Assessing Sustainable Practices: A Systematic Literature Review of Green Rating Frameworks for Pre-engineered Steel Buildings

Shailendra Kumar Khare[a], Dr Sunita Bansal[b], Dr Devendra Vashist[c]

[a] *Ph.D. Scholar, Manav Rachna International Institute of Research & studies, Faridabad, India*

[b] *Professor, Manav Rachna International Institute of Research & studies, Faridabad, India*

[c] *Professor, Manav Rachna International Institute of Research & studies, Faridabad, India*

***Abstract*:**

Background: There is a growing interest in eco-friendliness in the building business, prompting the creation of green grading systems. Modern construction relies heavily on pre-engineered steel structures, and the efficiency with which they use their resources is of critical significance.

Objective: The purpose of this SLR is to give a synopsis of the literature on pre-engineered steel building green rating frameworks. Our goal is to review the literature, draw conclusions, and recommend ways to improve sustainable building methods.

Methodology: The SLR employs a methodical approach that includes extensive searches of major academic databases and scholarly sources. To pick appropriate and high-quality literature, we define inclusion and exclusion criteria. The studies chosen undergo a thorough evaluation of their methodology.

Findings: This analysis traces the history of sustainability grading systems and how they have developed to include pre-engineered steel construction. Energy efficiency, materials, design, and life cycle analysis are common topics that keep popping up in the research. This analysis also highlights the study highlights the practical usefulness of these frameworks for industry stakeholders.

Conclusion: This SLR helps fill up the gaps in our knowledge of existing green rating systems for prefab steel structures. This shows the importance of these frameworks in influencing sustainable building practices and calls for further study and innovation in this area. The results provide helpful information for those working in the field, as well as academics and politicians studying the construction business.

Keywords: *Green rating framework, pre-engineered steel buildings, sustainability, systematic literature review, sustainable construction.*

Introduction

The construction industry has historically been one of the most resource-intensive sectors, both in terms of raw material consumption and energy use. As global attention shifts towards sustainability, there is an ever-increasing need for construction practices that are eco-friendly, cost-efficient, and resource-conserving. Within this context, the emergence of green rating frameworks has been a significant development. These frameworks provide a standardized measure to assess and certify the sustainability of buildings, offering an objective benchmark against which builders, architects, and other stakeholders can gauge their projects.

Among the myriad of construction materials and methodologies available today, pre-engineered steel buildings (PESBs) have gained considerable traction. Characterized by their speed of erection, durability, and cost-effectiveness, PESBs are now at the forefront of modern construction, especially in commercial and industrial sectors. However, despite their inherent advantages, there remains a need to evaluate and optimize their sustainability profile. It is within this context that green rating systems tailored for PESBs become indispensable.

Historically, sustainability in construction was often an afterthought, taking a back seat to other priorities such as cost, durability, and functionality. Traditional building methods were frequently resource-intensive and had significant environmental footprints. The evolution and popularization of green rating frameworks in the last few decades have dramatically shifted this paradigm. Today, there is a collective realization that buildings not only need to be functional and durable but also environmentally conscious. This transition has been fueled by a combination of regulatory pressures, growing societal awareness about environmental issues, and the tangible benefits (both economic and environmental) that sustainable construction offers.

Focusing specifically on pre-engineered steel buildings, several unique challenges and opportunities arise. Steel, as a material, has favorable attributes such as being 100% recyclable and having a potentially long lifespan. Nevertheless, the process of steel production, transportation, and assembly, among other factors, can have significant environmental implications. Hence, it's essential to comprehensively study and understand the sustainability aspects of PESBs within the larger ambit of green construction.

However, despite the increasing popularity of PESBs and the pressing need for sustainable construction methodologies, a consolidated understanding of green rating frameworks tailored for PESBs is conspicuously absent. This systematic literature review (SLR) aims to bridge this knowledge gap. By analyzing the existing body of literature, this review intends to map the trajectory of green rating systems as they pertain to PESBs, highlighting the key areas of focus, prevailing methodologies, and the potential avenues for further research.

In conclusion, as the world grapples with climate change and its associated challenges, the role of sustainable construction becomes ever more critical. Pre-engineered steel buildings, with their unique set of attributes and challenges, are poised to play a significant role in the future of sustainable construction. By understanding and optimizing the green rating frameworks tailored for these structures, we take a step closer to a future where buildings are not just shelters but are also stewards of our planet.

Pre-engineered Steel Buildings (PESBs)

Modern construction methods like pre-engineered steel buildings (PESBs) emphasize efficiency, flexibility, and speed. PESBs employ standard parts and connections, making design and construction quicker and cheaper than conventional techniques. Primary components are made off-site to established specifications and brought to the building site for assembly. This technology cuts on-site labor and waste, speeding up erection and lowering project expenses. Steel's strength, durability, and environmental resistance make PESBs ideal for commercial, industrial, and certain residential applications. The recyclability of steel makes PESBs a sustainable alternative for modern construction.

