Setting Building Energy Performance Targets: Econometric versus Baseline Models

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Abstract

The University of British Columbia (UBC) is encouraging design of energy efficient buildings by employing a method to set aggressive energy use intensity (EUI) targets. The approach is based on the adaptation of econometric models of existing building performance to provide a "building energy rating."

The approach differs from how new building performance is popularly gauged in North America, in which the simulated energy use of a new design is compared to a code-based baseline model. Instead, EUI targets are defined based on a rating that accounts for the building's utilization and energy sources. Initial indications show the rating approach is simpler and more consistent.

1. INTRODUCTION

To help achieve its greenhouse gas reduction targets, the University of British Columbia is setting aggressive, realistically attainable building energy use intensity (EUI) targets. We developed a methodology for designating EUI targets for major renovations and new construction.

The approach deviates from how new buildings' performance is popularly gauged in North America, which most often employs energy performance modelling protocols referenced in the LEED® Green Building Rating System for new construction (LEED NC). LEED is a U.S.-based third-party certification program for the design, construction and operation of high performance green buildings. LEED is internationally recognized and applied, including Canada's adaptation tailored to its buildings industry. LEED NC references energy performance modelling protocols established by the American Society of Heating, Refrigerating and Air-Conditioning's Standard 90.1 (ASHRAE 90.1). For Canada's version of LEED, modellers most often reference the Model National Energy Code of Canada (MNECB) instead.

With both ASHRAE 90.1 and MNECB, performance typically is compared against models derived from rules and provisions defined by the respective codes. These performance modelling procedures dictate comparison to a "baseline" building model. This baseline model is fictitious and, oftentimes, unrealistic for the conditions of the project. It can often award credit for design decisions that actually increase source energy use (e.g., increasing glazing or ventilation to the allowed limits, or even employing electric heating sources). Moreover, simulators and the software they use are highly inconsistent in the creation of the baseline model – and can require a significant amount of the modeller's time, especially if he/she must manually build and document the creation of the baseline model. Finally, the application and interpretation of the relatively convoluted modelling rules result in widely varying performance indicators, independent of the actual design configuration and characteristics [Turner, C., Efficiency New Brunswick].

For these reasons, UBC (and other entities) are exploring alternative approaches to evaluating the building performance provided by whole-building energy models. In our methodology, modelled energy use is compared to performance of existing buildings. Comparison to actual building performance is a logical approach that many have long considered. However, its application has challenges and, admittedly, cannot be applied in all cases. This paper attempts to address the many challenges to effectively referencing existing building data, and provides some initial comparative results of the evaluation tool we have devised.

2. METHODOLOGY

To develop high performance (low energy use) buildings, UBC identified the need to set EUI targets for design of new buildings and major renovations. UBC hired EnerSys Analytics to develop a methodology and an associated Microsoft Excel application ("Building Energy Target Tool" or "BET Tool") to define a building performance rating and associated EUI target for any new or existing building.

ENERGY STAR Rating System

The methodology and spreadsheet tool are based on econometric models derived from existing building performance. More specifically, we adapted the methodology of the U.S. Environmental Protection Agency (EPA) online Portfolio Manager and Target Finder applications, which support the EPA's ENERGY STAR initiatives. The econometric models hinge on defining dependent variables that explain how the building is used, but not necessarily why a facility performs the way it does. Hence, variables linked to utilization (e.g., how long the building is open and how many people will use it) influence the building energy target.

A somewhat novel approach to establishing a performance target for new construction is linked to the requirement to meet increasing "energy performance rating" levels. The establishment of such ratings has been implemented by the EPA and LEED for existing buildings (LEED EB) for quite some time now. With LEED EB, for instance, an existing building must achieve an ENERGY STAR rating of 69 to qualify, and can receive the maximum number of "Energy & Atmosphere Credit 1" (EAc1) points with a rating of 95 or better.

An ENERGY STAR rating is determined by comparing a facility's energy use to a normalized benchmark. It derives EUI benchmarks (in kBtu/ft²) from representative statistical models that were generated from building energy consumption and characteristics data (i.e., actual building performance data) collected from U.S. census information. The rating system originally was released in 1999 and has been updated with more recent census data and expansion of building types. It presently applies to about 60% of the commercial building stock across the United States, distinguished by at least a dozen different building occupancy types.

