A comparative analysis of different post-occupancy building assessment standards

Prepared by: Hooman Shahrokhi
Majed El Saadi
Ryan Runyu Huang
Kinza Iqbal
Muhammad Ahsen Khan

Project Client: Prof. Thomas Froese

Presented to: Prof. Nemkumar Banthia

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Contents

1. Introduction 6
2. Background 6
   2.1. What is POE? 6
   2.2. Why is POE important? 7
   2.3. Prior POE on CIRS 7
3. Literature Review 8
   3.1. Assessment Tools 8
   3.2. Comparison 8
      3.2.1. Assessed buildings 9
      3.2.2. Life-cycle 10
4. Methodology 11
   4.1. Selection of assessment tools 11
   4.2. Evaluation criteria of assessment tools 11
5. Selected Assessment tools 12
   5.1. WELL Building Standard 12
      5.1.1. Introduction 12
      5.1.2. Evaluation Method 14
      5.1.3. Scoring 15
   5.2. SPeAR 16
      5.2.1. Introduction 16
      5.2.2. Evaluation 16
      5.2.3. Scoring 18
   5.3. BREEAM 18
      5.3.1. Introduction 18
      5.3.2. Evaluation Method 19
      5.3.3. Scoring 21
   5.4. BOMA 22
      5.4.1. Introduction 22
      5.4.2. Evaluation Method 23
      5.4.3. Scoring 25
6. Comparison 26

6.1. Linkages 26
6.2. Advantages 28
6.3. Deficiencies 28
7. Recommendation 28
8. Conclusion 31
9. References 32
10. Appendices 34

List of Tables

Table 1: Applicable Preconditions and Optimizations Based on Project Type. Adapted from (Delos Living LLC., 2015) 13

Table 2: Applicable Preconditions and Optimizations Based on Certification Type. Adapted from (Delos Living LLC., 2015) 13

Table 3: Applicable Preconditions and Optimizations Per Concept. Adapted from (Delos Living LLC., 2015) 15

Table 4: BREEAM In-Use International Environmental Section Weightings. Adapted from (BRE Global Limited, 2015) 20

Table 5: BREEAM In-Use International Rating Benchmarks. Adapted from (BRE Global Limited, 2015) ... 21

Table 6: BOMA BEST Certification Levels. Adapted from (BOMA Canada, 2016) 22

Table 7: BOMA BEST Energy Performance Benchmarking. Adapted from (BOMA Canada, 2016) 23

Table 8: BOMA BEST Scoring by Assessment Section. Adapted from (BOMA Canada, 2016) 26

Table 9: Comparison of the Selected Four POE Tools on the Topic of Energy 29

Table 10: Comparison of the Selected Four POE Tools on the Topic of Health & Wellbeing 30

Table 11: Comparison of the Selected Four POE Tools on the Topic of Pollution 31

List of Figures

Figure 1: Categorization of Assessment Tools Based on Building Type. Reprinted from (Haapio & Viitaniemi, 2008) 10

Figure 2: Categorization of Assessment Tools Based on Building Life Cycle. Reprinted from (Haapio & Viitaniemi, 2008) 10

Figure 3: Sample SPeAR POE Assessment Result. Reprinted from (ARUP, 2012) 17

Figure 4: SPeAR Sample Indicator Set. Reprinted from (ARUP, 2012) 17

Figure 5: SPeAR Sample Questionnaire. Reprinted from (ARUP, 2012) 17

Figure 6: SPeAR Rating System. Reprinted from (ARUP, 2012) 18

1. Introduction

Centrally located on the UBC campus, the Centre for Interactive Research on Sustainability (CIRS) was constructed in 2009. It represented and further developed UBC's sustainability vision by striving to achieve energy, water and social sustainability through design and operations. To strengthen and verify its sustainability objectives, a post occupancy evaluation can be conducted.

Sustainability rating standards such as LEED usually focus on the design process. However, some buildings perform differently than intended. Accordingly, post occupancy evaluations measure a building's actual sustainability performance. However, different standards address different performance areas; some focus on technical aspects, while others on financial and social. Past research was conducted for CIRS on post occupancy evaluation using the iiSBE standard. The research indicated gaps in energy performance and occupant comfort. The challenge is finding a standard that best measures a building's actual performance.

The research team has set out to explore a number of different post occupancy evaluation schemes with the objective of identifying the right tool to be applied to CIRS. This report involves identifying the different assessment tools for the different building phases and types. It then moves on to identify the best standards to be used for post occupancy evaluation. Analysis is done on the best standards to identify strengths and weaknesses for each. Finally, a suitable set of indicators to assess the performance of a building is recommended.

2. Background

2.1. What is POE?

Post Occupancy Evaluation (POE) is a process to investigate and analyze the operational performance of a green building in its occupancy phase, which compared the performance with predefined benchmarks such as predicted design goal, typical standard, and performance of similar buildings, etc. The process enable stakeholders of the building to learn design lessons, to identify concerns that need to be addressed, and provide feedback and knowledge to the green building industry.

There are two components associated with Post Occupancy Evaluation - the building performance and building occupants. POE involves both qualitative methods such as occupant feedback and quantitative methods such as measuring energy use, indoor environment quality factors etc. to assess a building. Currently, there are several indicators and methodologies used to assess the two components of POE such as SB tool developed by iiSBE , CBE's occupant IEQ survey ASHRAE building assessment guidelines, ISO Standards, SpEAR developed by Arup, BOMA BEST etc.

2.2. Why is POE important?

Generally, POE provides a platform for stakeholders to better understand the actual performance of the sustainable building and identify problems and lessons for operation and for future design and construction of sustainable building industry. We believe the most important value POE provides is, which as Zimmerman and Martin (2001) pointed out: "The overarching benefit from conducting POE is the provision of valuable information to support the goal of continuous improvement".

2.3. Prior POE on CIRS

Initiated by iiSBE Canada, a prior research titled "Building Performance Evaluation for the Centre for Interactive Research (CIRS)" was conducted in studying the post occupancy performance of CIRS as part of the "Canadian Building Performance Evaluation Project". The goal of the project was to better understand the operational performance of CIRS buildings and identify performance gaps and lessons for the owners, design teams and the construction industry.

Based on the standardized evaluation framework introduced in the project, this research focused on seven assessing areas as following:

1. Energy
2. Water
3. Economic Factors
4. Indoor Environment
5. Occupancy
6. Site
7. Materials

Also, there are three key performance indicators (KPIs) providing a more intuitive performance evaluation in this research:

1. Predicted performance at the design stage,
2. Actual building performance, and
3. Reference values for typical building of similar use

The result of the research indicated that although the general evaluation feedback of the CIRS building were largely positive the CIRS building has had difficulty achieving its net-positive performance target for energy and water due to the heat exchange challenges, higher electricity consumption for lighting and plug-loads, and rainwater and wastewater treatment systems. (Chu et al., 2014)

3. Literature Review

Several research papers were reviewed in order to search for assessment tools that focused on POE and could potentially be applied to CIRS. The research papers reviewed for this purpose discuss the applications and limitations of various assessment tools and after a thorough comparison, the research team categorized them into groups based on the type of projects the tools are well suited for and the life-cycle phase of the building they can be applied to.

3.1. Assessment Tools

Initially all tools discussed in the research papers were looked at and whether they were applicable on the POE aspect of the buildings or not. They are listed below:

1. CASBEE
2. Green Building Challenge
3. LEED
4. SPeAR
5. BREEAM
6. ATHENA
7. WBC
8. Living Building Challenge
9. BOMA
10. iiSBE

3.2. Comparison

There are several assessment tools that are suited for many different kinds of applications (Haapio & Viitaniemi, 2008). For example, assessment tools may vary according to the environmental issue that they consider is most important to address. They may also vary by location and can be global, national or regional. They may be applicable to different stages of a building's lifecycle and therefore may impact different users such as designers, architects, contractors, tenants etc. These tools also vary according to the type of buildings. Buildings could be new or existing and can be subcategorized as residential, office or commercial buildings. Other than that, some tools focus only on quantitative data like energy usage, carbon emissions and consumption of water whereas some focus on qualitative data like overall air quality. Quantitative data is measurable and generally points are given if these criteria are met. Qualitative data on the other hand cannot be measured or calculated.

