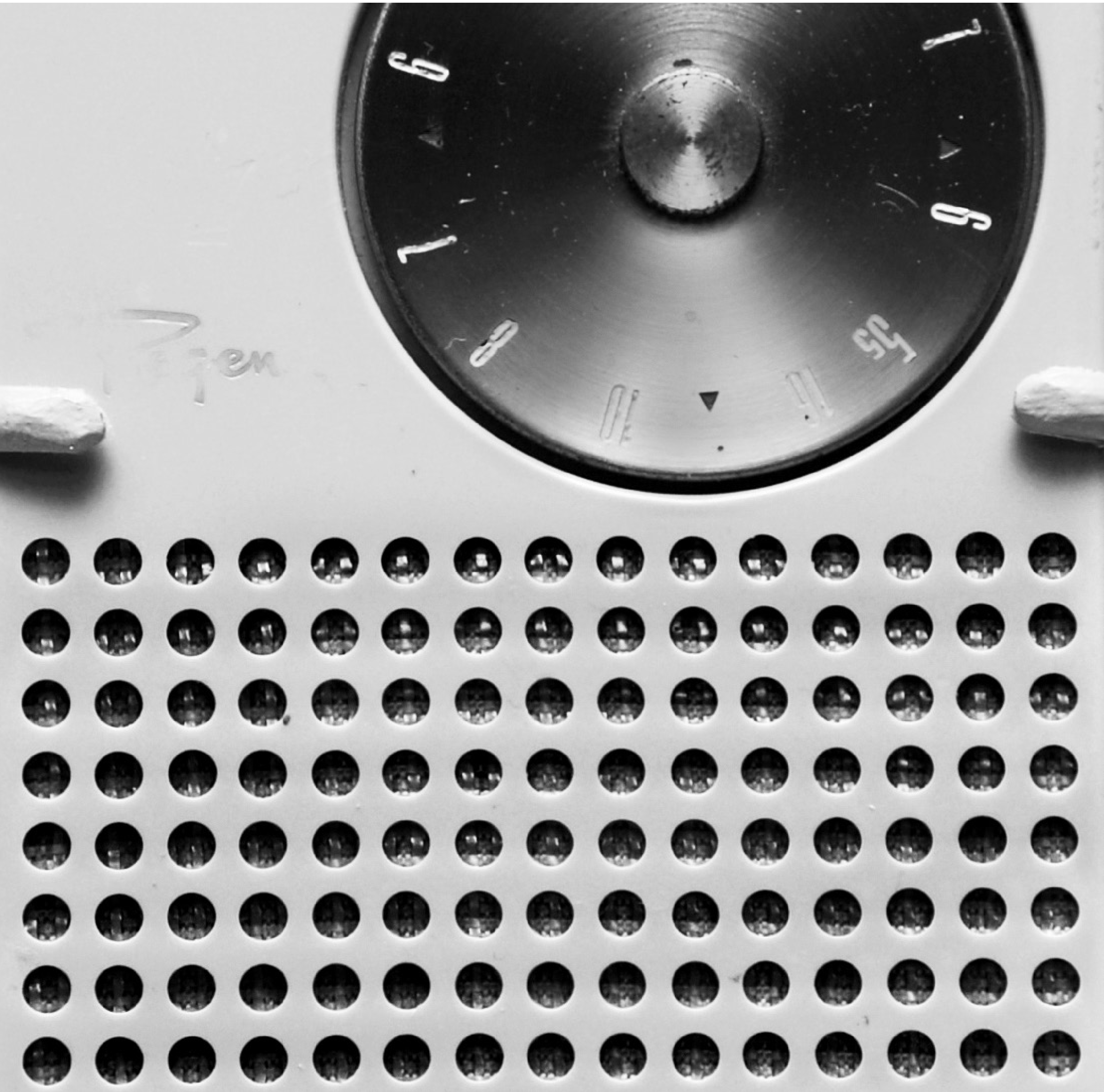
Perkins&Will

Research Journal

2009 / VOL 01.01



03.
CHOOSING THE RIGHT GREEN BUILDING RATING SYSTEM
An Analysis of Six Rating Systems and How They Measure Energy

Michael Driedger, BA Dipl.T., LEED® AP, *michael.driedger@busbyperkinswill.ca*

ABSTRACT
This paper is based on a technical report that was intended to provide the University of British Columbia's (UBC) Sustainability Office with a potential strategy to move the Point Grey Campus to carbon neutrality without the purchase of carbon offsets by 2030 and to recommend a green building rating system that would form part of this strategy. The paper will focus on the analysis of the following green building rating systems and how they measure energy and carbon.
• BOMA Go Green (Canada and the US)
• BREEAM (UK)
• Green Star (Australia)
• Passive House (Germany and the US)
• The Living Building Challenge (Canada and the US)
• LEED® (Canada and the US)
The paper will look at available rating systems for new and existing buildings, but will not cover single family residential rating systems.

KEYWORDS: Green Building, Rating Systems, Carbon, Energy

1.0 INTRODUCTION
The Architecture 2030 Challenge, along with the USGBC and CaGBC's adoption of a more stringent energy standard for LEED, demonstrates an increasing focus on energy efficiency. This is nothing new to the green building industry; however the increasing emphasis on energy's carbon emissions is indicative of our urgency to address climate change.

It is not uncommon for a client to ask, "Which green building rating system standard will result in the greatest reduction on our carbon footprint?" While this is a very legitimate question there are very few straightforward answers. The Architecture 2030 Challenge was meant to address the lack of clarity in the industry however the need for building ratings remains.

This report is based on the UBC Sustainability Office's commissioning of a report by Busby Perkins and Will to help answer one question:

- What green building rating system for new and existing construction would be most appropriate to UBC's Point Grey campus, given the University's goals for greenhouse gas emission reductions?

The report looked at: BOMA Go Green, BREEAM, Green Star, Passive House, The Living Building Challenge and LEED.

2.0 PAPER METHODOLOGY
Given the objective of this study, this section provides clarity regarding the terminology used pertaining to greenhouse gas emissions and criteria used to rank and evaluate the green building ratings systems.

Any general references to GHG, GHG emissions or carbon within this document refer to a gross emissions estimate, for six greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro fluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Therefore, the common terms of GHG, GHG emissions, carbon and CO_2 are more specifically in reference to CO_2 equivalence (CO_2e), which indicates the relative contribution of each gas to global average radiative forcing on a 100-year Global Warming Potential (GWP)1.

The majority of clients are interested in green building rating systems that could help them meet GHG reduction targets. This report therefore, outlines only those ratings systems that are applicable to a North American climatic zone and are available in English. The following criteria have been developed for evaluating and prioritizing green building rating systems:

- *Criteria #1: Effectiveness at reducing CO2 emissions.* Effectiveness is measured by the rating system's rigour regarding energy reduction and therefore, CO2e reductions, as well as the rating system's ability to accurately measure CO2e. This criterion has been multiplied by a factor of two in order to reflect the importance of CO2 reductions. Both LEED and Green Globes have been analyzed as though 5 (LEED) and 50 (Green Globes) energy credits were the energy minimums. The importance of a rating system's effectiveness at accurately measuring and reducing GHG emissions is therefore the most important criteria. To demonstrate this, all scores are multiplied by a factor of 2.
- *Criteria #2: Cost of certification.* This includes the cost of registration and certification and does not include soft costs associated with documentation and energy modeling. Costs can range from no cost to very expensive (relative to no cost self assessments) as defined in the table below.
- *Criteria #3: Market adoption and ease of use in its country of origin.* This refers the capacity on the part of the provider to respond to user needs in the marketplace. "Ease of use" is defined as the amount of documentation required for certification under the rating system. Criterion 3 is further defined in the table below.

