, 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. 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).

As shown in Figure 1, the MNECB+CBIP standard is nearly 11% less stringent than ASHRAE+LEED for the overall commercial building sector. This is based on energy costs for regulated end-uses. Based on energy consumption, the difference narrows to less than 9%. The implications of this difference is that an equivalent adaptation of LEED for Canada would require nearly 11% in energy cost savings over respective MNECB+CBIP reference cases to satisfy LEED's EA Prerequisite 2.

LEED-Canada, however, plans 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% energy cost savings, or 16% savings on energy consumption. This is based on applying LEED's methodology for calculating the percent savings by excluding non-regulated plug loads, as compared to the CBIP methodology which includes the 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. Assuming LEED-Canada would follow an equivalent scoring system as LEED 2.1 from the United States, we generated the LEED-Canada EA equivalency table shown in Table 1. This table provides a point awards system for energy cost savings for LEED-Canada that would be equivalent to the USGBC system.

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.

Figure 1. Equivalency Savings Bins for LEED-Canada vs USGBC LEED

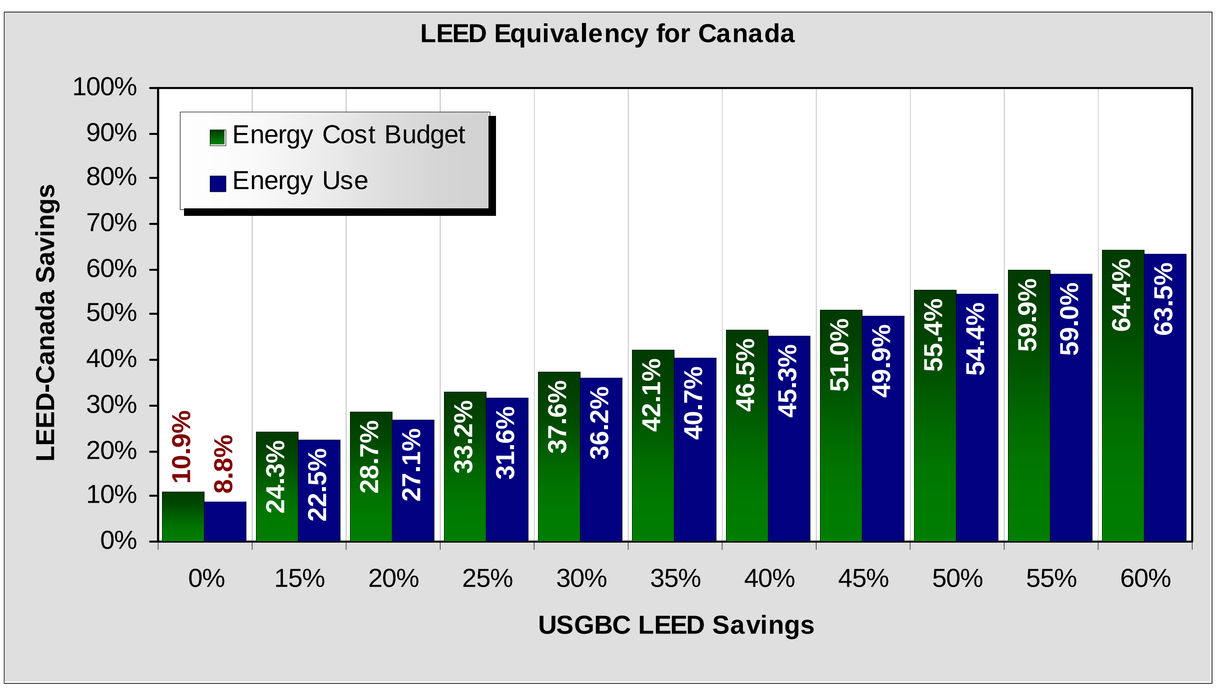


Table 1. LEED-Canada Equivalency

Percent Savings		Points
LEED-Canada	LEED 2.1	
*< 10.9%**	*0%*	*U.S. LEED 2.1 Prereq 2*
CBIP (25.4% Avg. Savings)	*~18.0% on Energy Use*	*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*

Regional and Building Type Results

Figure 2 provides more detailed results on a regional basis for the seven regions evaluated as part of the study. For each location, Figure 2 compares the overall MNECB+CBIP reference energy performance to the equivalent ASHRAE+LEED budget performance. The results include a weighted average of all building types within each region. As shown in the graph, 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.

