Post Occupancy Evaluation in Canada: Challenges, Potential Improvements and New Frontiers

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Abstract:
Canada's Build Smart strategy has a goal to build high-performance buildings by integrating occupant comfort with energy efficiency. Despite having established best practices to design high-performance buildings, there is a considerable gap between sustainable design and the actual performance of the building. Building performance evaluation provides tools and methods to investigate and analyze performance gaps in the buildings. Pre-occupancy and post-occupancy evaluations can be used to assess the way buildings function and establish a better understanding of sustainable performance. First, this study discusses the background and evolution of post-occupancy evaluation techniques in Canada. Second, the paper summarizes the methods and findings of a 2014 study by the International Institute of Sustainable Built Environment Canada that conducted post-occupancy evaluations of several green buildings across Canada, and it identifies the limitations of this study's protocol. Third, the paper discusses potential improvements to refine and prepare the protocol for a new iteration of studies in 2020, including foundations for a more rigorous and specific level of post-occupancy evaluations.

Keywords:
Post-occupancy Evaluations, Building Performance Evaluations, Performance Gap, Building Information Modeling

1. Introduction

The building sector accounted for almost 1/3 of the total energy consumption and Green House Gass (GHG) emissions in Canada in 2016 according to a Natural Resources of Canada's survey. Moreover, according to the World Green Building Council's report in 2015, people spend a significant amount of time indoors (almost 90%). Therefore, indoor environment plays a vital role in occupants' health, well-being and productivity [1].

Efforts to address buildings' impact on the environment while still addressing the occupants' experience have inspired several sustainable agendas and policies in Canada such as the Energy Step Code in British Columbia and the Build Smart strategy at the federal level. Despite these initiatives, there is a lack of effort in evaluating these green building relative to their expected performance criteria. When these evaluations are conducted, there are often gaps between the expected and actual performance [2], which is regarded as 'the performance gap' in the industry. Therefore, there is a need to measure the performance of the buildings after they are occupied to understand the performance of the implemented strategies, to investigate the performance decay over time and to inform decision making to improve facilities management.

Building Performance Evaluation (BPE) is a systematic and rigorous approach encompassing a number of activities including research, measurement, comparison, evaluation, and feedback that take place through every phase of a building's lifecycle, including: planning, briefing/programming, design, construction, occupancy and recycling [2]. Apart from the technical aspects, it also helps to establish the effects of human behaviour, needs and desires.

Post-Occupancy Evaluation (POE) is a part of BPE that can be used to obtain feedback about various parameters such as energy performance, indoor environmental quality (IEQ), occupant satisfaction, productivity, etc. [1]. Based on the collected data, Key Performance Indicators (KPIs) can be derived to establish a better understanding of the performance gap and to provide potential solutions.

The primary aim of this paper is to determine the current state of and potential improvements for POE in Canada.

First, the paper provides background of POE and discussion the findings from a 2014 POE study by the International Institute of Sustainable Built Environment Canada (iiSBE). Second, the discussion section describes the POE protocol developed by iiSBE . Third, the limitations of the 2014 iiSBE protocol are discussed. Fourth, potential improvements and suggestions are proposed for a new series of POE studies that iiSBE is planning to conduct in 2020.

2. Points of Departure

This section summarizes reviews of POE by Li et al. [1] and Mallory-Hill et al. [2], [3].

2.1. The Background and Evolution of POE

The roots of POE date to the 1960s. Since then, POE has evolved to include a variety of practices. Simultaneously, the building sector's shift towards achieving energy efficiency and minimal environmental impact has driven the industry towards the adoption of the green certification systems [2]. There are at least 150 different green certifications around the world such as LEED, Green Globe, ASHRAE etc. However, their ability to provide the expected performance is comprehensively debated in the literature.

Li et al. [1] argues that even though POE is gaining popularity, it is still an underdeveloped concept. The analysis of 146 POE studies in the paper concludes that residential buildings are the primary research targets, and occupant comfort is the most common focus among all the studies, which results in occupant surveys being the most frequently used method. Ultimately the paper gives five topics as a future direction of POE: from one-off to continuing, from high-level to detailed, from researchers-oriented to owners/occupants oriented, from academia to industry, and from independent to integrated.

The nature of POE studies varies according to their purpose. Also, it is difficult to link POE studies back to original root causes and project phases [2]. Despite decent efforts from the industry, POE studies are difficult to generalize, which makes standardizing POE protocol a challenge [1].

2.2. POE in Canada – iiSBE Studies 2014

The 2014 iiSBE study was initiated as a Canada-wide study of a total 9 different green buildings across different regions. The main objective of the study was to create a standardized POE protocol suited to the Canadian Industry.

Despite the limitations, the team was successful in identifying crucial performance gaps in all nine buildings. Analyses of these gaps helped the team conclude key issues, potential areas of improvement in design, construction, commissioning & operations phases, and evolution of POE as a process. Below are the key takeaways from the 2014 iiSBE POE study [3].

- More emphasis on communication and commissioning stage rather than primarily on the design stage.
- Benchmarking is difficult except for energy.
- Without recalibrated models, it is difficult to determine the performance gap
- Commissioning is often overlooked and should be one of the key process for improving the performance.
- Without submetering, collecting desired data is challenging.
- Three building underperformed in the modeled and actual energy performance. Some of the factors are inconsistency in occupancy modeling, unregulated occupant behaviour and lack of building systems commissioning.
- Water use is depended on the occupancy.