Table 1: Rating system ranking criteria.

SCORE	CRITERIA #1 Effectiveness at reducing CO2	CRITERIA #2 Cost of Certification	CRITERIA #3 Adoption and ease of use in North America
0	Does not address the criteria.	Very Expensive >$10,000	No North American market adoption unable to respond to user needs
1	Addresses the criteria by prompting action but without measuring carbon or setting an energy minimum	Expensive $5,000 - $10,000	Some North American market adoption and able to respond to user needs
2	Somewhat addresses the criteria, but does not have effective tools for measuring CO2	Moderate cost $2,000 - $5,000	Good North American market adoption and the provider plans to respond to user needs
3	Addresses the criteria by measuring carbon and the provider plans to add regional accuracy to carbon measurement and raise the energy minimum.	Low cost $1 - $2,000	Strong North American market adoption and the provider responds to user needs
4	Fully addresses the criteria of reducing carbon	No Cost $0	Best North American market adoption and the provider actively responds to user needs

3.0 ANALYSIS OF RATING SYSTEMS, CHALLENGES, AND CODES

An analysis of various green building rating systems, challenges and energy codes is outlined in section 3. A summary and recommendation of the most appropriate rating system is presented in section 4 of this paper.

3.1 Green Building Rating Systems

A summary of the following green building rating systems is provided in this section: the LEED Green Building Rating System, Green Globes, BOMA Go Green and Go Green Plus, BREEAM, Passive House, Green Star and the Living Building Challenge. For each rating system a description of the energy standard, certification procedure and estimated cost of certification is provided.

3.1.1 Leadership in Energy and Environmental Design (LEED) Summary

The Canada Green Building Council (CaGBC) and United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) Green Building Rating System is a voluntary and consensus

based rating system used by a diversity of market sectors in Canada and the United States as the certification Benchmark for high performance green buildings.
LEED is a system made up of prerequisites and credits. All prerequisites must be achieved in order to seek LEED certification. If a project can not meet a prerequisite, then the project can not seek certification with either the USGBC or CaGBC. The system is divided into 5 environmental categories and a sixth category for Innovation and Design:

- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality
- Innovation and Design

Achieving a certain number of credits will determine what level of certification a project will receive. There are four levels of certification:

- Certified
- Silver
- Gold
- Platinum

The difference between registration and certification is an important distinction. A "Certified" building is one that has gone through the rigorous process of third party assessment upon completion of the project. Whereas a registered project is one that is under design and will most likely pursue final certification upon occupancy.

There are a number of LEED "products" available in the marketplace including, but not limited to:

- LEED NC (for New Construction & Major Renovation projects), available in Canada
- LEED EB (for Existing Building minor renovations and operational efficiencies), available in Canada in 2009
- LEED CI (for Commercial Interiors or other tenant improvements), available in Canada
- LEED CS (for Core and Shell developments for developer driven projects), available in Canada

There are also two new rating systems, LEED for Homes (H), and LEED for Neighbourhood development (ND), which will not be discussed in this paper.

The Canada Green Building Council will be rolling out LEED 2009, the next iteration of LEED for the Canadian market place in the fall of 2009. LEED Canada 2009 will closely parallel LEED 2009 by the USGBC and it will assess projects based on the new 110 point scorecard.

To further emphasize the role that buildings play on the environment, the USGBC has mandated that all LEED for New Construction 2.2 and Core and Shell 2.0 buildings must achieve the first two energy and atmosphere credits and will automatically (at no cost) be registered for LEED for Existing Buildings. This increased energy requirement will result in a minimum energy reduction of 20% for all new projects. This requirement has not yet been adopted by the CaGBC, but will appear when the CaGBC launches LEED 2009.

LEED for New Construction
LEED NC 1.0 was the first product released by the USGBC and CaGBC. LEED NC is designed to assess the performance of new or major renovations of largely owner occupied buildings, such as commercial and institutional buildings.

Since we are interested specifically in how effective a rating system is at reducing GHG emissions, the analysis in Table 2 was prepared to assess the energy performance of 5 energy credits for 7 LEED projects in BC. It compares the energy intensity for a building that is 35% better than ASHRAE 90.1-1999 (i.e., 5 LEED Energy credits); however White Rock Operations Facility and Dockside Green Synergy were left as they were modeled to give a sense of the energy intensity ranges associated with percentage energy reductions. A column has also been added for heating energy intensity in order to assess the feasibility of using the Passive House Standard (see Section 3.1.5).

The New Buildings Institute released a study of 121 LEED NC buildings in March of 2008, that outlined the average energy intensity of buildings built to varying LEED certification levels. The study, completed for the USGBC, revealed that the average energy intensity for LEED Gold buildings was 161 kwh/m²/yr. This analysis did not account for the number of energy credits pursued or the building type. Rather, this data included projects that achieved between 0 to 10 energy credits, buildings from Arizona to Alaska and lab buildings to largely empty warehouses. The study largely surveyed: interpretive centres, K-12 schools, libraries, mixed-use buildings, multi-unit residential buildings, office buildings, municipal buildings, lab buildings and a range of miscellaneous buildings.

As the data in Table 2 will testify, it is difficult to conclude average energy intensity for an energy standard that is meant to be relative to a reference building in a specific climate.

Table 2: Comparative modeled energy performance for LEED New Construction Buildings[7].

Building Name; Location, Energy Credits	Total Energy Intensity (kWh/m²/yr)	Heating Energy Intensity (kWh/m2/yr)	Building Type	Source	Location
Computer Sciences Building University of Victoria based on 5 credits	130	3 - Electric	Office, Class, Lecture	CaGBC Letter Templates	Victoria, BC
Vento based on 5 credits	197	97.8 - Natural Gas	Multi-unit Residential	CaGBC Letter Templates	Calgary, AB
Aquatic Ecosystems Resource Lab (UBC) based on 5 credits	123	71 - Natural Gas (Steam)	Lab, Class, Lecture	CaGBC Letter Templates	Victoria, BC
Life Sciences Building (UBC) based on 5 credits	1,378	667 - Natural Gas (Steam)	Lab	CaGBC Letter Templates	Victoria, BC
White Rock Operation Facility based on 8 credits	81	17 - Mixed	Office	CaGBC Letter Templates	White Rock, BC
Dockside Green Synergy based on 10 credits	98	3 – Biomass	Multi-unit Residential	CaGBC Letter Templates	Victoria, BC
Average Gold Building energy credits vary	160	Data not available	All types from lab to empty warehouses	New Buildings Institute Study 2008	Throughout the U.S.

LEED for Existing Buildings

LEED EB-O&M (Operations and Maintenance) is one of the newest rating systems developed by the USGBC. The documentation is designed to be completed by operations and maintenance staff and focuses on actual building performance data and improvements. Currently only buildings in which 75% of the spaces meet the standard can be certified under this rating system. This eliminates a single floor in a building from achieving LEED EB-O&M certification. For a building to retain its LEED certification status it must re-register and certify under LEED EB-O&M every 5 years. The intention is to ensure that a building is performing as designed and for improvements to be made during the operational stage of the building. LEED EB-O&M is currently being reviewed and adapted by the CaGBC and will be launched in summer of 2009.

The most applicable credits to this paper pertain to the Energy and Atmosphere section. This rating system is the only system that awards a project for reporting GHG emissions through formal participation in a third-party voluntary reporting or certification program. There is also the option of using a calculation methodology of a technically sound third party voluntary reporting or certification protocol with a performance period between three months and 2 years.