While the rating system applies to U.S. commercial building stock, EnerSys has observed from its studies and projects that it is representative for most Canadian conditions (the far north excluded) for most occupancy types—especially offices and schools. Further, the EPA system allows for the adjustment of comparative benchmarks based on dependent characteristics that were found to statistically correlate to energy use (e.g., weather, electricity use versus natural gas or district heat consumption, number of personal computers, operating hours, and number of occupants). Once a user defines these parameters, the system generates normalized source and site benchmark energy intensity values against which to compare against the building's energy performance. It then assigns a "baseline rating."

The baseline ENERGY STAR rating corresponds to how well, or poorly, the building's *source* energy intensity (EUI) compares to the median EUI for the corresponding identified
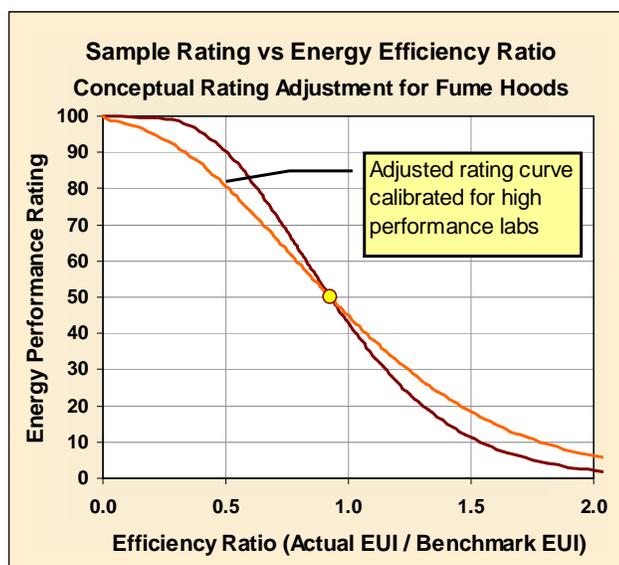
building conditions. Further, the rating is based on the distribution of the census building EUIs that are the foundation of the EPA's econometric models. A building with a rating of 90, for example, is estimated to perform better (i.e., have a lower EUI) than 90% of the comparative existing building stock – normalized for weather, occupancy and other pertinent dependent characteristics. Figure 1 illustrates how the rating is derived from the comparison (ratio) between the actual building's source EUI and the median benchmark source EUI.

Another key aspect of the EPA's system is how the building's energy sources affect the rating, with the relative proportion of electricity use having the most significant impact.

Figure 1: Illustration of Energy Performance Rating Based on the Distribution of Actual versus Median Energy Use Intensity

This is due to the relative weighting of metered site electricity use based on its source input energy content (i.e., potential). Electricity has a site-to-source factor that is 3.2 to 2.6 times the same factor for other energy sources, such as natural gas or district heat. The site-to-source ratios in the system cannot be changed directly, which could cause concern for jurisdictions who feel their resource mix for electricity should not be so negatively weighted compared to competing fossil fuels. However, as described later, the weightings proved satisfactory based on sensitivity tests for the different building types. Further, our tests indicated that this did not significantly affect the site EUI targets since the site-to-source ratios were applied to the estimated energy use inputs, and then were backed out of the model (see Step 8 below). That is, the same ratio is multiplied by the site metered utility data that is input into the econometric models, and then is divided into the resulting median and/or target source energy use that is output from the models.

The BET spreadsheet tool builds on the EPA's documented formulas to calculate EUI benchmarks based on a facility's annual energy consumption, corresponding weather data, and operational characteristics. After determining comparative source and site benchmark EUIs, the Tool then calculates the energy performance rating, which is equivalent to an ENERGY STAR score. The BET Tool applies the following general steps to determine the benchmark EUI for applicable building types:

Step 1. Enter a year of energy consumption data for the facility, including for all energy sources (e.g., electricity, central steam, natural gas).

Step 2. Compute the source energy use by applying applicable site-to-source energy ratios. The EPA statistical models use these ratios to define the required independent energy use variables.

Step 3. Compute the building source energy use by converting the source energy use for the facility to consistent units, then dividing by the gross floor area for the facility. Dividing by the gross floor area provides the total source EUI, which some statistical models use directly instead of the total source energy.

Step 4. Collect and enter the applicable dependent operational data (e.g., operating hours, heating degree-days) to determine the comparative benchmark energy use or EUI, depending on the calculations that apply.

Step 5. Apply the EPA formulas for the applicable statistical model to compute the benchmark source energy use or median EUI. If the statistical model yields energy use instead of the EUI, divide by gross floor area to provide the benchmark EUI.

Step 6. Compute the energy efficiency ratio by dividing the actual source EUI (*Step 3*) by the benchmark source EUI (*Step 5*).