The dissimilarities among different tools are because of the fact that they have been designed for different purposes. Therefore, it is not easy to compare them without grouping them into categories and subcategories as discussed in (Ding, 2008). This paper discusses a number of tools and two classification systems to group the tools namely "Assessment Tool Typology" that was developed by

ATHENA classification system and IEA Annex 31 classification system. The ATHENA classification system distributes the tools into three different levels depending on the purpose of each tool. The IEA Annex 31 goes into more detail and in addition to the tools, it also discusses energy modelling software, several environmental protocols and product certifications. Finally, the tools were grouped into categories based on the ATHENA classification system and the pros and cons of each tool were discussed.

The ATHENA classification system has the following three levels to classify the assessment tools:

1. Level 1: Product comparison tools and information: This level focuses on the procurement stage and can be used to create databases at early stages.
2. Level 2: Whole building design or decision support: This level focuses on specific areas such as energy, lighting and several environmental factors. These tools may involve scoring for adherence to certain standards or guidelines like ASHRAE, ISO etc. and are more quantitative and data-oriented.
3. Level 3: Whole building assessment frameworks or systems: These tools cover a broad range of sustainability related issues and are a combination of quantitative and qualitative data. These tools are mostly certifications.

In addition to classifying the tools according to these different levels, it is also necessary to classify them based on specific categories like building life cycle, type of buildings, the users of the tools, the database of the tools etc.

3.2.1. Assessed buildings

The environmental assessment tools can be used to assess new buildings, existing buildings, buildings undergoing refurbishment etc. Level 1 tools basically focus on building product comparisons whereas levels 2 and 3 focus on environmental assessment of the entire building as shown in figure 1.

Assessed buildings

ATHENA classification	Assessment tool	Existing building	New building	Refurbishment of a building	Building product/ component	Buildings	Residential building (multi-unit)	Residential building (single family)	Office building	Other type of building
1	BEES 4.0				■					
	TEAM™				■	■				
2	ATHENA™	■	■	■			■	■	■	■
	BEAT 2002	■	■	■	■	■				
	BeCost				■	■				
	Eco-Quantum					■		■		
	Envest 2								■	
	EQUER		■				■	■	■	■
	LEGEP®	■	■		■					
	PAPOOSE				■	■	■	■	■	■
3	BREEAM	■	■	■			■	■	■	■
	EcoEffect	■	■	■	■		■		■	■
	EcoProfile	■					■	■	■	■
	Environmental Status Model	■					■	■	■	
	ESCALE		■				■	■	■	■
	LEED®	■	■	■			■	■	■	■

Figure 1: Categorization of Assessment Tools Based on Building Type. Reprinted from (Haapio & Viitaniemi, 2008)

3.2.2. Life-cycle

Different tools focus on different phases of a building's life cycle such as design, construction, operation, maintenance etc. therefore it is necessary to classify them accordingly as shown in figure 2.

Phases of the life cycle

ATHENA classification	Assessment tool	Production	Construction	Use/operation	Maintenance	Demolition	Disposal
1	BEES 4.0	■		■	■		■
	TEAM™	■	■	■	■		■
2	ATHENA™	■	■		■	■	■
	BEAT 2002	■	■	■	■	■	■
	BeCost						
	Eco-Quantum	■	■	■	■	■	■
	Envest 2	■	■	■	■	■	■
	EQUER	■	■	■	■	■	■
	LEGEP®		■	■	■	■	
	PAPOOSE	■		■	■	■	■
3	BREEAM	■	■	■	■		■
	EcoEffect	■	■	■	■	■	■
	EcoProfile			■	■		
	Environmental Status Model						
	ESCALE	(■)	(■)	■	■		
	LEED®	■	■	■	■	■	■

Figure 2: Categorization of Assessment Tools Based on Building Life Cycle. Reprinted from (Haapio & Viitaniemi, 2008)

As a conclusion, it can be said that since the available assessment tools greatly differ from each other, it is difficult to choose the correct tool for a specific project. Some of these tools might give better results for a particular kind of building but may not be applicable to other buildings. It is not easy to compare

these tools without categorizing them into different groups according to the purpose each tool was built to serve. Therefore, it is necessary as the user to first know the relevance of selected tool to the building project before implementing it.

4. Methodology

As per past research, it has been proven that it is very difficult, if not impossible, to compare these assessment tools under one criteria since different tools have been designed for different project life cycles, different types of building structures, or different regions. So for the purpose of this research project, the most accessible tools in terms of open access and relevance were short-listed and then a criteria which best fit the definition of post-occupancy analysis was defined so the tools can be successfully compared on their respective evaluation method and scoring methodology.

4.1. Selection of assessment tools

In the early stages of this project, 10 tools were listed in table-format found in appendix A and then researched upon. The research team then looked into the organization, basic characteristics such as availability, region of application, cost of application, user-application, methodology of evaluation and scope definition. After thorough research and carefully considering the above mentioned factors, four tools were shortlisted for a detailed comparison:

- BREEAM
- BOMA
- Well-Building Challenge
- SPeAR

4.2. Evaluation criteria of assessment tools

For a successful comparison some sort of common criteria had to be defined which cover the definition of post-occupancy and at the same time would be a benchmark for a fair comparison. In the list of tools shown in appendix A, it is clearly shown that different tools have different scopes. They cover a wide range of areas such as human & environmental health, sustainable site development, water & energy efficiency, materials selection, indoor environmental quality, waste management, resource management and others. It was decided that for post-occupancy analysis, tools will be compared regarding three criteria Energy, Indoor Environment Quality or Health & Wellbeing and Pollution as they are common and highly rated amongst all tools and will form a fair basis for comparison.

The energy section covers energy consumption, energy efficient features, energy monitoring and management, energy supply, energy generation and other sub features. The indoor environment quality section covers green space access, indoor air quality, noise mitigation and monitoring, health and safety in design and operation, risk regulation and occupants' comfort issues. The pollution section covers

direct and indirect emissions, ambient air quality, waste monitoring and management, light pollution and waste in operation.

For each of the above selected tools these sections were compared directly using a linkages method, where the questions and requirements from each tool for a specific feature were directly compared. Also a general comparison regarding tool evaluation and scoring methodology was performed.

5. Selected Assessment tools

In this section, a detailed description of each of the four POE schemes focused on the three areas of Energy, Indoor Environment Quality or Health & Wellbeing, and Pollution is provided.

5.1. WELL Building Standard

5.1.1. Introduction

The WELL Building Standard was initiated by Delos and is managed by the International WELL Building Institute (IWBI) which is a public organization focused on improving human health and wellbeing. It is also certified by Green Business Certification Inc. (GBCI) which is responsible for LEED Green Buildings certification.

The WELL Building Standard's primary focus area is human health and wellbeing. It encompasses several scientific as well as medical researches and seeks to translate these studies into building practices. It is based on the belief that many environmental factors shape not only our overall health but our behavior and productivity as well. Therefore it is a tool to measure the degree of wellness in a building and ensures that the individual needs of all occupants are met.