There are 4 credits for building energy and water metering that address load patterns and occupant behavior. For example, LEED EB-O&M requires that a building measure one water source for each water credit (i.e., intake water for 1 credit and the addition of heated water for a second credit). Similarly, it requires that a building separate at least one energy load (such as lighting) for 1 credit and at least 2 loads (e.g., lighting and plug loads) for 2 credits. The advantage of measuring specific loads in existing buildings is that it enables operations staff to implement more effective building energy efficiency measures based on actual occupant use patterns.

The following table outlines the various LEED products and relevant energy code or standard it references.

Table 3: LEED product and applicable energy standard.

PRODUCT	ENERGY STANDARD
LEED NC Canada 1.0	ASHRAE 90.1 1999 and the MNECB
LEED NC USGBC 2.2	ASHRAE 90.1 2004
LEED EB for Operations and Maintenance	Energy Star
LEED CI Canada	ASHRAE 90.1 2004 E-Benchmark Commercial Building Incentive Program
LEED CI US	ASHRAE 90.1 E-Benchmark
LEED CS	ASHRAE 90.1 2004
LEED H US	Energy Star using Home Energy Rating System (HERS)
LEED H Canada	EnerGuide and HERS

LEED Summary Energy Summary

While the new LEED EB for Operations and Maintenance is the only LEED product with a credit for carbon reporting, all other LEED products track carbon through the LEED letter template. The Canadian LEED letter template shows not only total energy reduction, but also total carbon reduced in tonnes. The GHG emissions reduction values generated within the template are based on Environment Canada's GHG emissions inventory 1990-2002 data (average intensity for Canada, which is approximately 270 tonnes CO2e/GWh)[6] with an adjustment factor to account for line losses and upstream emissions. Therefore, the GHG emissions calculation within the letter template does not accurately reflect the energy mix (of approximately 84 tonnes CO2e/GWh) used in British Columbia or any other province.

A LEED NC, CS or CI certified building in Canada can cost anywhere between $3,675 to $17,000 to register and certify based on square footage and whether a full energy review is requested. A LEED EB-O&M project (registered with the USGBC) typically costs $3,000 to $8,000 to register and certify.

Table 4: LEED summary.

Rating System	Energy Standard	Energy Minimum	Criteria #1 CO2 Reduction	Criteria #2 Cost	Criteria #3 Market Adoption	Total Score
LEED NC, CS or CI (Canada)	ASHRAE 90.1 and MNECB	35% better than ASHRAE; 42% better than MNECB	6 points	0.5 points	3 points	9.5 points
LEED EB (U.S. and Canada in 2009)	Energy Star or EnerGuide	20% better than National Average	6 points	1.5 points	3 points	10.5 points

Table 5: LEED ranking criteria summary.

Rating System	Criteria #1 CO2 Reduction		Criteria #2 Cost		Criteria #3 Market Adoption	
LEED NC, CS or CI (Canada)	3 points: Addresses the criteria by measuring carbon and the provider plans to add regional accuracy to carbon measurement and raise the energy minimum.	3x2= 6 points	$3,675 to $17,000 to register and certify	0.5 points: Between Expensive and Very Expensive	Strong North American market adoption and the provider responds to user needs	3 points
LEED EB (U.S. and Canada in 2009)	3 points: Addresses the criteria by measuring carbon and the provider plans to add regional accuracy to carbon measurement and raise the energy minimum.	3x2= 6 points	$3,000 to $8,000 to register and certify	1.5 points: Between Moderate and Expensive	Strong North American market adoption and the provider responds to user needs	3 points

3.1.2 Green Globes

Green Globes is a system developed using the Building Research Establishment's Environmental Assessment Method (BREEAM). In 1996, the Canadian Standards Association (CSA) published BREEAM Canada for Existing Buildings. In 2000, the system became an online assessment and rating tool under the name Green Globes for Existing Buildings. In the same year, the Canadian Department of National Defense and Public Works and Government Services developed a system for the design of new buildings. The product underwent a further iteration in 2002 by a team of representatives from Arizona State University, the Athena Institute, BOMA and several federal departments including Public Works and Governments Services and Natural Resources Canada.

Projects are awarded points based on their performance in seven areas of assessment in the New Construction module and six in the Existing Building module. The checklist (or scorecard) for the New Construction module is organized by green building practices as well as the sequence of the design process. The project dashboard is divided into 6 project delivery phases:

- Pre-design Project Initiation
- Pre-design Site Analysis
- Design Development
- Construction Documents
- Contracting and Construction
- Commissioning

Each of these phases is subdivided into seven assessment areas: Project Management, Energy, Indoor Environment, Site, Water, Resources, and Emissions (similar to Indoor Environmental Quality in LEED). Projects complete an online questionnaire at the end of each stage, in addition to offering project design teams suggestions aimed at reducing the building's overall environmental impact. Green Globes has dedicated most of its points to energy performance, however there are no specific energy targets. Much like LEED EB-O&M, Green Globes uses performance benchmark criteria to evaluate the probable energy consumption of a building. The existing building module compares a building's energy performance against data generated by the EPA's Target Finder (Energy Star), which reflects real building performance. The New Construction Module uses the Canadian Model National Energy Code for modeled building comparison.

Green Globes can be used for self-assessment, but if a project team wishes to claim compliance with a specific Green Globe certification, a third-party review of the documentation is required. Official certification is obtained through the submittal of required project documentation as well as a project walk-through by regional reviewers. Projects are awarded a final rating of one (35–54 percent), two (55–69 percent), three (70–84 percent) or four (85–100 percent) globes based on cumulative point totals.

The entire rating system is based on 1000 total points with 380 points allocated to energy. The 380 points are distributed over 5 different energy credits that address: energy performance, energy demand, energy systems, renewable energy and transportation energy. The most relevant sections to this study are Credit 1 (energy performance) and Credit 3 (integration of energy efficient systems).

Credit 1 for energy performance allocates 100 points and projects must employ a design that meets the energy performance targets below:

- less than 258 kWh/m²/yr, which is 20% more efficient than MNECB
- less than 215 kWh/m²/yr, which is 25% more efficient than MNECB
- less than 194 kWh/m²/yr, which is 30% more efficient than MNECB
- less than 172 kWh/m²/yr, which is 35% more efficient than MNECB
- less than 151 kWh/m²/yr, which is 40% more efficient than MNECB
- less than 130 kWh/m²/yr, which is 45% more efficient than MNECB
- less than 108 kWh/m²/yr, which is 50% more efficient than MNECB

The Green Globe rating system has attempted to conclude an average energy intensity can be inferred from an energy standard that is meant to be relative to a reference building in a specific climate. As noted in section 4.1.1, it is very difficult to draw a parallel to energy intensity and a percentage energy reduction relative to MNECB or ASHRAE.

A 50% reduction or more is worth 100 points and a 40% reduction is worth 50 points (roughly equivalent to 5 energy credits under LEED NC). For a detailed comparison of Green Globes and LEED please see Table 6.

Credit 3 for integration of energy efficient systems is worth 66 points and requires specific energy efficient technologies, such as:

- High-efficiency lamps and luminaries with electronic ballasts
- Lighting controls
- Energy-efficient HVAC equipment.
- High efficiency or condensing type boilers or other higher-efficiency heating systems (e.g. infrared heating in industrial buildings)
- High efficiency chillers
- Energy-efficient hot water service systems
- Building automation systems
- Variable speed drives
- Energy-efficient motors on fans/pumps
- Energy-efficient elevators
- Other energy-saving systems or measures (i.e., displacement ventilation, cogeneration systems, heat recovery system, etc).

Table 6: Green Globe / LEED Energy credit comparison.