Step 7. Determine the energy performance rating by referencing the closest energy efficiency ratio listed in the corresponding EPA lookup table.

Step 8. Calculate the site benchmark EUI. This first requires disaggregating the source EUI from *Step 5* into its component energy type sources based on the relative allocation by energy type from *Step 2*. For instance, if electricity comprises 60% of the actual facility's source energy use and steam the remaining 40%, the benchmark source EUI would be equivalently divided to represent 60% electricity and 40% steam source energy components. Dividing by the respective site-to-source factors yields the site EUIs by energy type. Summing the component energy type EUIs provides the total site benchmark EUI.

Building Occupancy Type Econometric Models

UBC identified four key building occupancy types that comprise the vast majority of their campus building stock:

- Office
- Classroom
- Student residence
- Laboratory.

The first, offices, required no special considerations in the application of the EPA algorithms since it represents a well-defined and analyzed building type. Further, we have found the EUIs produced by the ENERGY STAR system to be quite indicative of actual local building performance.

Residence halls also are directly represented as an EPA building type. We admittedly had less experience with how existing residence halls consume energy (although plenty with similar multi-unit residential buildings), but comparison to UBC data indicated the EPA econometric models provided comparable EUIs. However, the statistically based formulas were inconsistent with the other building type econometric models. This proved challenging because it prevented combining the residence hall's econometric model with those of other occupancy types when representing mixed-use facilities. As the online algorithms were not fully accessible, we had to reverse-engineer a system that replicated the EUI and rating results of the EPA's residence hall models to be compatible with the other building types.

The EPA models do not include a building occupancy type for university classroom facilities. Based on comparisons to UBC classroom building EUIs, we identified the high school application of the EPA's K-12 school econometric model as the best representation. As with all of the building types, we tested actual facilities to see if the EPA-based ratings and EUIs were reasonably close based on our extensive experience with actual building performance in the local market. The relative ratings of the UBC historical averages for its offices and residence halls were significantly higher (i.e., better than) than the EPA median at energy performance ratings of 76 and 63, respectively. Conversely, the UBC average for classrooms was lower the EPA-based high school industry average, at a 33 rating. But we took this into consideration when "localizing" the ratings and identifying what constitutes "high performance" for each of the building types (discussed later).

The laboratory building type was the most problematic since the EPA has no models that are a direct representation. Further, the highly variable and energy intensive laboratory functions related to fume hoods and instrumentation significantly differentiate this building type from the EPA building types with developed statistical models.

To represent the laboratory building type, we started with the office statistical model and adjusted for increased ventilation due to fume hoods. We based this on the following observations:

- Lab facilities typically have a reasonable amount of office space and often maintain typical office hours.
- Offices typically have higher plug loads compared to many other building types.
- The office statistical model accounts for operating hours, occupant density and number of computers (the latter of which we translated to represent lab equipment);
- The classroom econometric model was a consideration, but its inherent occupancy levels differed significantly from relatively lightly occupied labs.
- The EPA's hospital model also was a consideration due to its relatively high energy intensity, but its inherent operating schedules (24 hours per day) and specific independent variables made it an inappropriate choice.

We modified the statistical model to include the number of fume hoods as a dependent variable. This resulted in a significant upward shift in the EUIs compared to the core office model. Also, we accounted for an estimated variation in fume hood performance levels, as some configurations provide for significant energy savings compared to others. This resulted in the energy performance rating curve previously shown in Figure 1.

For mixed-use facilities that contain more than one of the four building occupancy types, the facility benchmark EUI represents the area-weighted average of the associated occupancy type benchmark EUIs. More specifically, the benchmark EUI for each of the occupancy types is multiplied by its respective gross floor area to produce the total benchmark energy use for the facility. This benchmark total energy use is then divided by the total facility floor area to provide the facility benchmark EUI. As for facilities with a single occupancy type, the resulting "energy efficiency ratio" is used to look up the rating from a table – except that the table is a blended representation of the different building occupancy types that contributed to the EUI.

New Building Adaptations and Localization

Establishing an EUI performance target is a by-product of attaining a specified energy performance rating. Since the rating is dependent on utility bills, which are unknown early in the design process, an alternative method must be adopted for new building designs. Hence, we established high performance targets based on representative UBC and other facilities. That is, local buildings that are known to be high performing establish what might be considered a high rating.