The WELL Building Standard v1.0 was launched in October 2014 with the aim to further enhance and clarify the already available features. It is applicable to commercial and institutional buildings and looks at three types of projects (Delos Living, LLC, n.d.):

- New and Existing Buildings for WELL Certification: This type of project typology applies to new and existing buildings where 90% of the office area is occupied by the owners and about 10% by the tenants or some other management. It applies to all aspects of building design, construction and operations.
- New and Existing Interiors for WELL Certification: This type of project typology applies where majority of the building is occupied by people other than the owners for e.g. tenants or some other management or to a building that is not being renovated.
- Core and Shell Developments for Compliance: This typology is for those who want to employ the applicable features to the entire building to benefit future tenants. At least 30% of the building should be used for commercial purposes. However, it is mandatory for 100% of the building to fulfill all Core and Shell Compliance requirements.

WELL Building Standard comprises of seven major concepts namely Air, Water, Nourishment, Light, Fitness, Comfort and Mind. These concepts are further narrowed down to a number of features. Each feature is based on existing government standards as well as conducted research and aims at altering human behavior in a positive way and increasing productivity. These features can be categorized either as preconditions or optimizations and the number of applicable preconditions and optimizations vary according to each concept, the kind of project typology and the kind of certification.

Preconditions:

Preconditions are features that are mandatory for all kinds of WELL Certifications and WELL Core and Shell Compliance. In order for the WELL Certification or Compliance to be granted, all applicable preconditions per concept should be met.

Optimizations:

Optimizations are features that are not mandatory for Silver level certification but are optional design approaches or technologies that one might strive to achieve. It is encouraged to apply as many optimizations per concept as possible as they can help lead to Gold and Platinum certifications.

The table below shows the number of applicable preconditions and optimizations on the basis of different project typologies:

Table 1: Applicable Preconditions and Optimizations Based on Project Type. Adapted from (Delos Living LLC., 2015)

Project Type	Applicable Preconditions	Applicable Optimizations	Total Applicable Features
New and Existing Buildings	41	61	102
New and Existing Interiors	36	64	100
Core and Shell Compliance	26	30	56

The breakdown of applicable preconditions and optimizations on the basis of different types of certifications can be shown in the table below:

Table 2: Applicable Preconditions and Optimizations Based on Certification Type. Adapted from (Delos Living LLC., 2015)

Certification Type	Preconditions	Optimizations
Gold	All applicable	40% of applicable

Platinum	All applicable	80% of applicable
Silver	All applicable	None
Core and Shell Compliance	All applicable	One optimization per concept

5.1.2. Evaluation Method

All projects are registered on WELL Online. After registration, the project team is required to gather all information for documentation review within a required timeframe. To qualify for WELL Certification or Compliance, all required documents per feature need to be submitted by project teams within five years of initial registration. All documents are supposed to be uploaded via WELL Online. After the first round of assessment, if any additional documents are required, the WELL Assessor contacts the project team within 20-25 business days. If all documents are not found to be satisfactory after two rounds of assessment, additional fee is charged (Delos Living LLC., 2015).

The breakdown of the documentation is shown below:

1. Annotated documents that include design drawings, employee handbooks and operations documents that have been highlighted or marked to specify the applied WELL preconditions and optimizations.
2. Letters of Assurance from Architects, Engineers or Contractors to confirm that WELL features have been incorporated into the design, construction and operations for every specified concept.
3. General documents such as Electrical and Mechanical drawings etc. which provide the assessor information and detail on the project.

After the Documentation Review, a Performance Verification is carried out by a WELL Assessor. The project team may schedule a site visit after all the documents have been approved on WELL Online. The site visit may take several days depending upon the type and scope of project and its purpose is to verify the provided documentation, to carry out tests in order to assess indoor air and water quality, lighting, acoustic tests, thermal conditions and other environmental factors and compare them against standards established by the International WELL Building Institute (IWBI). If the project team does not schedule a site visit within five years from the initial date of project registration, the registration will expire. For New and Existing Buildings and for New and Existing Interiors, the site visit can only be scheduled if it has been at least one month since the issuance of certificate of occupancy with a minimum of 50% occupancy in the building.

A detailed feedback called the WELL Report will be available 40-45 days after the site visit and will include details and results of tests conducted and whether the project has met the required criteria or not. The project team can generate an appeal within 180 days after the WELL Report is made available online. WELL Certification or Compliance is awarded after the WELL Report generated indicates a pass.

Once the certification is awarded, the project team should annually submit certain documents to IWBI such as POE surveys, maintenance proofs and environmental assessment test results for recertification. An additional fee will be charged at recertification if these requirements are not met.

5.1.3. Scoring

Individual concept scores are calculated based on the number of preconditions and optimizations met per concept. For new and existing buildings, the applicable preconditions and optimizations per concept are listed in the table below:

Table 3: Applicable Preconditions and Optimizations Per Concept. Adapted from (Delos Living LLC., 2015)

Concept	Applicable Preconditions	Applicable Optimizations
Air	12	17
Water	5	3
Nourishment	8	7
Light	4	7
Fitness	2	6
Comfort	5	7
Mind	5	14
Total	41	61

If the preconditions incorporated per concept in a particular project that fits into the New and Existing Buildings typology are equal to the applicable preconditions required by that concept, then this indicates a pass and vice versa. This is shown below:

Fail:

If preconditions achieved/Applicable Preconditions < 1 then the wellness score would be (preconditions achieved/Applicable Preconditions) x 5.

Pass:

If preconditions achieved/Applicable Preconditions = 1 then wellness score would be 5 + (Optimizations achieved/Applicable Optimizations) x 5.

Scores less than 5 would indicate a fail. Scores between 5 and 6 are generally for silver certification, between 7 and 8 for Gold certification and between 9 to 10 for Platinum Certification. The WELL Scorecard shows the scores per concept.

This research is focused primarily on three main areas of Energy, Health & Wellbeing and Pollution. The WELL Building Standard is focused more on the Health & Wellbeing of the occupants therefore it talks less about the energy aspect. It covers many aspects within Health and Wellbeing and Pollution as will be discussed in the later sections.

5.2. SPeAR

5.2.1. Introduction

SPeAR (Sustainable Project Appraisal Routine) has been developed by Arup as an appraisal scheme for sustainability, over the years it has been implemented over 100 projects in across 10 countries. SPeAR can be used for wide variety of projects. It can be used to monitor and evaluate project performance throughout the various stages in the project life cycle, perform baseline appraisal and identify key performance indicators. This tool helps in identifying design risks and guide decision-making regarding social, environmental and economic factors. It covers all types of projects such as design and delivery of new infrastructure, master plans and individual buildings.

5.2.2. Evaluation

The evaluation methodology of this tool works in a way that it has 23 core performance indicators distributed among three segments Economic, Social and Environmental as shown in Figure 3. Each performance indicator then has further sub-indicators as shown in Figure 4. There are a total of 151 sub-indicators distributed among the 23 core indicators. Furthermore each of these sub-indicators has a set of questions which need to be answered by the evaluating party to get a rating according the “Best Case” and “Worst Case” scenario mentioned for each question as shown in Figure 5.