Green Globes	Green Globes Points	LEED MNECB Value	LEED Points
20%	10	24%	1
25%	20	29%	2
30%	30	33%	3
35%	40	38%	4
40%	50	42%	5
42%	60	47%	6
44%	70	51%	7
46%	80	55%	8
48%	90	60%	9
50%	10	64%	10

Most of the process is online and "third party verification" amounts to the design being assessed by a verifier. A verifier is either a licensed architect or building engineer with knowledge and experience of green building technologies and integrated design. Once the verification is complete, the project is awarded a Green Globes certificate. The verifiers under this system would not be considered third party verification under LEED as there are no rules that the verifier can not be part of the design team. There are a number of conflicts of interest inherent in the Green Globes assessment methodology and little documentation is required for an assessment of a project.

Table 7: Green Globes summary.

Rating System	Energy Standard	Energy Minimum	Criteria #1 CO2 Reduction	Criteria #2 Cost	Criteria #3 Market Adoption	Total Score
Green Globes (New Building Module)	MNECB	None defined	4 points	3 points	2 points	9 points
Green Globes (Existing Building Module)	Energy Star	None defined	4 points	3 points	2 points	9 points

Table 8: Green Globes ranking criteria summary.

Rating System	Criteria #1 CO2 Reduction		Criteria #2 Cost		Criteria #3 Market Adoption	
Green Globes (New Building Module)	2 points: Some what addresses the criteria. Does not have effective tools for measuring carbon	2x2= 4 points	$250 to $500 for self assessment and verification	3 points: Low cost	Good North American market adoption and the provider plans to respond to user needs	2 points
Green Globes (Existing Building Module)	2 points: Some what addresses the criteria. Does not have effective tools for measuring carbon	2x2= 4 points	$250 to $500 for self assessment and verification	3 points: Low cost	Good North American market adoption and the provider plans to respond to user needs	2 points

A Green Globes existing or new building in Canada can cost anywhere between $250 for a self assessment and an additional $500 for a verifier to certify the building.

3.1.3 Building Owners and Managers Association (BOMA) Go Green and Go Green Plus

BOMA Go Green and Go Green Plus are voluntary programs designed for existing or occupied buildings. It is offered by BOMA Canada as a service to all member and non-member commercial building owners. It is not the intent of this program to direct building owners on how to manage their buildings, but simply to recognize those buildings where environmental best practices have been implemented into the operations.

Criteria for the BOMA Go Green program were established following consultation with the building industry. The underlying premise to the criteria development was a belief that most buildings are currently managed by professionals who have implemented, or are planning to implement, good environmental practices into daily operations.

Notable requirements for the program include an energy audit and preventative maintenance programs. An energy audit of the applicant's building must have been performed within the past three years for the building to be eligible for certification. Building management staff must also have a written plan to address energy issues raised in the audit and must have in place a heating, ventilation and air conditioning (HVAC) preventative maintenance program.

Energy audit requirements are for a 'Phase 1' audit. This is an energy inventory performance analysis with a plan that identifies energy reduction opportunities. It does not require a capital cost analysis. An energy audit may cost anywhere from $4,000 and upwards. The audit may be completed by 'in-house' technical staff provided the audit and report meet the minimum standard of practice as specified in the BOMA reference guide. There are three alternative means of compliance for the energy audit requirement, which are as follows:

- Buildings that are less than three (3) years old may provide a design energy report produced during the design of the original building.
- Buildings that have over 75% of the total energy consumption directly purchased by tenants may provide an energy communications plan that encourages conservation by tenants in lieu of an energy audit.
- Buildings that have had an energy audit performed more than three years ago, but less than five years ago, and have implemented the majority of measures recommended in the audit may provide an energy update report in lieu of a new energy audit. This report must identify which conservation measures have been implemented since the time of the original report.

A Go Green or Go Green Plus certified building can cost anywhere between $750 to $7,000 based on square footage and whether the submission comes from a BOMA member or non member.

Table 9: Go green and go green plus summary.

Rating System	Energy Standard	Energy Minimum	Criteria #1 CO2 Reduction	Criteria #2 Cost	Criteria #3 Market Adoption	Total Score
BOMA Go Green Go Green Plus (U.S. and Canada)	Energy Audit	None defined	2 points	3 points	2 points	7 points

Table 10: Go Green and Go Green Plus Ranking Criteria Summary.

Rating System	Criteria #1 CO2 Reduction		Criteria #2 Cost		Criteria #3 Market Adoption	
BOMA Go Green Go Green Plus (U.S. and Canada)	1 point: Addresses the criteria by prompting action but without measuring carbon or setting an energy minimum	1x2= 2 points	$750 to $700 for self assessment and verification	3 points: Low cost	Good North American market adoption and the provider plans to respond to user needs	2 points

For buildings that have completed energy audits there is not a great deal of additional GHG reductions offered by using Go Green or Go Green Plus. The same could also be said for BOMA as the system does not require close analysis of an existing building's operations and maintenance.

3.1.4 Building Research Establishment Environmental Assessment Method (BREEAM)

As part of a mandate from the UK Government, the Building Research Establishment (BRE) has developed specific tools and packages for sustainable development.

For the purposes of design of new buildings and the renovation of existing ones, BRE developed the BRE Environmental Assessment Method (BREEAM) rating system in 1990, in conjunction with a series of targeted guidelines and working methodologies that have since been integrated into the British building code. Part L of the U.K. building code stipulates regulations on energy use and has recently been updated. Included in Part L are regulations governing the following:

- Energy Performance of Buildings
- Methodology of calculation of the energy performance of buildings using the Standard Assessment Procedure (SAP 2005)

- Consequential improvements to energy performance
- CO2 emission rate calculations
- Quality of Construction including testing
- Operations + maintenance info

BREEAM uses the Standard Assessment Procedure (SAP) as its energy performance standard. SAP is a detailed assessment method that incorporates many variables into the data that drives the final rating, a scale from 1 to 100, where 100 is zero net carbon emission. This is very similar to an EnerGuide rating.
SAP covers the following categories:

- Dwelling dimensions
- Ventilation rate
- Heat losses
- Domestic hot water
- Internal gains
- Solar gains + utilization factors
- Mean internal temperature
- Degree days
- Space heating requirements
- Total energy use + fuel costs
- Energy cost rating
- CO2 emissions + primary energy
- Building regulations

There are 5 performance levels and for each standards (such as water or energy). The performance levels are as follows:

- Pass (P)
- Good (G)
- Very Good (VG)
- Excellent (E)
- Outstanding (O)

The rating system functions much like an International Standards Organization (ISO) certification and requires a great deal of documentation. The BREEAM Assessor Manuals are technical guidance documents that aid licensed BREEAM Assessors in carrying out project assessments.

The number of credits achieved under the energy section is determined by comparing the building's CO2 index (EPC Rating) taken from the Energy Performance Certificate (EPC). There is no energy or CO2 minimum for buildings that are less than VG (Very Good). The minimum standard for an E (Excellent) rating is an EPC index of 40 for new buildings and 47 for existing buildings.

The cost for an assessment is approximately £1,500 (approximately Canadian $3,000); however there are no assessors in Canada.

Table 11: BREEAM summary.

Rating System	Energy Standard	Energy Minimum	Criteria #1 CO2 Reduction	Criteria #2 Cost	Criteria #3 Market Adoption	Total Score
BREEAM (U.K.)	SAP 2005	Excellent rating= EPC of 47	6 points	2 points	0 points	8 points

Table 12: BREEAM ranking criteria summary.