3. Methodology

A literature review has been conducted to identify the BPE & POE concepts. Moreover, a thorough study of the 2014 iiSBE project is conducted to describe the findings and limitations of the project. These findings have been used as a base to suggest improvement and to determine next steps for POE in Canada. Also, these suggestions will be used as a part of the second iteration of iiSBE project in 2020.

4. Discussions

4.1. POE - Concepts and Definitions

POE has a very wide range of definitions and scope according to various literature [1]. Pre-Occupancy Evaluations (Pre-OE) and Post-Occupancy Evaluations (POE) forms a part of systematic BPE approach. In this section, concepts of Pre-OE and POE in the context of the iiSBE Canada project have been summarized.

Post-Occupancy Evaluation (POE):
POE is a process of evaluating building performance after it has been occupied for at least 2 years. It is usually a measure of how well the design objectives are met without compromising the occupant comfort [3].

Pre-Occupancy Evaluation (Pre-OE):
Pre-OE evaluates the existing building before retrofits and addition of green features. Moreover, it can be used to assess the current conditions of occupants who will occupy a greener building. It uses techniques that are similar to POE [3].

4.2. The 2014 iiSBE Protocol

The protocol formed by iiSBE was intended to help standardize the gathering and processing of information for the KPIs.

The protocol's objective is to use a series of indicators to compare simulated performance at the design stage with actual performance achieved after at least 2 years of occupancy. Moreover, it can also be used to provide reference values for typical performance for similar buildings in the same region.

4.2.1. Key Performance Indicators

Below are the KPIs chosen by the research team for the assessment of nine buildings across Canada.

- Energy
- Water
- Materials & Waste

- Indoor Environmental Quality
  - Lighting
  - Thermal Comfort
  - Acoustics
  - Co2
  - Particulates
  - TVOC
- Economic Factors
- Occupancy Factors

4.2.2. Methodology

- Onsite building observation,
- Collection of design documentation regarding building type, spatial allocation, floor plans, green building rating systems, etc.,
- Collection of metered data for water and energy use,
- Spot measurements for IEQ with the use of an IEQ measurement cart,
- A standard survey of occupant comfort,
- Interview with design team, building owner/manager and when possible, occupants,
- Data Analysis & KPI determination, and
- Findings & Conclusion.

4.3. Challenges in the 2014 iiSBE Protocol

Observed limitations in the 2014 iiSBE protocol are as follows:

- The definition of the performance gap is very holistic.
- Data collection and management procedures needs to be more structured.
- There needs to be a standardized benchmarking for equipment used for spot measurement and its data collection.
- New buildings have started to integrate sensors as a part of Building Management Systems (BMS), however, there are no provisions regarding using BMS data along with spot measurements.
- There is not an efficient way to measure occupancy with high accuracy.
- Better visualization required to communicate the performance gap at a non-technical level.

4.4. Proposed Improvements in the iiSBE Protocol

Based on the literature review and identified gaps, potential improvements are proposed to generalize the POE process and make it more robust.

4.4.1. Levels of Evaluations

The BPE process should be divided in three levels for better data collection and analysis purposes.

Level 0: Pre-Occupancy Evaluations (Pre-OE)
Evaluations for existing buildings using the same KPIs from the 2014 iiSBE protocol.

Level 1: Post Occupancy Evaluations (POE)
Preliminary evaluations using the 2014 iiSBE protocol after the new green building has been occupied for at least 2 years.

Level 2: Post Occupancy Evaluations (POE)
Detailed Investigation after conducting preliminary Level 1 evaluations.

4.4.2. Data Collection & Management

- Standardize the equipment with specifications and tolerance for consistency,
- Integration of the data from BMS systems and other sensors along with the spot measurements,
- Pilot and implement efficient ways for occupancy tracking,
- Cloud based and structured database for the effective data management and collaboration, and
- An interactive occupant survey to encourage more engagement.

4.4.3. Data Analyses and Visualization

- Visualization of POE through Building Information Models (BIM),
- Spatial models of occupant satisfaction for effective communication at a non-technical level, and
- Analyses of the occupant survey databases is a very crucial topic and subjected to further research

5. Next Steps

- Revisit and refine level 1 iiSBE protocol developed in 2014,
- POE studies will be conducted on several new green buildings across Canada in 2020, and
- An attempt will be made for visualizing POE and occupant comfort data through BIM models.

6. Conclusions

- POE is a vital component of the design – construction – operations life cycles of the building. Although, it's still underdeveloped in Canada, it should be integrated as a part of sustainable agendas and green building certifications.
- Due to the unique nature of POE studies, it is difficult to generalize the protocol, however, it is possible to develop a protocol that can be

easily customized according to the nature and location of the building and purpose of POE.

- Despite of the limitations, the 2014 iiSBE protocol lays a solid foundation for 2020 POE studies.
- The current iiSBE protocol can be improved by linking BMS into data collection, utilizing cloud for better organization and collaboration, efficient occupancy tracking and effective visualization of spatial comfort and performance gaps through BBIM

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