As another point of comparison, we referenced EUIs from applicable building stock averages (e.g., UBC historical averages by building type). Knowing where high and typical performing facilties rate within the adapted EPA system, we were able to set performance goals localized to UBC's specific conditions. This localization of the U.S. EPA's system to UBC's conditions resulted in the establishment of high performance rating goals.

If different energy sources were being considered for a new design, the target EUIs should differ according to the energy source in order to achieve the same rating. For instance, central steam has served most of UBC's campus facilities historically, but electricity (heat pumps)

are often considered for heating new facilities. To provide for an equivalent comparison, we translated the steam heat used by the historical average facility to an electrical heat pump equivalent. As efficient use of electricity for heating is desired by UBC (if used at all), the steam use was divided by 3.0 (i.e., to represent a good seasonal heat pump efficiency) and added to the input (non-heating) electricity use.

The use of electricity for heating typically results in requiring a significantly lower EUI than the same design served by natural gas or district heat. Once again, this is because the site-to-source factor applied to electricity is much higher than for other heating sources. Notice that the lower EUI that results from use of the relatively high efficiency heat pumps is roughly comparable to the electricity site-to-source factor. Whereas the efficiency losses associated with the upstream generation of district heat (not reflected on the site meter) provides for a much lower site-to-source factor that is closer to one. The relative difference results in energy ratings that are quite close for designs that use a heat pump versus district heat or natural gas. This is arguably beneficial in that an efficient on-site heat pump cannot completely mask a relatively ineffectual envelope and/or ventilation system.

3. BUILDING ENERGY TARGET (BET) APPLICATIONS

The energy performance rating system may be applied to setting EUI targets and/or potentially as a point award system (e.g., similar to LEED EB). UBC focused on the former for establishing tangible energy performance goals for new designs. On a broader basis, the system could be used to award points for progressively higher ratings and correspondingly lower EUIs.

Goal Setting for UBC

As previously alluded to, UBC's primary focus was to set performance ratings and resulting site EUIs that new designs could strive to achieve. Should pertinent building utilization requirements and/or the energy source mix change, UBC can generate an updated target EUI to maintain the same (or better) high performance rating. A secondary objective was for projects to qualify for a minimum specified level of EAc1 points under Canada's LEED NC rating system. Based on preliminary results, these two objectives do not always align.

The setting of EUI goals for UBC required identifying energy performance ratings that would be achievable, yet aggressively push for low energy intensities. We first tested the ratings for UBC's historical building type averages to compare the existing campus building stock to the EPA-based median benchmarks. From this exercise, UBC's existing offices, labs and residence halls performed better than a comparative EPA median, indicating that the local building stock tended toward relatively higher ratings. Conversely, the classroom building type showed lower ratings and thus, a localized BET adaptation might relax what constitutes a high performance rating compared to the other building occupancy types.

The next iteration involved testing of known local high performance buildings – both existing buildings and low-energy building models completed for LEED and other policy-based studies. While the performance ratings for study archeypes proved informative, we found the BET ratings for low-energy facilities of particular assistance. This was due to our real-world understanding and appreciation of how these highest performers used energy. Thus, it was reasonable to expect that new designs should be able to perform as well or even better.

Based on these tests, each building type was assigned the following high performance ratings that should be achieved by new designs:

- Office: 95
- Classroom: 80
- Residence Hall: 90
- Laboratory: 80

We entered these high performance ratings into the BET Tool so it could generate a corresponding target EUI, which is displayed as part of an "Energy Performance Summary" report (Figure 2).

The high performance targets are easily accessible in the tool so they may be updated as experience is gained through application of the Tool. Most recently, we had an opportunity to (retroactively) generate ratings for eight recent projects where energy performance modelling was completed. All eight projects were considered "high performance" designs with relatively high LEED EAc1 points.

Energy Performance Summary
for CWEC Typical Year

Sample UBC New Design
University of British Columbia

Facility Floor Area:
10,000 m² (107,640 ft²)

Annual Energy Use Intensity (EUI):	**244 kWh$_e$/m²**	(77 kBtu/ft²)
Electricity:	172 kWh$_e$/m²	(70%)
Thermal:	72 kWh$_e$/m²	(30%)
Median Benchmark EUI:	**458 kWh$_e$/m²**	(146 kBtu/ft²)
Difference with Industry Benchmark:	**-47%**	
Energy Performance Rating:	**80**	

Energy Use Intensity Comparisons

Your Building — 244 kWh/m²
84 Rating (High Perf.) — 213 kWh/m²
89 Rating — 180 kWh/m²
79 Rating — 246 kWh/m²

Figure 2. Sample Building Energy Target Rating Report

As shown in Figure 3, five of the high performance projects did not meet (i.e., energy use was higher than) the desired EUI target. However, all but one were reasonably close to the target. Hence, this initial sampling indicates an appropriate setting for (or "localization" of) the EPA-based rating system.