Rating System	Criteria #1 CO2 Reduction		Criteria #2 Cost		Criteria #3 Market Adoption	
BREEAM (U.K.)	3 points: Addresses the criteria by measuring carbon and the provider plans to add regional accuracy to carbon measurement & raise the energy minimum but regional accuracy will be for the U.K.	3x2= 6 points	Approximately $3,000 Canadian	2 points: Moderate cost	No North American market adoption unable to respond to user needs	0 points

3.1.5 Passive House

The Passive House (Passivhaus in German) program was developed by the Passivhaus Institute in Germany in 1996 and is a rigorous, voluntary standard for energy use reduction in buildings. The goal of the program and associated methodology is to achieve ultra-low energy buildings that require little energy for space heating or cooling. The voluntary standard is not confined only to houses. Several office buildings, schools, kindergartens and a supermarket have also been constructed to the standard. Although it is mostly applied to new buildings, it has also been used for building refurbishments.

Since the inception of the tool, more than 6,000 Passivhaus buildings have been constructed in Europe, most of them in Germany and Austria, with others in various countries world-wide. In North America, the first Passivhaus was built in Urbana, Illinois in 2003, and the first to be certified was built in Waldsee, Minnesota, in 2006. The Passive House Institute U.S. certifies and commissions homes built to the Passive House standard in North America.

A building that achieves the Passive House standard typically includes:

- very good levels of insulation with minimal thermal bridges
- well thought out utilization of solar and internal gains
- excellent level of air tightness
- good indoor air quality, provided by a whole house mechanical ventilation system with highly efficient heat recovery

By specifying these features the design heat load is limited to the load that can be transported by the minimum required ventilation air. Thus, a Passive House does not need a traditional heating system or active cooling to be comfortable to live in - the small heating demand can be typically met using a compact services unit that integrates heating, hot water and ventilation in one unit (although there are a variety of alternative solutions).

Performance characteristics of a Passive House building are:

- Airtight building shell <or= 0.6 ACH @ 50 pascal pressure, measured by blower-door test
- Annual heat requirement <or= 15 kWh/m2/year
- Primary Energy <or= 120 kWh/m2/year

In addition, the following are recommendations varying with climate:

- Window u-value <or= 0.8 Watt/m2/K
- Ventilation system with heat recovery with <or= 75% efficiency with low electric consumption @ 0.45 Wh/m3
- Thermal Bridge Free Construction <or= 0.01 W/mK

These figures are verified at the design stage using the Passive House Planning Package (PHPP). The building science research behind PHPP gives a building's detailed heat load, heat loss and primary energy usage. The latest version of the PHPP also estimates cooling, cooling loads and latent cooling loads. Based on feedback gathered from several completed buildings, the software is frequently refined and incorporates updated calculations for various climates around the world.

The use of "primary energy" allows for a comparison of different buildings independent of the type of energy source. For example, the primary energy factor used in the PHPP software for electricity is 2.7 kWh primary/kWh final. As a result, a building using only electricity would have a 120 kWh/m^2/yr final energy intensity, but a 44 kWh/m^2/yr primary energy intensity. This allows the fuel sources to be factored according to its GHG profile, as most countries in Europe and most U.S. States have power sources that carry a heavy GHG footprint.

The PHPP software contains a series of excel spreadsheets that allow building designers to verify energy demand based on inputting data into cells that calculate the performance characteristics required of a Passive House. The PHPP spreadsheets also measures CO2e using the same emissions factors as LEED NC 1.0 from the CaGBC (electricity at approximately 270 tonnes of CO2e/GWh versus the BC average of 80 tonnes of CO2e/GWh). While the energy performance criteria are rigorous, the PHPP tool appears to constrain design in that it requires designers to limit the use of operable windows and glazing ratios as they are not factored within the software or allowed within the design principles. The software does assume that all HVAC systems will employ heat recovery. The software and design principles assume that only the heat actually stored in the interior air extracted by the ventilation system can be reused in the building and that windows would never be used for ventilation. This would eliminate free cooling and heating from operable windows during shoulder seasons by occupants on the perimeter of the building. As a result, any addition of window ventilation may yield higher than 15 kWh/m^2/yr energy consumption.

While the Passive House standard has been used on only a few buildings greater than 2 stories, its simple requirements could be applied to larger buildings since a secondary school, libraries, warehouses and postsecondary trade school have been certified in Europe. All of these building types typically have low energy intensities, but a building with higher energy intensities such as a lab or academic facility with many computers, may be able to meet some of the criteria of the Passive House Standard. The plug loads in a lab or facility with many computers and servers will typically exceed 120 kWh/m^2/yr, but the air tightness and heating demand criteria of Passive House could be met.

The PHPP software costs approximately $180 and the cost for a Passive House rating is approximately $1,500 for a 2000 SF home, and for larger projects the cost will proportionately increase. The institute requires construction photos and a signed statement by the contractor that everything has been built according to the drawings and specifications provided for review. A blower-door test result from an independent agency is required to prove that the building complies with the specified air tightness requirement. The Institute then files all the information provided, verifies it and issues the certificate “Quality Approved Passive House” if all criteria are met.

Table 13: Passive house summary.

Rating System	Energy Standard	Energy Minimum	Criteria #1 CO2 Reduction	Criteria #2 Cost	Criteria #3 Market Adoption	Total Score
Passive House	Energy Intensity	Maximum Energy <120 kWh/m^2/yr	6 points	3 points	0 points	9 points

Table 14: Passive house ranking criteria summary.

Rating System	Criteria #1 CO2 Reduction		Criteria #2 Cost		Criteria #3 Market Adoption	
Passive House	3 points: Addresses the criteria by measuring carbon and the provider plans to add regional accuracy to carbon measurement and raise the energy minimum.	3x2= 6 points	Approximately $1,700 for a 2000 ft2 home including design tools	3 points: Low cost	No North American market adoption unable to respond to user needs	0 points

3.1.6 Green Star

Green Star is an Australian national, voluntary environmental rating scheme that evaluates the environmental design and achievements of buildings. Green Star was developed for the property industry in 2003 by the Green Building Council of Australia (GBCA) in order to establish a common language and set a standard of measurement for green buildings.

Green Star covers a number of categories that assess the environmental impact that is a direct consequence of a project’s site selection, design, construction and maintenance. The nine categories included within all Green Star rating tools are:

- Management
- Indoor environment quality
- Energy
- Transport
- Water
- Materials
- Land use & ecology
- Emissions
- Innovation

These categories are divided into credits, each of which addresses an initiative that improves or has the potential to improve the environmental performance of a building. Points are awarded in each credit for actions that demonstrate that the project has met the overall objectives of Green Star.

Once all claimed credits in each category are assessed, a percentage score is calculated and Green Star environmental weighting factors are then applied. Green Star environmental weighting factors vary across Australia's states and territories to reflect diversity of environmental concerns.

The following Green Star Certified Ratings are available:

- Star Green Star Certified Rating (score 45-59) signifies 'Best Practice'
- 5 Star Green Star Certified Rating (score 60-74) signifies 'Australian Excellence'
- 6 Star Green Star Certified Rating (score 75-100) signifies 'World Leadership'

Although Green Star certification requires a formal process, any project can freely download and use the Green Star tools as guides to track and improve its environmental performance. A project cannot publicly claim or promote a Green Star rating or use the Green Star rating logo unless the GBCA has validated the project's achievement through a formal assessment process.

Green Star Certification is a formal process that involves a project using a Green Star Rating Tool to guide the design or construction process during which a documentation-based submission will need to be collated as proof of this achievement. The GBCA will commission a panel of third-party Certified Assessors to validate that the documentation is in compliance with all the claimed credits. There are two rounds of third party assessment available to a project. If the desired Certified Rating is not awarded in the first round, a project may, in limited circumstances, be eligible to appeal the certification.