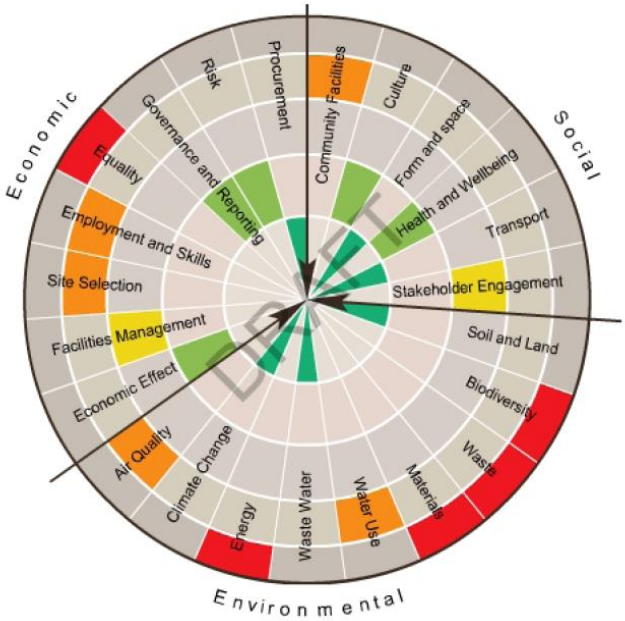

Figure 3: Sample SPeAR POE Assessment Result. Reprinted from (ARUP, 2012)

Segment	Indicator	Sub-Indicator
Core Indicators		
Social	**Community Facilities**	Recreation
		Education
		Healthcare
		Retail

Figure 4: SPeAR Sample Indicator Set. Reprinted from (ARUP, 2012)

Social - Health and wellbeing

Wellbeing is a positive affirmation of an individual's good physical and mental health. The built environment can have a significant impact on the health and wellbeing of individuals and communities and projects should strive to both consider and contribute to the wellbeing of all stakeholders involved. This indicator encourages projects to make positive contributions to both internal and external environments, consider community cohesion and enrich social vibrancy.

Access to green space 3 2 1 0 -1	**Questions** • Is green space provided by the development? Is the quality of local green space improved? • What percentage of total space does the green space comprise? Refer to local planning documents to determine guidance and masterplan strategy for area. • Is access to green space improved? This could be achieved through creation of access points, improving the quality of the green space, education, signage and improving safety. • How will the space be managed and maintained?	
	Best Case Provides access to quality green space close to where people live and work. Protects and enhances the distribution and quality of open space with amenity value. Space is well-managed with input from the users. Adequate lighting and good design promote feeling of safety for users. Local/regional / national guidance is exceeded.	**Worst Case** Loss of green space or reduction of access to green space. Fails to enhance the distribution or quality of public open space. Perception of risk associated with the space, making probability of use infrequent. Lack of clear ownership of space and low maintenance.

Figure 5: SPeAR Sample Questionnaire. Reprinted from (ARUP, 2012)

For the Post-Occupancy analysis it was decided that a building would be analyzed regarding three criteria Energy, Indoor Environment Quality/Health & Well-being and Pollution. For the Energy segment

SPeAR evaluates Energy, Energy demand and Energy generation. Under the Energy indicator SPeAR evaluates energy supply, energy conservation and efficiency, energy monitoring and day lighting. For Energy generation it evaluates renewables resources, low carbon energy and energy security. As for Energy demand it evaluates performance of lighting, heat demand, cooling/ventilation, construction energy reduction, energy monitoring, industrial energy reduction, appliances and ICT.

In the Indoor environment quality the tool evaluates the quality and management of green space access, control and comfort of indoor environment, health and safety risks to occupants both in the design and operation phase of the building. In the pollution category the tool evaluates waste monitoring and management, operational noise and vibration, light pollution and assesses air quality by checking direct and indirect emissions.

5.2.3. Scoring

The core indicators have been developed by global sustainability professionals and are relevant over a wide range of projects. Also these indicators can be modified from one project to another.

The SPeAR performance rating system for indicators is shown in Figure 6, it is a type of a traffic-light system. There are five different rating levels ranging from +3 to -1 with +3 being the “best case” scenario and -1 being the “worst case” scenario. Minimum standard has been set to zero. “Best case” scenario is described as improvement on already set international standard for that specific indicator by innovation or research. “Worst case” scenario is described as not meeting the minimum standard and breaking international/local specification or laws.

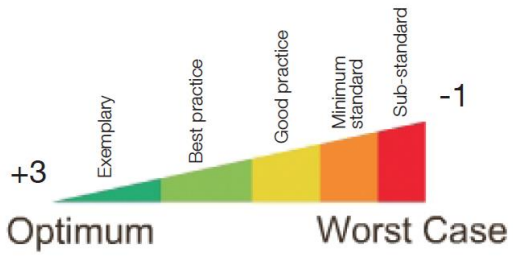

Figure 6: SPeAR Rating System. Reprinted from (ARUP, 2012)

5.3. BREEAM

5.3.1. Introduction

This section will be specifically focused on the BREEAM In-Use International as this is the applicable POE assessment tool for buildings such as CIRS. The BREEAM In-Use International is developed by BRE Global Limited, an independent third party approvals body providing certification on sustainability as well as other areas related to building sciences. The self-proclaimed world’s first sustainability rating scheme for the built environment, BREEAM (Building Research Establishment’s Environmental Assessment Method)

has been used to certify over 260,000 building assessments across the building life cycle in over 50 countries by March 2015.

According to the BREEAM In-Use International Technical Manual, the aims of this assessment tool are:

- To mitigate the life cycle impacts of buildings on the environment
- To enable buildings to be recognized according to their environmental benefits
- To provide a credible, environmental label for buildings
- To stimulate demand and create value for sustainable buildings, building products and supply chains.

BREEAM In-Use is specifically selected as it is designed for existing non-domestic buildings that are already in use. BREEAM also offers assessments for buildings in other life cycles such as Communities for master planning of larger community of buildings, New Construction for new buildings, and Refurbishment for domestic and non-domestic building fit-outs and refurbishments. After the completion of an assessment, BRE Global Limited issues a BREEAM certificate. This certificate provides formal verification of the building assessment according to the appropriate BREEAM assessment and the certified building will be listed on the BREEAM buildings listing: www.greenbooklive.com.

The BREEAM In-Use is comprised of three parts:

- Part 1 – Asset Performance: the performance of the asset's built form, construction, fixtures, fittings and installed services
- Part 2 – Building Management: the management of the asset
- Part 3 – Occupier Management: the management of building users and services

This study is focused on Part 1 of the BREEAM In-Use assessment tool as the aim of this study is aimed at POE of CIRS and as such, falls under the requirements of Part 1.

5.3.2. Evaluation Method

In order to be able to carry out the BREEAM In-Use International assessment, the building must meet the eligibility criteria as listed in the Technical Manual:

- The asset must have been occupied for at least one year prior to the start of the assessment in order to be assessed against Part 2 (Building Management) or Part 3 (Occupier Management)
- Consumption data related to the asset of at least one year must be available in order to be assessed against Part 2 (Building Management) or Part 3 (Occupier Management). This includes (but is not limited to): energy, water, transport and waste data
- The asset must contain occupied space(s) i.e. a room/rooms or space within the asset that is likely to be continuously occupied for 30 minutes or more per day by a building user)
- The asset must be a complete and finished structure

- An asset does not have to include the whole building; it could include just part of a building or a single floor. In such cases, the scope of the BREEAM In-Use assessment must include all relevant amenity and service areas
- An asset cannot normally include more than one building. The only exception is where
- several buildings meet the following criteria:
    a. connected to and share common services to meet the comfort and sanitary demands of the occupants (for example: heating, ventilation, cooling and hot water)
    b. the buildings have the same building function, similar performance, are of the same design and age
    c. building management and maintenance policies must be the same across the buildings
    d. share the same building envelope
- The asset must comply with all relevant environmental and health and safety legislation in its location

Once eligibility criteria have been met, a comprehensive list of questions are applied to the asset to determine the assessment score which will be discussed in more detail in the next section. The following table shows the weightings of different sections of the BREEAM In-Use International for Part 1 of the assessment.