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 simulated 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).

Figure 3 provides more detailed results for each building type averaged across all 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 3, the differences between the standards vary significantly among the building types. Further, the variation in basing saving on energy costs

Figure 2. Regional Equivalency Comparisons

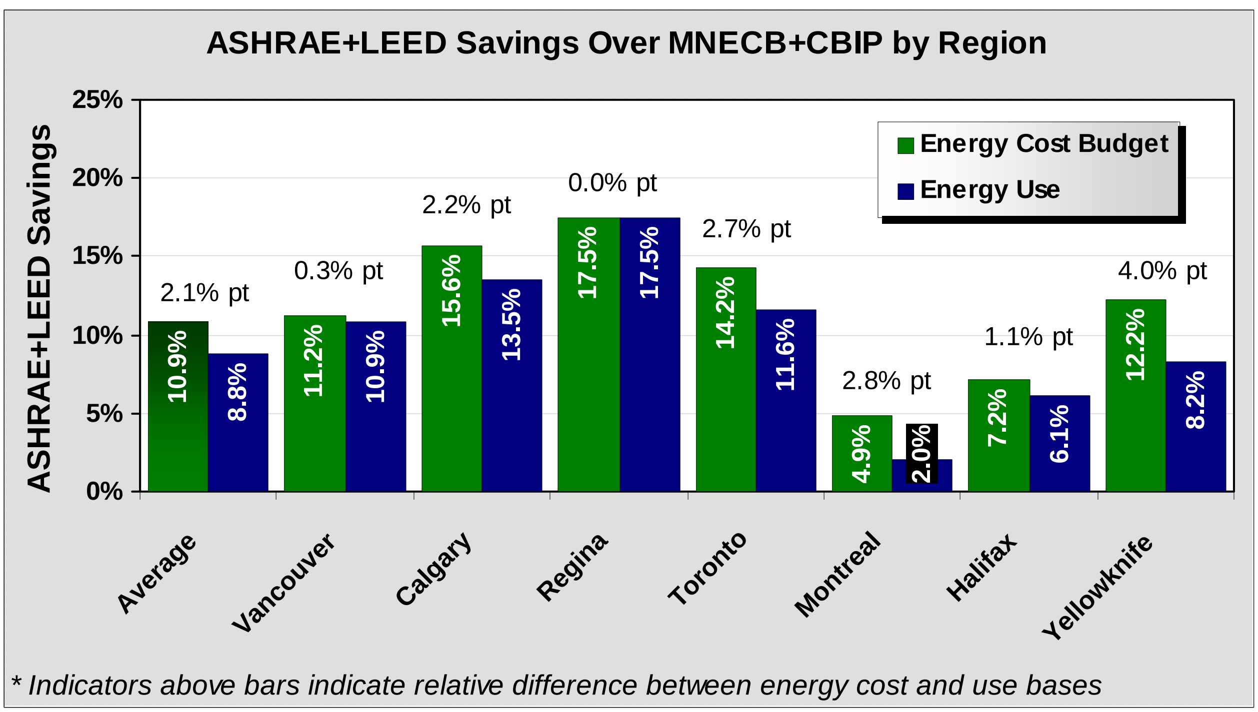
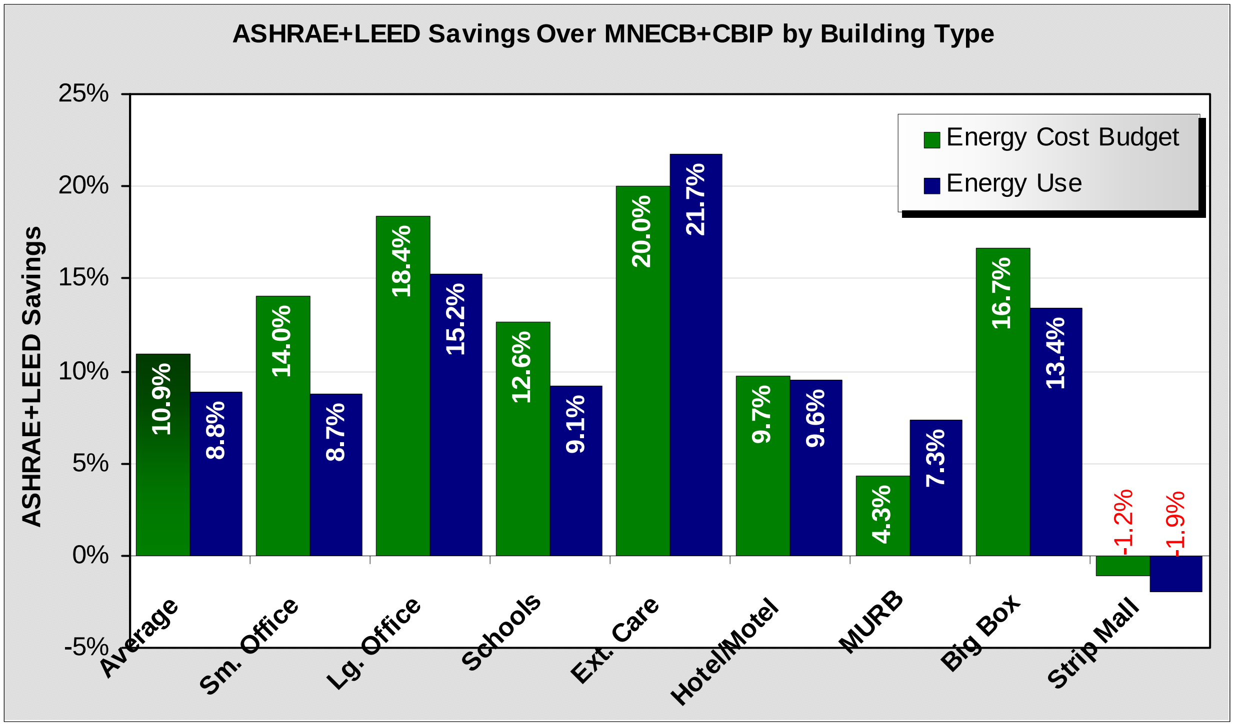