Under the energy section, the Energy Calculator measures CO2 in kg/CO2e-m²/annum as assessed by the Australian Building Greenhouse Rating (ABGR) Validation Protocol. A lower CO2 footprint will result in more points awarded. It is required that a project emit no more than 110 kg/ CO2e-m²/annum to be eligible for a Green Star rating. This means that the energy intensity value (measured in kWh/m²/yr) will vary by state in order to meet the national minimum CO2 intensity (measured in kg/ CO2e-m²/annum). The energy calculator only has emissions factors for states in Australia. In certain states the CO2 emissions factors for gas are not available for the purposes of the calculator. In that case a higher national average is used. If a project does not emit CO2, then the project receives the maximum score of 20 points.

The cost of assessment is between $4,000 and $18,000

Table 15: Green star summary.

Rating System	Energy Standard	Energy Minimum	Criteria #1 CO2 Reduction	Criteria #2 Cost	Criteria #3 Market Adoption	Total Score
Green Star (Australia)	ABGR Validation Protocol	110 kg/ CO2e-m²/ annum or 117 kWh/m²/yr	6 points	1 point	0 points	7 points

Table 16: Green star ranking criteria summary.

Rating System	Criteria #1 CO2 Reduction		Criteria #2 Cost		Criteria #3 Market Adoption	
Green Star (Australia)	3 points: Addresses the criteria by measuring carbon and the provider plans to add regional accuracy to carbon measurement and raise the energy minimum.	3x2= 6 points	$4,000 to $18,000 to register and certify	1 point Moderate cost	No North American market adoption unable to respond to user needs	0 points

Australian dollars (approximately $3,900 -$17,560 Canadian dollars).

3.1.7 The Living Building Challenge
The Cascadia Region Green Building Council (a cross border chapter of the CaGBC & USGBC) in 2006 issued a challenge to all building owners, architects, design professionals, engineers and contractors to build in a way that provides for a sustainable future. While the program is referred to as a "challenge", the Cascadia Region Green Building Council will issue "Living" status to buildings that achieve all performance areas of the challenge.

The Living Building Challenge is comprised of six performance areas or petals: site, energy, materials, water, indoor quality, and beauty & inspiration. Projects may apply for an individual petal designation by satisfying the requirements within that petal or for Living Building Status by attaining all requirements within the system. There are 3 rules to the challenge.

1. All elements of the Living Building Challenge are mandatory.
2. Many elements have temporary exceptions to acknowledge current market limitations. These exceptions will be modified or removed as the market evolves.
3. A Living Building designation is based on actual, rather than modeled or anticipated performance. Therefore, buildings must be operational for one year prior to being evaluated.

The energy requirement for the Living Building Challenge is for net zero energy performance. There is no particular method outlined for achieving this goal. Any building meeting the Living Building Challenge would also be carbon neutral. The Living Building Challenge User's Guide makes allowances for "project" or "site" net zero energy.

While it is called a "challenge", the Living Building program does constitute a rating system, the certification process for achievement will likely resemble that of LEED with a lower cost of certification and less submitted documentation. The Cascadia Region GBC has indicated that registration will be $100 and certification will likely cost between $2,500 to $7,000.

While all the requirements of the Living Building Challenge may not be relevant or achievable at this time, UBC may consider pursuing the energy prerequisite for a number of building projects underway on campus.

4.0 ENERGY STANDARDS AND CODES
Over the past couple of years, several new codes and standards have been launched into the market place. Although these standards and codes do not necessarily constitute a green building rating system, they provide

Table 17: Living building summary.

Rating System	Energy Standard	Energy Minimum	Criteria #1 CO2 Reduction	Criteria #2 Cost	Criteria #3 Market Adoption	Total Score
Living Building Challenge (North America)	None	Net zero energy	8 points	1 point	0 points	9 points

Table 18: Living building ranking criteria summary.

Rating System	Criteria #1 CO2 Reduction		Criteria #2 Cost		Criteria #3 Market Adoption	
Living Building Challenge (North America)	4 points: Fully addresses the criteria of reducing carbon but does not provide regional tools for measurement	4x2= 8 points	$2,500 to $7,000 to register and certify	1 point Moderate cost	No North American market adoption unable to respond to user needs	0 points

a framework for reducing a building's energy consumption or GHG emissions. It may be possible for UBC to adopt one or more elements discussed in this section and use some of the strategies within the codes for future building design guidelines.

4.1 Architecture 2030 Challenge

The 2030 Challenge was issued in 2006 by Ed Mazria from the Architectural Institute of America (AIA) to the entire building industry and sets a new standard for energy reduction in buildings. The initial phase of the Challenge, a 50% reduction of fossil fuel based GHG emissions, is designed to bring an immediate halt to the increase of GHG emissions in the building sector; subsequent phases are designed to incrementally and systematically reduce CO2 emissions in this sector.

The fossil fuel reduction standard for all new buildings according to the 2030 Challenge is:

- 60% in 2010
- 70% in 2015
- 80% in 2020
- 90% in 2025
- Carbon-neutral in 2030 (using no fossil fuel GHG emitting energy to operate)

The 2030 Challenge has been adopted by the:

- US Conference of Mayors (USCM)
- National Association of Counties (NACo)
- American Institute of Architects (AIA)
- US Green Building Council (USGBC)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) (supporter)
- International Council for Local Environmental Initiatives (ICLEI)
- Congress for the New Urbanism (CNU)
- States of Illinois, Minnesota, California and New Mexico
- Numerous consulting firm and other organizations

Although slower to act, the U.S. Federal Government has started to adopt the 2030 Challenge targets for all new and renovated federal buildings.

The energy standard is based on the Commercial Building Energy Consumption Survey (CBECS). CBECS is an American sample survey that collects information on the stock of U.S. commercial buildings, energy-related building characteristics and energy consumption and expenditures. Commercial buildings include all buildings in which at least half of the floor space is used for a purpose that is not residential, industrial or agricultural, so it includes building types that might not traditionally be considered "commercial", such as schools, correctional institutions and buildings used for religious worship. CBECS is not universally used in the U.S. and, therefore, Architecture 2030 issued a code equivalency guideline as outlined in the table below.

The 2030 Challenge only requires building be net zero

Table 19: Architecture 2030 Challenge code/standard equivalency summary.

CODE / STANDARD	COMMERCIAL	RESIDENTIAL
ASHRAE 90.1-2004	30% below	
ASHRAE 90.1-2007	25% below	
ASHRAE 189 (in progress)	0	
IECC 2006	30% below	30% below
California Title 24 2005		15%-20% below
California Title 24 2008	10% below	
Oregon Energy Code	25% below	30% below
Washington Energy Code	25% below	25% - 30% below
RESNET HERS Index		65 or less
LEED NC 2.2 / Homes	New-EA Credit #1:6 pts	
Renovation-EA Credit#1:8 pts	HERS Index: 65	
LEED 2009 (in progress)	New-EA Credit #1:7 pts	
Renovation-EA Credit#1:9 pts		
GBI Standard (in progress)17	PATH A, 8.1.1.1:15 pts	
EECC Option (prescriptive path)		EC-154
NBI Option (prescriptive path)	New- Core Performance w/ enhanced measures	

CO_2 emissions (as measured from fossil fuel based sources) whereas the Living Building Challenge requires a net zero energy building.

The 2030 Challenge only applies to GHG emissions generated by fossil fuel based energy sources. The implication is that projects in B.C. that use wood as a heating source would not need to measure their CO_2 footprint. It also means that low GHG emissions sources of electricity like those in B.C. would not be part of the measured energy under this challenge.