Table 4: BREEAM In-Use International Environmental Section Weightings. Adapted from (BRE Global Limited, 2015)

Environmental Section	Weighting
Management	-
Health & Wellbeing	17%
Energy	26.5%
Transport	11.5%
Water	8%
Materials	8.5%
Waste	5%
Land Use & Ecology	9.5%
Pollution	14%
Total	**100%**

5.3.3. Scoring

Before getting to scoring section breakdowns, BREEAM requires a set of information related to the asset. This information pertain to the nature of the asset, its context, ownership, type, and occupancy. Once the building details have been identified, the different environmental sections and issues can be applied in this assessment. The following table shows the BREEAM In-Use International scoring breakdown:

Table 5: BREEAM In-Use International Rating Benchmarks. Adapted from (BRE Global Limited, 2015)

BREEAM In-Use International Rating	% Score	Star Rating
OUTSTANDING	≥85	★★★★★★
EXCELLENT	≥70 to <85	★★★★★
VERY GOOD	≥55 to <70	★★★★
GOOD	≥40 to <55	★★★
PASS	≥25 to <40	★★
ACCEPTABLE	≥10 to <25	★
UNCLASSIFIED	<10	-

Each of the sections in Table 4 is made up of a comprehensive list of questions and criteria for scoring. To determine the BREEAM score, first the specific questions are applied to each environmental section. The total credits achieved are then divided by the total credits available to obtain a section score percentage. The section weighting from Table 4 is then applied and all weighted section scores are added up to obtain the final BREEAM score. The BREEAM rating is then determined according to Table 5. Each section issue is presented with the following information:

- Total number of credits available
- Whether the issue is a required minimum standard
- Issue question
- Aim of this issue
- Available credits breakdown
- Criteria for the assessment
- List of acceptable evidence documents
- Additional information where applicable

For the purposes of this study, the research team is only looking at the top 3 weighted environmental sections of Energy, Health & Wellbeing, and Pollution. The reason the research team chose to focus on

these 3 areas only is the limited amount of time available to carry out this study. These top 3 areas were chosen after an exploration of the 4 assessment tools mentioned in Part 3 of this study and finding a common grounds for highly rated issues in a POE.

5.4. BOMA

5.4.1. Introduction

BOMA, also known as Building Owners and Managers Association, is an international association consisting of commercial real estate professionals. The Canadian branch has approximately 3200 members and its objective is facilitating "national initiatives and the exchange of ideas that support our member associations in the promotion of education, advocacy, recognition of excellence and networking." There are 11 local BOMA Associations including one in British Columbia with more than 300 members managing or owning more than 80 million square feet in Vancouver valued at more than $8 Billion (BOMA BC, n.d.).

In 2005, BOMA Canada launched the BOMA BEST standard and certification administered through the 11 local associations. Since then, more than 3500 buildings have applied for certification or recertification. The certification is valid for 3 years and is designed to assess "environmental performance and management" of existing buildings and thus suitable for post occupancy evaluation. There are 6 areas for assessment and they are Energy, Water, Waste Reduction and Site, Emission and Effluents, Indoor Environment and Environmental Management System. The standard has specific assessments, consisting of questionnaires tailored for offices, open air retails, light industrial buildings, shopping centers, multi-unit residential buildings and, recently, healthcare facilities. The second version of BOMA BEST was introduced in 2012 and is the version considered for our study. Recently, it was announced that a version 3 will be launched in September 2016 which includes new questions, continuous metrics update, new software interface and updated energy benchmarking (BOMA Canada, n.d.-a).

The standard and assessment fees depend on the building size determined by the total gross floor area including "all floor area measured to the outside of the exterior walls including the aggregate floor area of the building, all tenant spaces and common areas, as well as all supporting functions such as: stairways, connecting corridors between buildings, heated parking facilities, lobbies, atria, cafeterias, storage areas, and elevator shafts." CIRS with its area of 61,085 square feet can be assessed as an office with an area less than 100,000 square feet. As per the 2016 price list, BOMA BEST Certification for CIRS will cost $2,600 if UBC is a BOMA member otherwise the cost is $4,100 (BOMA Canada, 2013; BOMA Canada, 2016). The below table indicate the 5 levels of certification and the required score in the questionnaire:

Table 6: BOMA BEST Certification Levels. Adapted from (BOMA Canada, 2016)

Certification Level	Score Range

Certified	Up to 59%
Bronze	60-69%
Silver	70-79%
Gold	80-89%
Platinum	90-100%

5.4.2. Evaluation Method

The questionnaire commences with a basic information section including the following information: building construction year, date of latest major renovation, percent of gross floor area conditioned, rentable floor area, annual operation costs, data center area, area of different room applications, primary cooling and heating systems, presence of a building management system and materials of walls, roof and windows. There is no credit for answering these questions but they are required to generate the report and recommendations. In the online questionnaire, there are approximately 90 questions concerning energy, 56 questions concerning indoor environment and 48 questions involving emissions and effluents (BOMA Canada, n.d.-b).

Energy

The energy section is the largest of the questionnaire and covers energy consumption, energy efficient features, energy management. The energy consumption portion requires entering data concerning electricity consumption and fuels consumption used to generate heat. Using the utility meter billing information, the monthly electricity consumption in kWh is entered for the last 12 months of the bill including the cost. Similarly, monthly consumption data and cost is entered for natural gas in cubic meters, fuel oil in liters, purchased steam in British thermal units, propane in liters, purchased chilled water in billion joules and on site generated heat in kWh. The total consumption is converted into a common unit, kWh/square foot/year, which is divided by the total gross floor area to represent an energy use intensity. This benchmarking does not involve normalization unless there are data centers in the building with sub-metered electricity information (BOMA Canada, n.d.-b). The below table indicates the benchmark scales noting that the maximum attainable score for this portion (BOMA Canada, 2016):

Table 7: BOMA BEST Energy Performance Benchmarking. Adapted from (BOMA Canada, 2016)

Energy Use Intensity (kWh/square foot/year)	Points
Less than 36	8
Less than 32	16

Less than 28	24
Less than 24	32
Less than 20	40
Less than 18	48
Less than 16	56
Less than 14	64
Less than 12	72
Less than 10	80

The remaining questions in the questionnaire are multiple choice. The energy efficient features involve questions concerning lighting technology, boiler age and efficiency, chillers age and efficiency, temperature control systems, building automation systems, hot water equipment, variable speed drives, exhaust air heat recovery, cogeneration, purchase or generation of energy from renewable sources, building envelope assessment (BOMA Canada, n.d.-b).

The energy management portion of the questionnaire addresses the management of the building rather than technologies. This portion includes 3 of the 14 best practices that must be met for certification. One is the requirement for having an energy assessment within the last 3 years with recommendations. This energy assessment must be "a minimum ASHRAE Level 1 Walk through" but BOMA has certain accepted equivalents. The second requirement is the existence of a building specific energy management plan to resolve the issues highlighted in the energy assessment. The third best practice requirement is having a preventive maintenance HVAC program. The other questions ask about excessive energy consumption monitoring policy, energy usage targets, staff training plans for energy monitoring, sub metering, documented operating instructions and maintenance and commissioning (BOMA Canada, n.d.-b).

Indoor Environment

The indoor environment section evaluates the indoor air quality, thermal comfort, lighting and noise. These questions addresses issues directly affecting the occupants. Ventilation questions addresses distance between air intakes and areas of pollution, exhaust outlets and free-standing water. Also, there are questions concerning corrosion in AHUs and levels of carbon monoxide. Filtration system question requires MERV-8 minimum filters to be used. There are questions specifying the humidification system type to be steam or spray. In addition, questions recommend distancing cooling towers from air intakes and outlets, equipping them with drift eliminators and maintenance program. Also, parking areas are recommended to be mechanically ventilated and measures must be taken to block exhaust fumes into the building from the parking and receiving areas. Indoor air quality recommendations include having a

designated smoking area, carbon monoxide detection and measures to prevent transport of local air pollutants from certain rooms. It is recommended to have documented procedure for local pollutant control including Legionella. The only best practice question in this section requires the building to have documentation of tenant and occupant complaints about indoor air quality (BOMA Canada, n.d.-b).