Green Rating Frameworks

Sustainable architecture and infrastructure needs green grading. Building environmental performance is analyzed, benchmarked, and certified using comprehensive criteria. A building's environmental footprint is assessed by its energy efficiency, water usage, waste management, and interior quality. LEED, BREEAM, and Green Star are worldwide frameworks that help builders, architects, and stakeholders use sustainable design and construction methods. Environmentally responsible frameworks may save operating costs, increase property value, and give tax benefits. Green buildings improve living and working conditions, making them important in modern cities. As society grows more eco-conscious, green grading systems define construction practices.

Research Method:

The "Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)" statement acts as a roadmap for this study. The terms "Green Rating Frameworks and Pre-engineered Steel Buildings" were searched to perform a comprehensive search of many prominent online libraries. Only papers written in English were considered for this review. On October 1, 2023, searches were performed in all available databases. Publications between 2000 and 2023 had their titles and abstracts read, with the complete text being acquired if there was any doubt as to their eligibility when written in English. There was a total of 24 publications included in this study, and they were all empirical studies of some aspect of topic's introduction or implementation. The current SLR strategy is broken down into its three main sections as shown below.

Step I. Study eligibility requirements are as follows: Specifying the eligibility criterion.

Step II. Extraction of Data: Using a Multi-Tiered Screening Process to Find Relevant Studies.

Step III. Execution of data: providing an overview of the papers that were determined to have similar results using content analysis, as well as the research profile and topic emphasis of those studies.

Study eligibility requirements

Inclusion Criteria

- English-language articles that have been published in a scholarly journal after extensive evaluation by academic experts before October, 2023
- Relevance to PESBs: Studies must primarily focus on pre-engineered steel buildings.
- Emphasis on Sustainability: The literature should discuss, analyze, or evaluate the sustainable attributes of PESBs, such as energy efficiency, materials used, lifecycle assessment, etc.
- Green Rating Frameworks: Included studies should provide insights into one or more recognized green rating systems (e.g., LEED, BREEAM, Green Star) and their applicability to PESBs.

Exclusion Criteria

- Articles not directly connected with topic.
- Matching authors, titles, volumes, issues, and DOIs in duplicate articles.
- Non-English Publications
- Non-peer-reviewed Sources: Exclude sources that are not peer-reviewed, such as blog posts, news articles, or personal opinions, to maintain academic rigor.
- General Sustainability Studies: Exclude literature that broadly discusses sustainability in construction without a specific focus on PESBs or green rating frameworks.
- Incomplete or Preliminary Findings: Exclude studies that represent preliminary results, works in progress, or those without concrete findings related to PESBs and green rating systems.

