Comparative Analysis and Optimization of Energy Calculation for Green Building Certification: A Case Study of GBI, LEED, and CASBEE

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Abstract

Most green building certifications are often rated on a scale of Certified, Silver, Gold, or Platinum, which are used mainly for benchmarking purposes. However, these green building rating levels do not always provide information on the actual energy performance of the certified building. This paper presents a comparative analysis of the energy performance methodologies used in LEED (International), GBI (Malaysia), and CASBEE (Japan) to identify an optimized and easy-to-adopt method that could be clearer and more straightforward for use in building projects in determining energy efficiency and the incorporation of relevant green building strategies to demonstrate building energy performance and its potential toward near-zero emissions. By comparing the building energy consumption calculation methods used in LEED, GBI, and CASBEE, the study aims to provide insights into the effectiveness of green building strategies in lowering building energy consumption before the integration of renewable energy. This can contribute to identifying best practices in energy efficiency for reducing carbon emissions in building projects. The findings can also serve as a showcase for green building certification as an effective building energy performance indicator towards lowering carbon emissions and contributing to reducing the overall environmental impact of building projects, in line with the global sustainability initiative.

Keywords: Green building certification, Energy Performance, sustainability

Introduction

Green building certification has become a common benchmarking tool for wholistic building performance and a measure of sustainability. These certifications are now available in most countries, each operating under their own rating systems. While many of these systems share a common goal of promoting energy efficiency, resource conservation, and environmental stewardship, they often differ in their specific criteria and methodologies. These differences are shaped by local climate conditions, legal frameworks, local building codes and construction practices unique to each region. For instance, while Leadership in Energy and Environmental Design (LEED) is widely used internationally, countries like Malaysia and Japan have developed their own systems — Green Building Index (GBI) and Comprehensive Assessment System for Built Environment Efficiency (CASBEE), respectively — that better align with their environmental priorities and regulatory requirements. Despite these variations, the underlying principles remain consistent, aiming to reduce the environmental impact of buildings and promote sustainable development globally.

As at 2023, GBI in Malaysia has had 1110 projects registered for certification (GSB,2023), with sees at least one (1) project application in a month, and approximately 45-65 project applications in a year. These are steady numbers by GBI despite Malaysia having several other rating tools such as the GreenRE by Malaysia Real Estate Agency and Mycrest and PHJKR, which are certification system from the government sector. Of the 1110 projects registered in 2023, 627 projects have achieved certification on various levels. Of these certified buildings, what are their carbon performance? And are they truly energy efficient?. The rating levels for GBI Non-Residential New Construction (GBI NRNC) are Certified, Silver, Gold and Platinum, based on 100 available points, where project must score from 50 points to achieve the Certified level, 66-75 points for Silver, 76-85 for Gold and Platinum level for 86 points and above. This rating levels are similar to that of LEED, but with slightly different weightage in terms of points scoring. CASBEE appears rather different from GBI and LEED. While it still assesses the same categories, they are split into two main assessment categories – Environmental Quality (Q), which covers Indoor environment, Quality of service, and Outdoor Environment on site, and Environmental Load (L) covering Energy, Resource & Material and Off-site Environment. Project would then calculate the Building Environmental Efficiency (BEE) to get the final rating, demonstrating an entire building performance, currently not available in both GBI and LEED, which makes CASBEE a suitable model to compare specific strategies in LEED (Doan,2017) and GBI.

Problem Statement

Do these certified green buildings really deliver? (Turner,2008). This is the long-asked question from the earlier LEED days before the emergence of other rating tools, that is still being asked today. Tools like GBI, LEED and CASBEE has established frameworks that guide sustainable design principles and aim to reduce the environmental impact of buildings. However, there not consistent – especially GBI and CASBEE, since they are meant to be localized to the country of origin. In this regard, how these certifications presents building's sustainability performance are also different.

RATING LEVEL	PLATINUM 86 - 100 Points	GOLD 76 - 85 Points	SILVER 66 - 75 Points	CERTIFIED 50 - 65 Points	Total Certified
NRNC	15	67	46	198	326
RNC	7	42	19	152	220
NREB	1	3	2	24	30
INC	-	2	5	17	24
IEB	-	1	-	3	4
ID	-	3	1	4	8
T	1	3	5	6	15
Total as of 31 October 2022	**24 (4%)**	**121 (19%)**	**78 (12%)**	**404 (65%)**	**627**

Figure 1 GBI Rated building by rating level (GSB,2023)

The current approach to green building certifications prioritizes comprehensiveness while attempting to maintain focus on key sustainability metrics. Certifications evaluate a broad range of factors, encompassing site strategies, material selection, water usage, operational efficiency, and indoor environmental quality as their major categories where improvements to a building can happen. This 'holistic approach' can inadequately highlight a building's strengths and weaknesses in crucial areas like energy efficiency and carbon reduction. This lack of clarity regarding a building's core environmental performance creates a cascade of issues. Primarily, building owners struggle to effectively communicate their sustainability efforts. The inconsistency in how certifications highlight strengths and weaknesses makes it difficult to convey the true impact of their green practices. Without clear metrics that directly address energy use and carbon emissions, owners lack a compelling narrative to showcase their commitment to environmental responsibility. One particular reason is due to the emphasis on scoring points (key concept in green building benchmarking), rather than focusing on building performance.