Potential Scoring System

UBC has localized the EPA's rating system to their campus conditions. While not presently being evaluated by UBC, we explored the applicability of expanding the system to the development of a scoring system that awards an increasing level of points for higher ratings.

Figure 3. Comparison of LEED Modelled EUIs versus Localized High Performance EUI Targets

As previously mentioned, LEED EB does this already for "ratable" existing buildings. For the small sample set we ran through the BET Tool, we took the relative EUI savings compared against the median benchmark EUI and plotted it against the energy *cost* savings from the LEED modelling exercise. As three different code-based baseline approaches were
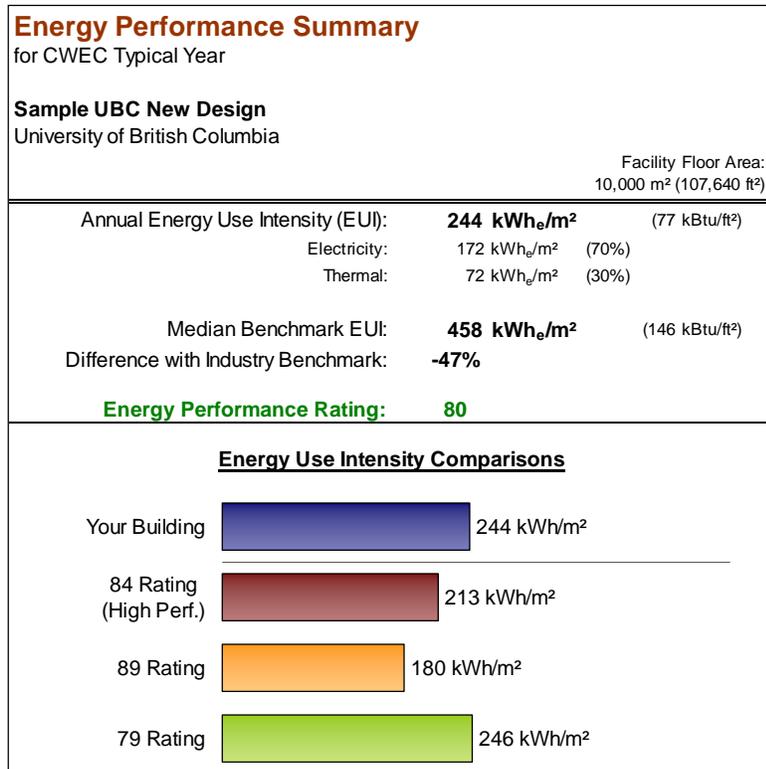
represented, the cost savings were adjusted to a consistent MNECB baseline[1] where necessary. Figure 4 illustrates the comparison in (a) the percent savings versus the median EUI against (b) the code-based cost savings referenced by LEED NC. As the figure shows, there is not a good correlation between the relative cost savings reported for LEED purposes and the EUI savings established through the assignment of a building energy rating.

Figure 4. Comparison of LEED Energy Cost Savings versus Median (Benchmark) EUI Savings

Note that the two points that are coloured differently (both with an 87 rating) represent a new office building that we added to the sample set represented in Figure 3. This project is one within the City of Vancouver, but not on the UBC campus. We added it not only to supplement the data set, but also to highlight how a building with the same rating and EUI can have inconsistent savings for LEED NC. That is, we modelled the project for LEED using two different available code baselines (ASHRAE 90.1-2007 Appendix G and the MNECB), which resulted in two points in Figure 4 for the same building since the baseline modelling approaches are not completely equivalent (i.e., they often provide different LEED points).

If this same project rating were applied against the LEED EB rating system, it would have qualified for 14 of 18 possible points. In this particular case, the LEED EB rating would significantly overstate EAc1 points compared to LEED NC. To a lesser extent, three other projects also would have scored higher when applying the LEED EB point system compared to the relative number of LEED NC points. Interestingly, all of the projects that would have scored better under the LEED EB system were newer LEED Canada version 2009 projects. The five older version 1.0 projects would have fared better or the same when applying their rating under the LEED EB framework. In other words, differences in the code-based modelling and LEED EAc1 protocols for different versions appear to influence the comparison to our rating/EUI-based point award system.