Extraction of Data

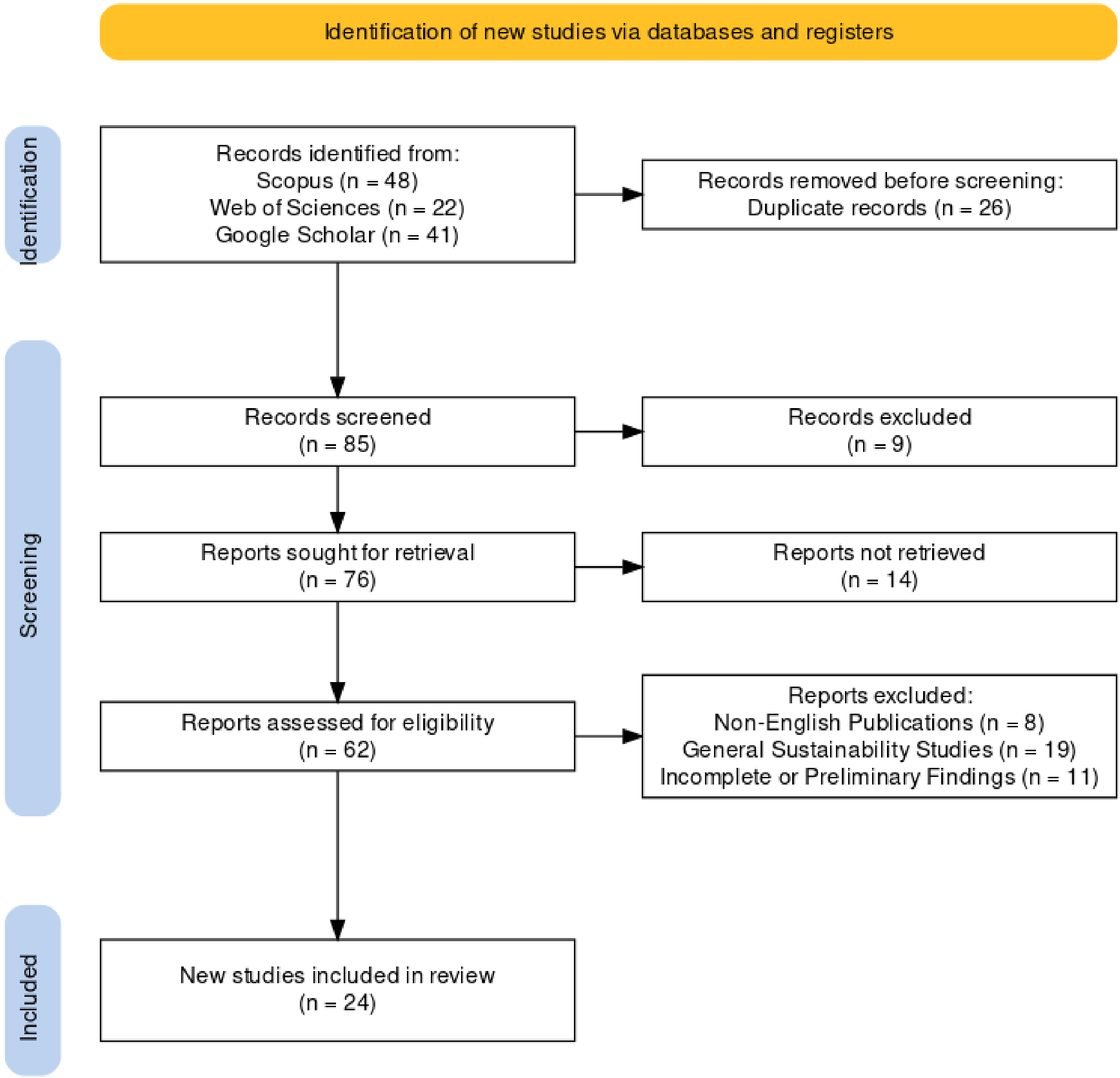

Fig.1 PRISMA Statement 2020 (Haddaway et al., 2022)

Source: Author Generated

The flowchart represents a meticulous approach adopted in the literature review to identify, screen, and eventually include relevant studies. Initially, new studies were sought through multiple trusted academic databases and registers. From Scopus, a total of 48 records were identified, while Web of Sciences contributed 22 records. Additionally, Google Scholar provided 41 records.

However, not all these records proceeded to the next phase. Before formal screening, 26 duplicate records were identified and removed, ensuring that each study was uniquely considered. The remaining 85 records underwent a preliminary screening process. Out of these, 9 records were excluded, leaving 76 reports.

An attempt was made to retrieve these 76 reports for a more detailed evaluation. However, 14 reports could not be accessed or retrieved, reducing the count to 62. These 62 reports underwent a rigorous eligibility assessment. During this phase, several reports were excluded for various reasons: 8 were non-English publications, 19 were general sustainability studies not specifically tailored to the review's focus, and 11 had incomplete or preliminary findings.

After this thorough filtration process, the final tally of new studies included in the review stood at 24. These studies formed the core body of literature that the systematic literature review was based on, ensuring that the review was comprehensive, relevant, and devoid of repetitions.

Execution of Data

Descriptive data, including year of publication and type of document selected for research, are offered to provide a profile of the research profile of the retrieved works.

Year wise Publication

The graph shows research article publication trends from 2004 to 2023. Research production was limited during 2004-2007, with 3 publications. This constancy continued throughout 2008-2011 with 3 publications. One research article was published between 2012–2015, a significant drop. In 2016–2019, 6 research articles were registered, accelerating momentum. However, the 2020-2023 period had 11 publications, the peak. The graph shows that academic interest in the topic has grown, notably in recent years.

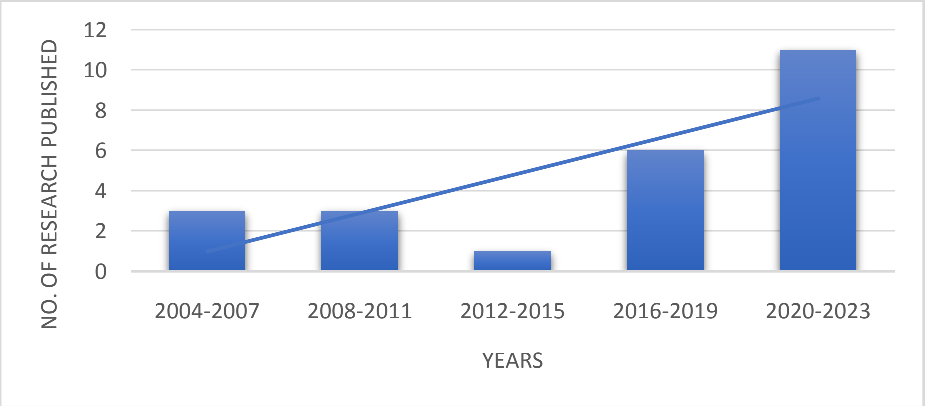

Fig2. Year wise publication on the topic

Source: Author Generated

Document Type

The pie graphic shows the 24 studies' source types. Journal papers make up 87% of the research. This dominance shows that journal-based articles are preferred in the topic under examination. The remaining 13% is books, which cover a wider range of scholarly literature. Journal articles give more detailed and concentrated views, while books may offer a more comprehensive analysis. The 24-research show that journal papers dominate, but books also contribute.