Thermal comfort questions deal with temperature and humidity monitoring and conducting a thermal comfort survey among the occupants. Lighting questions address glare control, lighting measurements meeting IESNA guidelines, lighting control by occupants, occupant lighting and visual comfort satisfaction surveys. Noise questions mainly involve conducting an acoustic privacy and noise disturbance occupant satisfaction survey and severity of noise generated due to base building condition and operation including documented history. Recommended noise levels are 35 decibels or less for background noise in meeting rooms and closed offices while 42-48 decibels for open office areas (BOMA Canada, n.d.-b).

Emission and Effluents

The Emission and effluents section concerns air emissions, ozone depleting refrigerants, water effluents, hazardous materials and pesticides. Air emissions questions concern low nitrogen oxide emitting boilers. As for ozone depleting refrigerants, it is required to enter the percentage of refrigerants used. Different type of refrigerants have different ODPs and GWP. ODP is the ozone depleting potential and measures the ozone depletion effect of the refrigerant relative to that of CFC11. Whereas, GWP compares the amount of heat trapped by this refrigerant relative to that of carbon dioxide. It is recommended for the building to have floor and roof drains are to be isolated and radon levels less than 200 Becquerel per cubic meter. There should be management plans for asbestos, storm water, snow and ice, PCB, and storage tanks. It is also recommended to have material safety data sheets less than 3 years old for hazardous products and labels on regulated products as per the Workplace Hazardous Materials Information System adopted in Canada (BOMA Canada, n.d.-b).

A best practice question recommends having a documented management plan for ozone depleting substances which contain inventory of refrigerants, maintenance reports, staff training, periodic leak testing and destruction procedures for refrigerants. Another best practice question requires completion of a hazardous building materials survey and a chemical inventory within the last 3 years. A third one requires a hazardous products management plan (BOMA Canada, n.d.-b).

5.4.3. Scoring

In order to apply for BOMA BEST certification, a building must be one year old and have a minimum 70% average occupancy for at least 12 consecutive months. The certification process involves completing an online assessment consisting of a total 175 questions divided into 6 sections for each of the aforementioned assessment areas. There are 14 questions forming the “BEST Practices” and must be satisfied in order for the building to be certified. Most questions are multiple choice and each has an allocated number of credits and the maximum score for the complete assessment is 1000 points. The multiple choice answer representing the best answer receives the maximum allocated credit and the

other choices receive smaller portions of the maximum credit. The below table indicate the number of points for each section in the questionnaire (BOMA Canada, 2016).

Table 8: BOMA BEST Scoring by Assessment Section. Adapted from (BOMA Canada, 2016)

Assessment Section	Maximum Number of Points
Energy	350
Indoor Environment	180
Emissions and Effluents	170
Waste Reduction and Site	110
Environmental Management Systems	110
Water	80

After completion of the questionnaire, an online report could be generated with a broken down scoring for each section. It also includes a summary of the entered information along with recommendations for enhancements. In addition, the local BOMA association is automatically verified where the local program administrator or appointed 3rd party verification party will set up for a verification site visit. The visit involves a building tour and review of building and management documents (BOMA Canada, 2016).

6. Comparison

The BREEAM and BOMA assessments achieve a balance in evaluating the building performance based on technical performance and occupant wellbeing while the WELL Building Challenge is more focused on the occupant. Despite addressing more areas, SPeAR does not scrutinize as well as the other mentioned assessment tools with respect to scoring and detail of questions addressed. For this reason and in addition to the more available documentation on BREEAM, BREEAM is used as a reference for linking the selected post occupancy evaluation tools.

6.1. Linkages

The WELL Building Challenge, BREEAM and BOMA assessment tools result in certification. Accordingly, all three involve registration, meeting a certain score on a measureable questionnaire and site verification. On the other hand, SPeAR scoring system involves a subjective approximate severity indication of “Best case” or “Worst case”. Accordingly, the overall result of SPeAR could be different for the same data evaluated. Furthermore, the end result of the SPeAR assessment tools is an overall indication.

Only BREEAM questionnaire has separate sections for asset performance, building management and occupant management. Whereas, WELL Building Challenge, BREEAM and BOMA have building and occupant management questions with regards to policies and strategies intertwined with asset management questions.

Due to the fact that the primary focus of the WELL Building Challenge is the health & wellbeing of the occupant, there are common sustainability measurement criteria with BREEAM with respect to health & wellbeing and pollution. All health & being criteria in BREEAM are mention in WELL Building Challenge and only pollution prevention and detection system criteria are not addressed with regards to the pollution area. This can be expected of the WELL Building Challenge as it does not focus on the technical design of a building. This is further verified by the fact that only HVAC, ventilation strategy and mechanical & electrical heating equipment criteria of the Energy section of BREEAM is addressed in WELL Building Challenge.

SPeAR and WELL Building Challenge do not require an evaluation of energy design of a building. BOMA evaluates the energy design based on electrical consumption and fuel consumption for heat generation using billing data compared to performance benchmarks. However, BREEAM has a more extensive energy modeling evaluation comparing user inputted data with performances benchmarks with regards to:

1. Heating building characteristics and generation performance
2. Cooling building characteristics and generation performance
3. Heating distribution efficiency
4. Cooling distribution efficiency
5. Lighting efficiency
6. Ventilation efficiency
7. Hot water generation

BOMA does address the above issues in addition to renewable sources generation through a questionnaire but not modeling. However, there are some energy criteria covered by BREEAM but not by BOMA and vice versa. Criteria covered by BREEAM are such as glazing, specific fan power and legislation. BOMA covers criteria such as energy innovation and management. All issues of pollution addressed by BOMA are addressed by BREEAM except for hazardous materials emissions but BOMA does not cover flood risk. With respect to health and wellbeing, BOMA addresses noise while BREEAM does not. BOMA recommends regular verification of lighting control and occupant satisfaction survey while BREEAM in part one does not. There is little linkages between BREEAM and BOMA with regards to indoor air quality as only the following issues are in common: control of pollutants at source and thermal comfort.

6.2. Advantages

SPeAR is useful for building management to assess their internal satisfaction with the building performance rather than measuring it to a well-defined standard. WELL Building Challenge is more suited for healthcare buildings were occupant is the primary focus but also energy assessment would be lacked. Whereas BREEAM and BOMA are best for industrial building. Other building types such as retail, residential and offices must have a balance of occupant-focused and asset-focused criteria. BREEAM measures more energy aspects of a building than BOMA but with fewer questions. BREEAM provides a more precise measurement by separating the measurements of the asset, building management and occupant management thus assisting in more accurately resolving building deficiencies.

6.3. Deficiencies

SPeAR does not have a defined set of indicator and thus is not as helpful as the other standards. The WELL Building Challenge by itself is not sufficient but BOMA and BREEAM are not as extensive in occupant health criteria. It appears that a more suitable assessment tool would include the same level of focus on both but that would incorporate a criteria importance measurement as stated by building manager and occupant.

7. Recommendation

As noted in previous sections, the four Post Occupancy Evaluation schemes investigated in this study have significant overlap in the areas they cover. The linkages between the different assessments tools are highlighted which demonstrates a strong consensus on the areas of focus in evaluating buildings' performance post occupancy. However, there are also areas addressed by some assessment tools and not by others. The team has put together tables 9-11 showing those areas. Additionally, there are areas addressed by different assessment tools but to different extents. One assessment tool may require the mere existence of a certain feature whereas another assessment tool is concerned not only by the existence of the feature but also with the quality of its output and provides ranges of scores for the performance of the particular feature. As previously mentioned, these different tools have been developed by different organizations with different missions and target audience.