4. DISCUSSION

The methodology for determining a building energy performance rating and associated benchmark EUI is encapsulated in an Excel workbook template built specifically for this purpose. UBC may use it to help set EUI targets to improve (i.e., lower) the existing and new building stock's energy use.

Generally, we recommend that establishing a target EUI for a given facility should *focus on setting a high performance rating* and not necessarily an absolute EUI. The rating should ideally account for how similar buildings perform in the local market. Econometric models adopted from other jurisdictions cannot fully represent all local conditions for how buildings are constructed, operated and utilized. Even within the U.S., the EPA models would surely provide for different ratings for the same building situated in different regions with varying
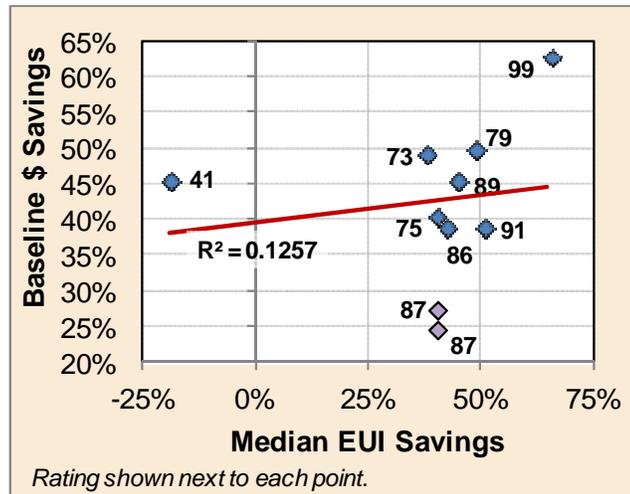
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[1] LEED Canada NC version 1.0 references MNECB and ASHRAE 90.1-1999, while the 2009 version references MNECB and ASHRAE 90.1-2007.

demographics, utility rates, conservation ethos, etc. Also, as a building's EUI is influenced by its use of electricity versus fossil fuels, this further highlights how striving for a high rating should be the prime objective.

Influence of Electricity versus Fossil Fuel

As previously explained, the energy sources used by a facility for heating purposes can have a significant influence on the facility EUI. Using electricity for heating (resistance or heat pumps) will provide for a lower metered site EUI than using natural gas to heat the same facility, for instance. But the EPA's rating approach will (correctly) penalize facilities that use proportionally more high-grade electricity over a lower-grade fuel source, i.e. the focus is on the performance of the building itself.

For UBC (and heating dominated climates in general), how a building satisfies its space and service water heating (thermal) loads has a significant influence on the rating. This is because the source of energy is weighted differently based on source-to-site energy factors. With relatively inexpensive electricity prices across many jurisdictions in Canada, combined with the cheap capital and maintenance costs of electric resistance heating, many facilities across Canada are heated via electric resistance means. An increasing number of new facilities are heated much more efficiently using heat pumps, but as this is an electric source, the energy performance rating is typically dampened in comparison to a heat pump's influence on LEED NC points, which is based on code-based modelling protocols and energy cost savings.

Figure 5 shows how the site EUI non-linearly decreases relative to the proportion of metered electricity use (with natural gas as the remaining site metered energy use). Notice that the "high performance rating" for the four respective building occupancy types remain constant. For instance, a typical new office can reach a 95 rating with a site EUI of 125 kWhe/m² if half of its site energy use came from natural gas, but would need to lower the EUI to 97 kWhe/m² if the building only used electricity.
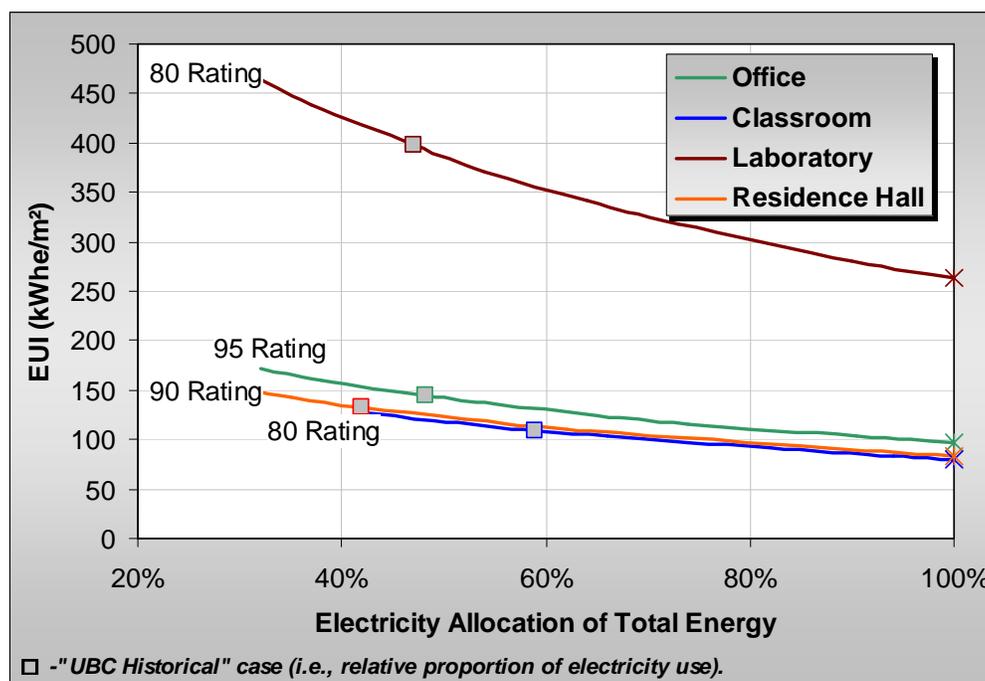
Figure 5. Influence of Electricity Allocation on the Target EUI for Suggested "High Performance" New Design Ratings