Figure 3. Building Type Equivalency Comparisons



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 0.3 percentage points.

Figure 3 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 regional difference between MNECB+CBIP and ASHRAE+LEED is observed in the strip mall retail segment, at about 1–2% more stringent for CBIP than LEED.

An interesting observation on the retail building type comparisons is how the two retail prototypes vary so significantly when their comparative modelling requirements are quite similar. The main reason for the difference lies in the approach to defining the lighting power densities. The big box retail is defined using the "building type" space use classification while the strip mall was defined by "space function." While arguably inconsistent, both approaches are perfectly valid under both systems, but result in disparate differences. This result exemplifies how following different, yet valid approaches can produce different results. This phenomenon applies equally to both rating systems.

CONCLUSIONS

The energy performance analysis of the commercial sector in Canada indicated that the energy performance (EA Prerequisite 2 and EA Credit 1) requirements of the U.S. LEED Rating System was nearly 11% more stringent than Canada's MNECB+CBIP energy performance requirements. This was based on the consistent application of dozens of hourly energy simulations of archetypal models for representative regions across the country. From these models, the minimum required energy performance and point awards table was derived for LEED-Canada. Both were consistent with LEED v.2.1 in that we provided an overall commercial sector average and did not differentiate among different building types or regions.

However, the energy performance modelling of specific cases provided indications as to how the many factors for a specific building and region can produce widely varying results. For instance, the composite strip mall reference in Montreal provided for MNECB+CBIP savings that were 10% *more stringent* that for ASHRAE+LEED. In contrast, the extended care reference in Regina was nearly 28% less stringent than for the comparable ASHRAE+LEED average extended care.

The potentially wide variance in project-specific results should not be of great concern when developing an equivalency between the standards. This mainly is because similar variances exist in both the MNECB+ CBIP and ASHRAE+LEED approaches, yet each references one, consistent set of program requirements. CBIP requires 25% energy savings and LEED provides for point awards at discrete levels regardless of the building type, weather region, HVAC configuration, fuel rates, plug loads, etc. In other words, modellers will get different levels of savings under different conditions and/or applications of the respective standard, even if the design's energy efficiency has theoretically not changed.

To provide for relatively wide acceptance in the market, a practical rating system must be simple and set clear guidelines. This goal is satisfied by the model-based assessment LEED-Canada followed to establish a sector-wide rating equivalency to LEED™. Hopefully, practitioners focus on the spirit of the rating systems instead of the inevitable simulation loopholes.

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