4.2. U.K. Energy Performance Certificate Program

The United Kingdom has begun a rigorous program of building certification that acts much the same way as a food labelling program. The concept is that a building must meet the Building Regulations 2000 standard for energy efficiency before it can be sold. The energy performance certificates are required for new and existing buildings and must be presented at the time of purchase or rental of any building.

According to the program requirements, the energy performance certificate must fulfill all the standards as set out in “Requirements for the energy performance standards at the point of purchase for England and Wales”.

The Building Regulations 2000 standard was used as a template to rate elements of the building’s energy efficiency. The nine elements that are rated include:

1. Main walls
2. Main roof
3. Main floor
4. Windows
5. Main heating
6. Main heating controls
7. Secondary heating
8. Hot water
9. Lighting

The elements are rated much like a school report card. A building can get a “D” with regards to its energy efficiency because of poor insulation and single glazed windows. The score card will show the total energy use in kWh/m^2 per year as well as lighting cost and heating costs per year. The certificates will also state the predicted CO_2 emissions per year for the building.

Enforcement of the new Energy Certificates will become the responsibility of the local authorities that currently enforce building standards in the country. In the case of larger cities like London or Manchester, the city is responsible for enforcement of the new energy standard, while in more rural areas the county will be enforcing the new standard using teams of assessors. This “energy performance standard at the point of purchase” is one of the most interesting and innovative ways in which to address the energy performance of the extensive existing building market in the U.K.

In Germany, a similar system has been adopted, which is known as the Energie Pass (or Energy Passport). All European Union members must create a similar program as part of the EU’s Energy Directive. While the U.K. example is older, the German Energie Pass website contains more resources and tools for people to understand the system.

4.3 American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) 90.1

The American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) has always been leaders of energy standards. The most current energy standard of ASHRAE 90.1-2007 improves upon past iterations of the standard. ASHRAE 90.1 is based on a percentage energy reduction over baseline conditions, which provides minimum energy efficiency design requirements for buildings under four storeys. The baseline is set for various building types and is usually modeled using EE4, DOE-2, TAS and E-quest software tools.

The newest standard being developed for ASHRAE is the Sustainable Buildings Standard 189 (which will exclude low-rise residential buildings). Standard 189 is not a building rating system, but rather a compilation of criteria that must be met in order for local building code officials to provide a certificate of occupancy for a facility. The proposed standard ASHRAE 189 will focus on-site renewable power generation instead of high-performance, green buildings relying completely on conventional energy sources. The standard encourages projects to produce a minimum percentage of their peak electrical load through on-site generation such as by photovoltaic panels or equivalent solar water heating systems.

Energy efficiency is also a large part of the standard. There is a goal for projects to achieve a minimum of 30% reduction in energy cost (and carbon dioxide equivalent) over that in ASHRAE 90.1-2007 - Energy Standard for Buildings except low-rise residential buildings.

4.4 Model National Energy Code for Buildings (MNECB)

The MNECB was prepared under the auspices of the Canadian Commission on Building and Fire Codes and was first published in 1997 by the National Research Council Canada (NRC). The MNECB applies to all buildings, other than houses of three storeys or less, and to additions of more than 10 square metres to such buildings, and was designed to create a nationwide standard. While the standard has never been adopted by provinces or territories it remains both as a LEED Canada NC 1.0 reference standard and the nation's energy standard.

The MNECB provides maximum thermal transmittance (1/RSI or U) levels for building envelope components per type of energy (oil, natural gas, electricity, wood, propane) for different regions of Canada. These levels were determined using regional construction and heating energy costs in a life-cycle cost analysis. As well, the MNECB gives regional U-values for windows, references energy-efficient equipment standards and identifies when heat recovery from ventilation exhaust is required for dwelling units. To allow flexibility in achieving a minimum level of energy efficiency, the code offers three compliance approaches: a Prescriptive Path, a Trade-off Path and a Performance Path.

The next edition of the MNECB is scheduled to be released in 2011, and will offer new information to facilitate the evaluation of innovative products and systems.

4.5 Energy Star

Energy Star is an international standard for energy efficient consumer products and buildings, first created by the US Environmental Protection Agency (EPA) in 1992. Since then Australia, Canada, Japan, New Zealand, Taiwan and the European Union have adopted the program. Devices carrying the Energy Star logo, such as computer products and peripherals, kitchen appliances, buildings and other products, save 20%-30% on average. However, many European-targeted products are labeled using a different standard, Telecommunication Certification Officer (TCO) Certification. This certification is based on a combined energy usage and ergonomics rating from the Swedish Confederation of Professional Employees instead of Energy Star.

According to the Environmental Protection Agency, Energy Star buildings use at least 15% less energy than standard buildings. Energy Star rated buildings usually include properly installed insulation, high performance windows, tight construction and ducts, energy efficient cooling and heating systems and Energy Star appliances, lighting and water heaters.

The LEED EB Operations and Management and EB 2.0 rating systems use the Energy Star Portfolio manager to track and rate buildings. The Portfolio Manager is an interactive energy management tool that allows project managers to track and assess online the energy and water consumption across an entire portfolio of buildings. Most commercial and institutional facilities can rate their energy performance on a scale of 1–100 relative to similar buildings across the U.S. The building analyzed is not compared to the other buildings entered into Portfolio Manager to determine an Energy Star rating. Instead, statistically representative models are used to compare the building against similar buildings from a national survey conducted by the Department of Energy's Energy Information Administration. The national survey, known as the Commercial Building Energy Consumption Survey (CBECS), is conducted every four years and gathers data on building characteristics and energy use from thousands of buildings across the United States. A building's peer group is compared to buildings in the CBECS survey that have similar building and operating characteristics. A rating of 50 indicates that the building, from an energy consumption standpoint, performs better than 50% of all similar buildings nationwide, while a rating of 75 indicates that the building performs better than 75% of all similar buildings nationwide. Buildings with a rating of 75 or greater may qualify for the Energy Star label.

While buildings in Canada can be analyzed using the Portfolio Manager, they can not be awarded an Energy Star rating because the data is based on American buildings. The Canadian EnerGuide Program functions in conjunction with the American Energy Star program. The Energy Star website offers a number of other resources. There is a building upgrade calculator, a financial value calculator and a cash flow opportunities calculator. To date, there are no resources for calculating GHG emissions.

4.6 E-Benchmark

E-Benchmark is a U.S. based energy standard that has been developed by the New Building Institute (NBI). NBI developed the E-Benchmark following a set of requirements largely based on the ANSI procedures for the Development and Coordination of American National Standards. E-Benchmark can be used as a stand alone system for individual projects or as a basis for high performance building programs sponsored by non profits, government agencies, utilities and others. As a stand alone system, E-Benchmark allows design teams to document compliance through a process of self-evaluation or through a certified third party commissioning agent.

E-Benchmark's criteria were designed to be compatible with LEED and other sustainable or green building programs. For design teams the criteria can assist in obtaining full or partial LEED credits. A separate guide is being developed to provide a more detailed description of how the E-Benchmark standard will work with the LEED system.

The basic criterion for the E-Benchmark tool allows a project to pursue either a prescriptive or simulation path under ASHRAE 90.1. If pursuing the prescriptive path, projects must achieve 10%-30% better than ASHRAE 90.1 and if using the simulation path 30% to 50% better than ASHRAE 90.1. A basic guide for steps to be followed during various stages of the design and construction are contained within the guide to help project teams meet the prescriptive or simulative targets. This tool is not applicable to hotels, motels and residential buildings as it does not have a defined criteria for 24-hour residential or guest room process loads.