Reaching the lower EUI for the 100% electric case might be achieved with the application of efficient ground-source heat pumps. But note that this might not result in as great a benefit (e.g., score) in regard to a system like LEED NC, when compared to the same building heated via natural gas.

The lower EUI targets associated with electrically heated designs would tend to influence designs to focus more on optimizing the heating loads. Thus, if the loads are reduced enough, it becomes progressively less important how the building is heated. Even designs that might decide to select electric resistance for heating may rate and perform very well if the heating requirements are relatively minimal. This leads to better designs that place emphasis on the heating requirements over the type of equipment employed to provide the heating.

Scoring System Considerations

As previously described, some degree of localization and assessment of past LEED NC projects is warranted in order to develop a rating system that challenges projects to strive for more efficient designs, yet is not overly stringent so as to deter its use. Moreover, a building rating system must be relatively simple to apply to promote its adoption.

UBC has adapted a rating methology that is localized to its specific conditions, with different high performance rating levels applying to different building functions. On a nation-wide basis, this degree of adaptation probably would be too complicated, as it likely would be undesireable to have different scoring systems for different regions and/or building types. Hence, a nation-wide scoring system may have to be simplified such that all buildings are compared using a consistent system. This will prove more or less favourable for a given jurisdiction, building types and/or energy source conditions. Note, however, that these same issues apply to the present code-based LEED NC system.

Technically, it would not be too onerous to adapt the EPA system for non-U.S. weather locations – Natural Resources Canada (NRCan) has already added Canadian econometric models for offices and schools to the EPA system beginning in summer of 2013, and plans to add more. Further, the EPA restructured its system to be more conducive to setting performance targets for new construction. Unfortunately, with ratings for only offices and schools presently available in Canadian locations, other building types must currently use a work-around by choosing the closest U.S. site to represent their location.

The source-to-site factors for electricity that are ingrained in the U.S.-based econometric models are of particular concern for many parties in Canada because of the relative abundance of hydropower generation in Canada compared to the U.S. The econometric models that NRCan added to Portfolio Manager, in fact, applied a lower factor. But many argue the source-to-site factors should be similar for Canada since the North American electrical grid is highly integrated. In either case, we feel that the application of either the U.S.' or Canada's electric site-to-source factor should not matter much as long as the application is consistent. This observation is based on limited tests of office buildings for locations with similar weather between the two countries, which resulted in nearly identical ratings and benchmark EUIs.

There are many factors to consider if a rating/EUI-based scoring system were developed in lieu of the present code-based baseline modelling approach LEED employs. The following highlights several of the key issues.

Benefits

Applying a rating system based on econometric models of existing building performance has several advantages and drawbacks, summarized below.

Less time and effort. The level of effort required to generate an energy performance rating and associated EUI would be at least an order-of-magnitude less than manually generating a comparative baseline model. This translates to less time wasted modelling a fictitious building that does not contribute to energy efficiency of the actual new building. Further, time spent reviewing the baseline (e.g., by LEED reviewers) is dramatically reduced – even for software programs that purport to automatically generate the baseline.