To address these shortcomings, a shift towards performance-based benchmarking could be the answer. This would move beyond awarding solely on rating levels but to also directly measure a building's operational and environmental impact, particularly its contribution to carbon emissions. A more transparent and readily available performance metric, clearly indicating emission performance is needed. This approach would incentivize real-world environmental improvements and ultimately pave the way for achieving zero-carbon buildings. By critically evaluating existing green rating tools and implementing performance-based benchmarks, green building certifications could evolve into a much more powerful tool for achieving the critical goal of a sustainable built environment.

Objective

This research aims to bridge the gap between existing green building certifications and the need for more targeted assessments of a building's environmental impact. While current certifications offer a valuable framework, inconsistencies and a focus on holistic performance can obscure critical metrics like energy efficiency and carbon emissions. To address these shortcomings, this study will develop and propose a performance-based framework for green building certifications.

This framework will directly measure a building's operational environmental impact, with a specific focus on energy efficiency and carbon reduction. By establishing clear, measurable metrics and a standardized reporting process, the proposed framework will enhance clarity and facilitate effective communication by building projects. This will empower informed decision-making based on reliable information about a building's true sustainability performance.

The objectives of the research is to perform a comparative analysis of Green Building Certifications based on energy performance metrics and criteria of GBI, LEED, and CASBEE as implemented in Malaysia - focusing on building energy Intensity (BEI), renewable energy, building envelope performance, active systems and other commonalities by developing a Performance-Based framework for Green Building Certification in Malaysia that can directly measure a building's operational environmental impact, focusing on energy use and carbon emissions. A clear framework will enable measurable metrics like BEI and the percentage of renewable energy usage, alongside a standardized reporting process of a certified green building.

Methodology

A mixed-methods approach, combining quantitative data analysis with qualitative case studies, as per Gultekin (2013) shall be adopted. It reviews existing literature on green building performance indicators, conducts interviews with industry professionals, and analyzes data from several high-performance green building projects. This comprehensive methodology ensures a robust understanding of the various factors that influence green building effectiveness. The methodology employed by Li (2020) involves a similar comprehensive review of existing literatures on green building performance metrics, followed by empirical analysis through a case study approach covering similar parameters.

In Malaysia, addressing the challenges is paramount to achieving long-term environmental sustainability and resilience. The current state of building practices in Malaysia, characterized by energy-intensive construction methods and reliance on fossil fuels for energy generation, exacerbates the country's carbon footprint and environmental impact. Against this backdrop, the research objective is to develop a comprehensive sustainable design framework tailored to the Malaysian context. This framework will integrate the principles of leading green certification systems, such as GBI, LEED, and CASBEE, in achieving zero-carbon buildings. To achieve this, the research will tabulate certification criteria/credits based on passive strategy

contributions towards lowering energy demand with direct criteria/credit contributing to energy performance before the introduction of renewable energy to establish operational performance, and carbon emissions performance. Based on this information, a test building shall be modeled and simulated using IES-VE software.