4.7 Standard Assessment Procedure (SAP) 2005

The Standard Assessment Procedure was developed in 2005 by the Building Research Establishment (BRE). The indicators for energy performance under SAP 2005 are energy consumption per unit floor area, an energy cost rating (the SAP rating), an Environmental Impact rating based on CO2 emissions (the EI rating) and a Dwelling CO2 Emission Rate (DER).

The SAP rating is based on the energy costs associated with space heating, water heating, ventilation and lighting, less cost savings from energy generation technologies. It is adjusted for floor area so that it is essentially independent of dwelling size for a given built form. The SAP rating is expressed on a scale of 1 to 100, the higher the number the lower the running costs of the building.

The EI rating is based on the annual CO2 emissions associated with space heating, water heating and ventilation and lighting, less the emissions saved by energy generation technologies. The EI rating is adjusted for floor area and is expressed on a scale of 1 to 100, the higher the number the better the standard.

The DER is a similar indicator to the EI rating, which is used for the purposes of compliance with building regulations. It is equal to the annual CO2 emissions per unit floor area for space heating, water heating, ventilation and lighting, less the emissions saved by energy generation technologies, expressed in kg/m²/year.

BRE uses SAP to measure a project's energy cost, CO2 emissions and emissions per m² for dwelling units. The method of calculating the energy performance and the ratings is set out in the form of a worksheet, accompanied by a series of tables. The methodology is compliant with the Energy Performance of Buildings Directive that all European Union countries must use.

5.0 SUMMARY OF RATING SYSTEM COMPARISON AND CONCLUSION

Based on the analysis completed in section 4 and as outlined in the following tables below, there is no single green building rating system that would perfectly meet the needs of reducing CO2 emissions from new or existing buildings and becoming GHG neutral. Most of the minimum performance thresholds for energy conservation or efficiency within the green building rating systems are set low in order to encourage market transformation and adoption.

5.1 New Building Rating System

The table on the next page summarizes the ranking of each system applicable for new buildings.

The LEED NC, CS and CI rating systems along with the Passive House and Living Building systems score the highest with 9.5, 9.0 and 10 points respectively. The biggest advantage of LEED-Canada over Passive House and the Living Building Challenge is that the CaGBC and USGBC have gained widespread market adoption in North America and LEED has been applied to a diversity of building types. In addition, the CaGBC and USGBC are actively working to improve the system and has created tools for campuses in Canada.

Table 2 revealed that the energy intensities of LEED buildings are not altogether different from the final energy intensities of Passive House buildings. The Passive House tools have not gained widespread adoption in the North American market place. For example, there are currently no laboratories, lecture theatres or other academic buildings constructed to the Passive House standards in Europe or in North America. Lastly, the tool uses a European rate for establishing energy primary intensity. The standard does have some very useful guidelines for air tightness that are missing from the

LEED reference guide and could be applied on LEED projects for greater energy performance.

The Living Building Challenge sets aggressive and laudable goals for buildings to achieve net zero energy. At present, no buildings that have been constructed to the Living Building Challenge standards and only a small number of zero energy buildings exist worldwide. A very progressive client may wish to pursue the Living Building Challenge prerequisite for net zero energy.

Based on the above analysis, LEED Canada NC continues to be the leader when constructing new buildings as the LEED Letter Templates attempt to measure the GHG footprint of buildings.

5.2 Existing Building Rating System

The Table below summarizes the ranking of each system applicable for existing buildings.

The LEED EB-O&M rating system scores the highest of the 4 rating systems surveyed with 10.5 points. The biggest advantage of LEED EB-O&M is that it rewards building owners for tracking and reporting on CO2 emissions. The LEED EB-O&M system requires the measurement of least 2 energy loads such as lighting and plug loads, which would enable most clients to build upon their existing metering program and pinpoint areas for demand side reductions.

5.3 Conclusion

Due to its wide marketplace acceptance, familiarity in the construction industry and effectiveness at reducing GHG emissions, the Leadership in Energy and Environment Design for New Construction (LEED® NC) green building rating system is best suited to meet a client's goals for reducing its carbon emissions from buildings while achieving a recognizable industry rating. LEED NC provides a framework for tracking and rewarding low energy use and total carbon emissions reductions,

Table 20: Rating system ranking summary.

Rating System	Energy Standard	Energy Minimum	Criteria #1 CO2 Reduction	Criteria #2 Cost	Criteria #3 Market Adoption	Total Score
LEED EB-O&M (U.S. and Canada in 2009)	Energy Star or EnerGuide	20% better than National Average	6 points	1.5 points	3 points	10.5 points
LEED NC / CS or CI (Canada)	ASHRE 90.1 and MNECB	35% better than ASHRE, 42% better than MNECB	6 points	0.5 points	3 points	9.5 points
BOMA Go Green/ Go Green Plus (U.S. and Canada)	Energy Audit	None defined	2 points	3 points	2 points	7 points
BREEAM (U.K.)	SAP 2005	Excellent rating= EPC of 47	6 points	2 points	0 points	8 points
Green Star (Australia)	ABGR Validation Protocol	110 kg/ CO2e-m²/annum or 117 kWh/m²/yr	6 points	1points	0 points	7 points
Green Globes Existing	MNECB	40% better than MNECB	4 points	3 points	1 points	8 points

however the current version of these systems track carbon emissions using North American averages that are higher than the provincial or state averages.

While the remaining new building rating systems analyzed scored well in certain areas, all the rating systems analyzed have a common shortcoming with regards to measuring carbon. None of the rating systems analyzed have the tools to accurately measure carbon on a state or provincial level. The primary reason for recommending LEED NC is that it most accurately measures carbon reductions using North American data. The CaGBC and USGBC have a track record of responding to industry demands and is the most well equipped organization to respond to a client's requirements for accurate GHG emissions reduction measurement. The organizations behind the other rating systems analyzed in this report do not have the industry support or track record of performance in the North American marketplace that the CaGBC and USGBC do with LEED.

The short list of existing building rating systems had the same shortcoming with regards to measuring carbon. Only LEED EB-O&M had a credit for tracking and measuring carbon emissions and their reductions. The primary reason for recommending LEED EB-O&M is that the CaGBC and USGBC are currently adapting it for the North American marketplace. LEED EB-O&M, in its current form, would most likely result in greater GHG reductions than Green Globes or BOMA Go Green, which do not require load specific metering and demand side reduction tracking.

REFERENCES

[1] AIA Sustainability Discussion Group, (2008). "Quantifying Sustainability: A Study of Three Sustainable Building Rating Systems and the AIA Position Statement", Report, Retrieved on 4/2009 from http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aias076586.pdf.

[2] Smith, T. M., Fischlein, M., Suh, S., Huelman, P., (2006). "Green Building Rating Systems: A Comparison of the LEED and Green Globes Systems in the US", Report, Retrieved on 4/2009 from http://www.foresthealth.org/pdf/LEED%20Comparison%20Study.pdf.

[3] Gavi, K., (2004). "Green Rating Systems: An Overview", ASHRAE Journal, pp. 56-59, Retrieved on 4/2009 from http://www.energycodes.gov/implement/pdfs/Sustainability.pdf.

[4] Olson. S., Arny, M. and Eisch, E., (2006). "Sustainable Building Rating Systems Addressing Building Maintenance and Janitorial Products, Policies and Methods", Report, Leonardo Academy, Retrieved on 4/2009 from http://www.leonardoacademy.org/download/Janitorial%20Products%20and%20Building%20Certification.pdf.

[5] Turner, C. and Frankel. M., (2008). "Energy Performance of LEED for New Construction Buildings", Report, New Building Institute, Retrived on 4/2009 from http://www.usgbc.org/ShowFile.spx?DocumentID=3930.