As important as it may be to standardize such schemes in order to better compare buildings of different uses located in different regions, it could be argued that it's more important not to lose focus of end-user's needs and the building context. For example, it can be argued that reduction in electrical energy consumption in British Columbia and Alberta are not directly comparable and should be weighted differently. The research team is in strong belief that the right POE tool for each project may look differently and weigh each section differently. As demonstrated through the example above, none of the POE tools account for the building context which has a significant effect on the impact of building on its users and environment. Electrical energy conservation in British Columbia where over 89% of energy comes from renewable sources should not be weighted equally and directly compared to the

neighboring province of Alberta where over 96% of electrical energy is produced from nonrenewable sources (Statistics Canada, 2007). Additionally, different building uses have different needs which are not addressed in the named POE schemes. For example, in an office building, the inhabitants would be working for long periods of time and an outside view is argued to increase their productivity and reduce stress. However, in a museum, the inhabitants' main objective is viewing galleries and appreciating the contents inside the building; accordingly, an outside view may not carry the same importance as in an office building.

Table 9: Comparison of the Selected Four POE Tools on the Topic of Energy

Energy Topic Area	BREEAM	BOMA	WBC	SPeAR
HVAC	X	X	X	
Ventilation Strategy	X		X	X
Heat Loss	X			X
Pressure/Air Leakage	X			
Heating	X	X		X
Boiler Efficiency	X	X		X
Heat Pump Efficiency	X			X
Fuel Usage for Heat Generation	X			
Heat Distribution & Heat Emitter Type	X			
Mech. & Elec. Heating Equipment	X		X	
Cooling System	X	X		
Efficiency of Cooling System	X			X
Cooling Distribution	X			
HVAC Efficiency	X			X
Refrigerant Cooling System & Emitter Type	X			
Glazing	X			
Mech. & Elec. Cooling & Ventilation Equipment	X			
Specific Fan Power	X			
Leakage Tests	X			
Water Heating	X			
Water Heating Energy Sources	X	X		
High Frequency Ballast	X			
Internal Lighting Types	X	X		X
Automatic Lighting Controls	X	X		X
Occupancy Sensors	X	X		
Legislation	X			

Onsite Renewables	X	X		X
Energy Consumption		X		
Controls		X	X	
Envelope		X		
Energy Innovation		X		
Energy Management		X		X
Visual Lighting Design			X	
Electric Light Glare Control			X	
Outdoor Air Systems			X	
Increased Ventilation			X	
Direct Source Ventilation			X	
Appliances & ICT				X

Table 10: Comparison of the Selected Four POE Tools on the Topic of Health & Wellbeing

Health & Wellbeing Topic Area	**BREEAM**	**BOMA**	**WBC**	**SPeAR**
Glazing	X		X	
Glare Control	X		X	
Thermal Control	X		X	
Ventilation Controls	X		X	
Microbial Contamination	X		X	
Water Provisions	X		X	
Indoor and/or Outdoor Space	X		X	
Illuminance Levels	X	X	X	
Lighting Controls	X		X	
Inclusive Design	X		X	
Ventilation Requirements	X		X	
Indoor Air Quality		X		
Lighting		X		
Noise		X	X	X
Air Quality & Standards			X	X
Air Filtration			X	
Air Quality Monitoring			X	
Thermal Comfort			X	
Sound Reducing Surfaces			X	

Table 11: Comparison of the Selected Four POE Tools on the Topic of Pollution

Pollution Topic Area	BREEAM	BOMA	WBC	SPeAR
Pollution Prevention	X			
Flood Risk Assessment	X		X	
Impact Mitigation	X	X	X	
Impacts of Refrigerants	X	X	X	
Leak Detection System	X	X		
NO x Emissions	X	X	X	
Hazardous Materials		X		
Construction Pollution Management			X	
Pesticide Management			X	
Combustion Minimization			X	

8. Conclusion

A review of several different assessment tools has been conducted. Different assessment tools tackle different phases of a building life cycle and different types of buildings. From our review, we have narrowed down to four assessment tools suitable for post occupancy evaluation of the CIRS building. Despite having similarities, these tools differ in topics covered and weighting of topics varies from one tool to another. Accordingly, we have suggested that the best assessment tool would be comprehensive and most importantly will take into account the importance of the topic for the user as well as the context in which the building resides.

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10. Appendices

Appendix A – Assessment Tool Table 35

Appendix B – Mind Map 36

Assessment Methods	Organization	Basic Characteristics	Done before	Applicable	Accessibility	Method Scope	Information Requirement	Website	Assigned
Leadership in Energy and Environmental Design) Green Building Rating System™ (LEED)	Created by the US Green Building Council and used under license by the Canada Green Building Council,	An internationally recognized benchmark for the design, construction and operation of high performance green buildings. LEED has four levels of certification (certified, silver, gold and platinum).	Yes	Yes	CIRS Data	human and environmental health: sustainable site development, water efficiency, energy efficiency, materials selection and indoor environmental quality.		http://www.cagbc.org/CAGBC/LEED/CAGBC/Programs/LEED/Going_green_with_LEE.aspx?hkey=54c44792-442b-450a-a286-4aa710bf5c64	
The Living Building Challenge (LBC)	International Living Future Institute (ILFI)	Projects seeking LBC certification must demonstrate that they meet the performance requirements of the standard, over a 12-month period, in each one of the seven LBC key areas: site, water, energy, health, materials, equity and beauty.	Yes	Yes	CIRS Data	Site, water, energy, health, materials, equity and beauty.		http://living-future.org/lbc	
Sustainable Project Appraisal Routine (SPeAR)	ARUP	The Sustainable Project Appraisal Routine (social, economic and environmental sustainability)	no	Yes	30-day trial - http://www.oasys-software.com/spear.html		Works only on Windows need more time to analyse	http://www.arup.com/Projects/SPeAR.aspx	Mohammed
BOMA BESt Assessment	The Building Owners and Managers Association of Canada (BOMA Canada)	This survey provides a consistent framework for owners, managers and building operators to critically assess six key areas of environmental performance and management: Energy; Water; Waste & Site;Emissions & Effluents; Indoor Environment; and Environmental Management System. 175 detailed questions. Score % to determine Level 1 – 4 (higher the better)	No	Yes	Fee needed, http://www.bomabest.com/about-boma-best/certification-process-and-fees/	Energy; Water; Waste & Site; Emissions & Effluents; Indoor Environment; and Environmental Management System.		http://www.bomabest.com/	Majed
ASHRAE Performance Measurement Protocols	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)	Provide a consistent method of measuring, expressing and comparing: the energy use, water use, and indoor environment of buildings.	No	Yes		Energy Use, Water Use, Indoor Environment	Usage Data	https://www.ashrae.org/home	
WELL Building Standard	International Well Building Institute	The WELL Building Standard marries best practices in design and construction with evidence-based health and wellness interventions. It harnesses the built environment as a vehicle to support human health, wellbeing and comfort.	No	Yes	Fee needed, https://www.wellcertified.com/certification			https://www.wellcertified.com/	Kinza
Building Research Establishment Environmental Assessment Method (BREEAM)	BRE Global Ltd (part of the BRE Group)	BREEAM In-Use International is an assessment method which assists property investors, owners, managers and occupiers to drive sustainable improvements through operational efficiency, including how to continually manage the operation of their building effectively.	No	Yes		To begin,includes energy use, heating, lighting, and site impact. The second part focuses on design and procurement, assessing material specifications and on-site construction. Finally, management and operation are taken into account on occupied buildings.		http://www.breeam.com/in-use	Hooman
SB Challenge 2014	iiSBE Canada - International Initiative for a Sustainable Built	Compare predicted performance at the design stage with actual performance achieved after occupancy	Yes	Yes	http://iisbecanada.ca/umedia/cms_files/Report_-_CIRS_Final_May_2015.pdf	Location and site, "Design approaches and innovations", Energy, Water ,Environmental impacts,Materials, IEQ, Economic factors, Occupancy factors, Overall	Design and real performance Data, Interview	http://www.iisbe.org/sb_challenge	
ATHENA	Athena	Whole building design decision/decision support tools for life cycle assessment	No		http://calculatelca.com/software/impact-estimator/			http://calculatelca.com/	
Comprehensive Assessment System for Built Environment Efficiency (CASBEE)	Japan GreenBuild Council (JaGBC) / Japan Sustainable Building Consortium (JSBC)	CASBEE for Existing Building: This assessment tool targets existing building stock, based on operation records for at least one year after completion. It was developed to be applicable to asset assessment as well.	No	Yes	Free: http://www.ibec.or.jp/CASBEE/english/download.htm	Energy efficiency; Resource efficiency; Local environment; Indoor environment.		http://www.ibec.or.jp/CASBEE/english/overviewE.htm	Ryan