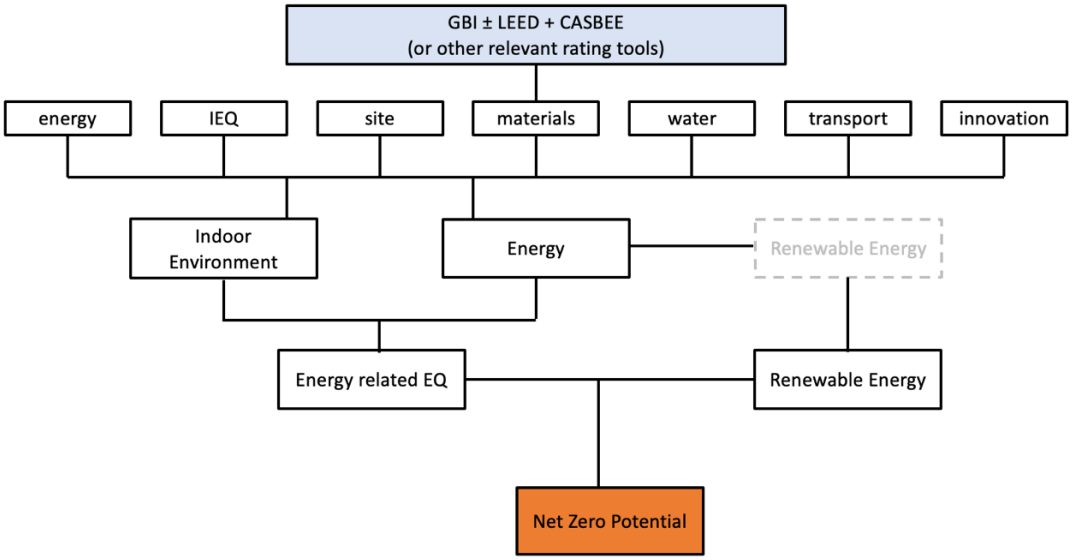

Figure 2 Proposed workflow for energy criteria analysis

Anticipated Results and Discussion

As an on-going research, the study shall rely on a sample building that will be modeled and simulated. The initial analysis is to collect and analyze data on building operation processes which involves gathering comprehensive information on energy consumption patterns, material usage, and occupancy dynamics, along with the climatic conditions of the project within its local context. Energy modeling shall be used for testing and assessment of passive designs and engineering features, enabling the creation of sophisticated simulations to give a 'what if' scenario and the potential impact of sustainable design interventions on carbon emissions.

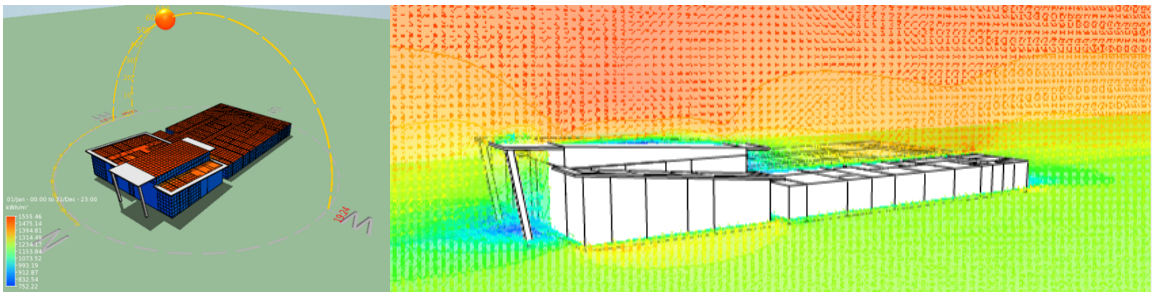

Figure 3 Sample building model

By comparing various scenarios, from baseline energy consumption to sustainable design alternatives, this study can pinpoint effective strategies for reducing carbon footprints. This must also demonstrate unique design choices, innovative technologies, and operational

strategies of the tested sample building. A set of strategies was introduced to test this parameters, and was simulated. The result demonstrated a steady reduction of energy when the strategy is applied accordingly. This indicates the importance of ensuring passive strategies are implemented before active systems. The result shows that when passive design is optimized, active strategies demand can be reduced significantly.