Simplicity and transparency. The generation of a rating is much simpler and does not require detailed knowledge of simulation methods and/or software. Yes, proficiency with modelling still is required to represent or review the model of a new design. However, a rating can be generated and/or verified by those without any modelling expertise, as long as the modeller provides the building energy use by energy source or a representative estimate early in the design process.

More applicable protocols based on building utilization. A building rating and target EUI is influenced by the weather and mix of energy sources (to account for source energy), as well as a handful of factors that explain how the building will be used (e.g., hours of operation, number of occupants/suites, number of computers, etc.). Performance modelling for a comparative baseline also accounts for these factors. However, LEED simulation rules are arguably less consistent and can vary based on configuration, regardless of the intended building utilization. The LEED comparative baseline model can vary depending on building size, exposure and amount of glazing, HVAC system zoning and configuration, and the amount of outside air, just to name a few.

Reduction of modeller inconsistencies and mistakes. The interpretation and application of LEED modelling rules requires care and is not consistent among modellers or software programs. From numerous LEED model reviews by ourselves and others, the application of ASHRAE and MNECB baseline modelling protocols can vary widely. Luckily, in Canada, a relatively thorough and proficient review process has been in place for many years[2]. Even so, our experience, reinforced by a study of independently reviewed models, indicates that the majority of submitted baseline models inconsistently apply modelling rules and/or contain mistakes. Most are relatively minor, but a significant number were major enough that they would have changed the number of LEED points.

Weaknesses and Challenges

Several drawbacks exist with the application of a rating system to gauge new building performance in comparison to the baseline modelling approach based on energy standards/codes. A few of these are discussed below.

Applicability to all building types. As admitted by the EPA, their database of econometric models applies to about 60% of the U.S. building stock (commercial and residential over three storeys). That leaves a significant number of building types that cannot be adequately rated. This might be partly overcome through the adaptation of existing econometric models for particular conditions – as we did with the modification of the office type econometric model for lab occupancy types. And some building types might reference a similar econometric model with little or no adjustment. For instance, preliminary indicators infer that the residence hall econometric model can substitute for multi-unit residential buildings (MURBs), with a possible adjustment for parkade uses.

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[2] Until very recently, all models submitted for LEED Canada and/or Natural Resources Canada's high performance new building initiative went through a review by a qualified independent reviewer, who typically spent about one person-week checking the proposed and baseline models.

Application to a scoring system. LEED and others have established systems that award points, incentives, recognition, etc. based on progressively higher energy savings compared to baseline models. ENERGY STAR and LEED for existing buildings provide systems that award points and recognition for attaining progressively higher ratings. This might be adapted to new buildings, but warrants further study to determine the modifications required to devise an appropriate system. Simply applying the current LEED EB rating system (as it would seem the most applicable and easy to implement option) may risk being overly generous.

5. CONCLUSION

The identification of target energy use intensities (EUIs) for new designs helps promote energy efficiency and gauge/score buildings' relative performance. The application of a system to generate target EUIs needs to provide aggressive, yet realistically attainable EUI targets that account for the intended building utilization. The econometric models devised by the U.S. EPA provide a good foundation for such a system since they are based on actual building performance and factors that effectively describe how a building functions. From UBC's perspective, this provides a target that is grounded in reality, facilitating the design of new buildings that are compared to practical performance metrics instead of somewhat inconsistent code-based modelling protocols.

In adapting and testing several of the econometric models as part of the development of a Building Energy Target (BET) Tool, we have found that the EPA-based approach also promotes the reduction of a building's loads over changing its heating source. This is indirectly due to the use of source energy as the dependent variable within the econometric models, which results in energy performance ratings that effectively penalize the use of electricity for heating purposes. Hence, the approach of selecting a heat pump that has appeared quite favourable for points awarded by LEED, is less successful when a design attempts to reach an equivalent BET rating by using heat pumps versus natural gas or district heat to serve the building heating needs. This contributes to better designs that focus on reducing heating loads first, before selecting the type of equipment to serve the space and service water heating.

Because of the variations in a design with respect to its utilization and/or energy sources, we recommend basing a potential scoring system on the energy performance rating and not explicitly the comparative benchmark EUI. What constitutes a reasonable scoring system, however, would require further study that focuses the applicable commercial buildings market. The scoring system applied by LEED EB, for instance, may serve as a good starting point. However, further investigation as to its appropriateness for new building models is warranted, as we have found LEED NC models often produce ratings that would score near the maximum number of LEED EB points available. Hence, a likely upward, and possibly non-linear, shift in the scoring system may be appropriate.

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