POE Tool Assessment

BREEAM

- Energy
  - HVAC
  - Ventilation Strategy
  - Heat Loss
  - Pressure/Air Leakage Test
  - Heating
  - Boiler Efficiency
  - Heat Pump Efficiency
  - Fuel Usage for Heat Generation
  - Heat Distribution
  - Heat Emitter Type
  - Mech. & Elec. Heating Equipment
  - Cooling System
  - Efficiency of Cooling System
  - Cooling Distribution
  - HVAC Efficiency
  - Refrigerant Cooling System
  - Cooling Emitter Type
  - Glazing
  - Mech. & Elec. Cooling Equipment
  - Specific Fan Power
  - Leakage Tests
  - Mech. & Elec. Ventilation Equipment
  - Water Heating
  - Water Heating Energy Sources
  - High Frequency Ballast
  - Internal Lighting Types
  - Automatic Lighting Control
  - Occupancy Sensors
  - Legislation
  - Onsite Renewables
- Health & Wellbeing
  - Glazing
  - Glare Control
  - Thermal Control
  - Ventilation Controls
  - Microbial Contamination
  - Water Provisions
  - Indoor and/or Outdoor Space
  - Illuminance Levels (Lux)
  - Lighting Control
  - Inclusive Design
  - Ventilation Requirements
- Pollution
  - Pollution Prevention
  - Flood Risk Assessment
  - Impact Mitigation
  - Impacts of Refrigerants
  - Leak Detection System
  - NOx Emissions

BOMA

- Energy
  - Energy Consumption
    - Q: Monthly Electricity Consumption and Cost
    - Q: Monthly Electricity Demand (Optional)
    - Q: Monthly Fuel Consumption and Cost to Generate the Electricity
  - Energy Efficient Features
    - Lighting
      - Q: High Efficiency Lighting Features
        - Compact Fluorescents
        - T8/T5 Flourescents in building/garage areas
        - LED Exit lights
        - High Intensity Discharge Lamps
        - Desk lighting level of 380-540 lux
        - Automated Lighting Controls
        - Occupancy Sensors
        - Daylight Sensors
        - % of total lighting fixtures with high efficiency lighting fixtures
    - Major HVAC Equipment
      - Q: Boilers age <20 years
      - Q: % of heating boilers with efficiency >85%
      - Q: Variable load control of boilers
      - Q: % of cool-top package units with high efficiency
      - Q: % of chillers with high efficiency
      - Q: Variable load control of chillers
    - Controls
      - Q: Temperature Setback
      - Q: Temperature/weather compensation
      - Q: Building Automation System
      - Q: Building Automation system control of:
        - Lighting Systems
        - HVAC (Heating, Ventilation, Air conditioning
      - Q: Integration of Building Automation System with energy monitoring and/or preventive maintenance
    - Hot Water
      - Q: Type of heating system for Domestic Hot Water
      - Q: High efficiency water heating equipment
      - Q: % of hot water faucets with water saving devices
      - Q: Domestic hot water temperature between 49 and 52 degrees Celsius
    - Other Energy Efficiency Factors
      - Q: VFDs used for:
        - Main supply air systems
        - Main chilled water pump and/or condensor water system
        - Heating pump systems
        - Domestic water booster pump
        - Cooling tower fan motor
      - Q: % of fan and pump motors with high efficiency
      - Q: Other energy efficient measures:
        - Exhaust air heat recovery
        - Cogeneration
        - Escalator/elevator with efficient control systems
  - Low Impact Electricity
    - Q: Renewable energy purchased
    - Q: Presence of renewable energy generation mechanisms
    - Q: % of total energy used is produced by renewable sources
  - Envelope
    - Q: Assessment of building envelope performance within 5 years with respect to:
      - Moist Air Transfer
      - Air Flow
      - Heat Transfer
    - Q: Energy Efficient Windows
    - Q: Window shading reducing cooling load
    - Q: Roof with cool materials with solar reflectance index > 70
    - Q: Double doors or revolving doors and vestibule heating cutting excessive heating
    - Q: Building Air sealed at:
      - Top
      - Bottom
      - Vertical Shafts and Elevators
    - Q: Comprehensive Building Condition Report within 5 years
    - Q: Comprehensive Building Condition Report used for Capital/ Building Maintenance Plan
    - Q: Comprehensive Building Condition Report used for Capital Plan
  - Energy Innovation
    - Q: Photoluminescent light EXIT signs or LED general lighting
    - Q: Impact of other energy saving systems
    - Q: Demand response capability of building
  - Energy Management
- Emission and Effluents
  - Boiler Emissions
    - Q: % of boilers with low NOx emissions
    - Q: Records of cleaning and calibration of burners, monitoring of controls, and analysis of flue gas
    - Q: Specification of low sulphur content of fuel oil in purchase order/ contracts
  - Emissions - Ozone Depletion
  - Emissions - Water Effluents
  - Emissions - Hazardous Materials
- Indoor Air Environment
  - Indoor Air Quality
  - Lighting
  - Noise
    - Q: Occupant satisfaction survey for privacy, noise and ease of interaction within last 12 months
    - Q: Are the results of the survey related to building operation and condition
    - Q: Documented history of acoustic problems related to building operation and condition

WBC

- Air
  - Air Quality & Standards
    - Formaldehyde levels
    - CO levels
    - Radon levels
    - Ozone levels
  - Ventilation Effectiveness
    - Ventilation Design
      - Compliance with ASHRAE 62.1-2013 standard
    - Demand Controlled Ventilation
      - CO2 levels below 800ppm
    - HVAC system
    - VOC Reduction
    - Air Filtration
    - Outdoor air systems
    - Increased Ventilation
    - Direct source ventilation
      - requires the isolation of indoor pollution sources in separate rooms or exhausted cabinets
  - Air quality monitoring
    - Real-time measurement, recording and transmission of key indoor air quality metrics
      - If installed, HVAC system goes under testing during the site visit
  - Construction Pollution Management
    - Filter replacement
    - Duct protection
  - Pesticide Management
  - Combustion minimization
- Light
  - Visual Lighting Design
  - Lux levels
  - Electric Lights Glare Control
  - Solar Glare control
  - Daylighting Fenestration
  - Automated shading and dimming controls
- Mind
  - Health and Wellness awareness
  - Post Occupancy surveys
  - Adaptable spaces
  - Stress treatment
- Comfort
  - Noise Intrusion
  - Thermal Comfort
  - Sound Reducing surfaces
  - Individual Thermal Comfort
  - ADA Accessible design standards
- Water
  - Water treatment
  - Organic contaminants

SPEAR

- Social
  - Health & WellBeing
  - Health & Safety
- Environmental
  - Waste
  - Light Pollution
  - Noise and Vibration
  - Energy Demand
    - Lighting
    - Heat demand
    - Cooling/ ventilation
    - Energy monitoring
    - Appliances
    - ICT
  - Energy Generation
  - Air Quality
  - Energy
    - Energy supply
    - Energy conservation and efficiency
    - Energy monitoring
    - Daylighting
- Industrial energy reduction
- Economic