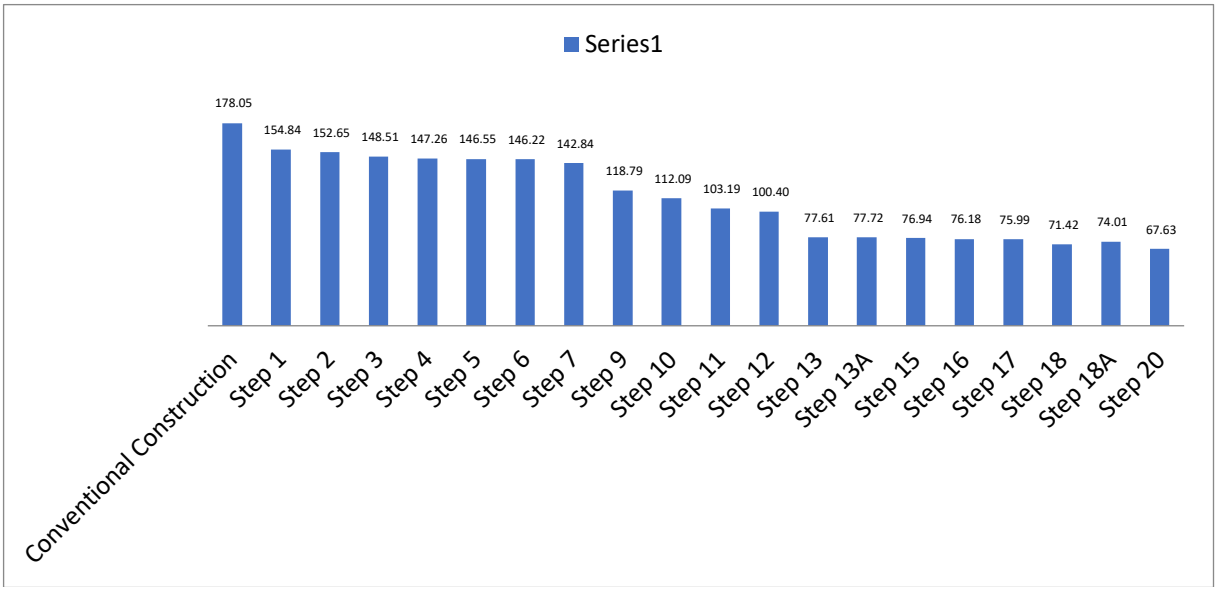

Figure 4 Step-by-step analysis using simulation model

Based on the criteria selection simulation, a model resembling CASBEE out was initiated. The performance output reporting using web-structure, much like CASBEE provides both graphical and numerical output which is very informative. This practical and performance-based approach to assessing the built environment's efficiency makes it a lot easier to assess as perception is immediate, due to the graphic output. Combining GBI (and LEED) with CASSBEE allows for a comprehensive assessment of sustainable design principles and promotes work efficiency and ensures a holistic approach is achievable. The synergy between these systems enhances the overall impact on energy efficiency, resource conservation, and occupant well-being.

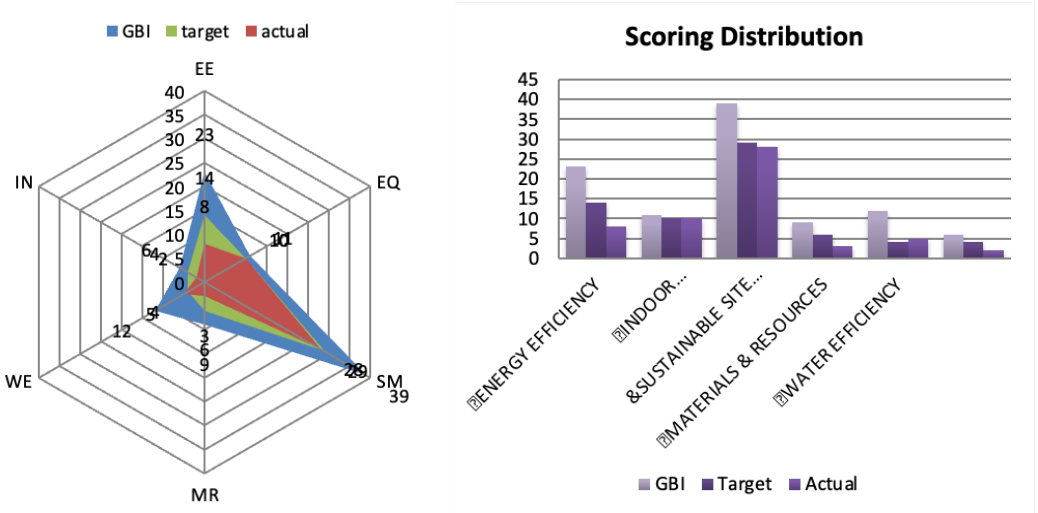

Figure 5 Sample GBI outcome, fashioned to CASBEE

The key challenge here is to identify relevant criteria/credit that gives direct impact to the performance so that it can be emphasized in projects. The findings could also be use to improve green building certification scoring, to highlight strategies that really matter or that have high impact to projects.

Conclusion

Combining immediate performance metrics with broader sustainability indicators can help to ensure buildings remain resilient and sustainable throughout their lifecycle. In regions like Malaysia, where tropical climates significantly impact building design, incorporating passive design strategies, natural ventilation systems, and shading devices is essential to optimize energy efficiency and occupant comfort while reducing reliance on mechanical cooling and improving on carbon emission reduction. Addressing these challenges requires interdisciplinary collaboration, innovative design, and a commitment to sustainability. This will fortify the role of green building certification systems like GBI, LEED, and CASBEE in reducing carbon footprints and achieving near zero-carbon emissions in the future, therefore contributing to global climate change mitigation efforts with the promotion of sustainable building practices. As the study progresses, further developments, adjustments, and additional insights will contribute to a more refined and robust analysis. It is important to acknowledge the preliminary framework and anticipate updates as the research advances towards its completion. The continuous improvement underscores the dynamic nature of the research process, enabling the future research opportunities.

The study's core contribution lies in the development of a novel performance-based framework for green building certification in Malaysia. This framework will incorporate process indicators to track project management effectiveness during design and construction. It will also include operational KPIs to monitor a building's performance after construction, focusing on metrics like energy consumption and water usage. Finally, the framework will establish a mechanism for long-term performance tracking of certified buildings.

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