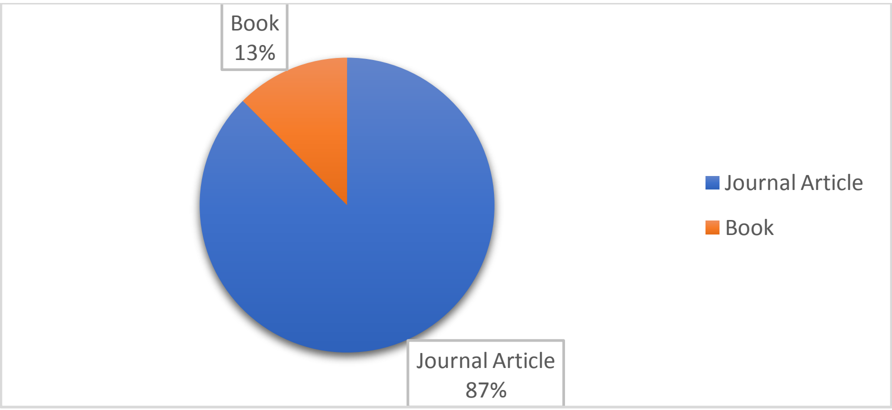

Fig3. Publication based upon Type of Document

Source: Author Generated

Literature Summary Table:

Author	Key Findings
Reeder, 2010	Guide to Green Building Rating Systems is a comprehensive guide for architects, designers, builders, and owners, detailing national rating systems, their evolution, objectives, benefits, and case studies from various climate regions.
Bernardi et al., 2017	This study explores the environmental impact of six main rating systems: BREEAM, CASBEE, DGNB, HQETM, LEED, and SBTool, aiming to understand their implications for building design.
Delavar, 2017	This study explores the benefits and applications of Building Information Modeling (BIM) for Pre-Engineered Building (PEB) construction, addressing challenges of automation and developing new BIM concepts.
Ferrari et al., 2022	The European Commission's Level(s) initiative aims to unify the construction sector and assess sustainability performance. Research reveals LEED is the most subjectively related system, while BREEAM and DGNB show greater affinity.
Khan et al., 2021	This research proposes a holistic framework for Pakistan's green building rating tool, Sustainability in Energy and Environmental Development (SEED), to improve the tool's cultural and governmental dimensions.
Nguyen et al., 2016	This paper presents an automated tool for rating green building designs using Building Information Modeling (BIM), integrating building knowledge frameworks into BIM platforms to streamline the complex and time-consuming assessment process.
Verma R & Singh R, 2020	This paper compares a 40-meter span of a pre-engineered metal building to a conventional steel building using finite element-based software ETABS (2013), revealing that pre-engineered steel buildings are both economical and stable.
Sánchez Cordero et al., 2019	The paper reviews common Green Building Rating Systems (GBRSs) in the EU, revealing that LEED and BREEAM are most affected by carbon emissions, while HQE and DGNB are less. It recommends alignment between GBRS and Level(s).
Sartori et al., 2021	This paper explores the use of Environmental Impact Assessment (EIA) tools like Life Cycle Assessment and Green Building Rating Systems to analyze a building's environmental performance, proposing future research directions.
Shahana Y. Janjua et al., 2019	This article reviews sustainability studies in the building and construction industry, focusing on environmental, social, and cleaner production strategies. It highlights research gaps and recommends further studies. The article emphasizes the need for diverse environmental impact categories and methodological breakthroughs in sustainability assessments.
Shrivastava & Shrivastava, 2022	The Pre-engineering Structure (PES) system is a cost-effective, sustainable, and rapid steel construction method that minimizes extra steel, ensures economic safety, and reduces time and expense.
Suman et al., 2020	The paper presents a framework for identifying sustainable office building renovation strategies, utilizing green building rating system criteria and cost-

	effective solutions, applicable across various systems and regional characteristics.
Wasim et al., 2023	The paper presents a case study on optimizing energy efficiency and cost in a light gauge steel building using various tools, resulting in better energy and cost savings, reduced energy consumption, and improved bending capacity.
Wen et al., 2022	The study uses Functional Quality Development to update green building rating tools (GBRTs) using Fuzzy Analytic Hierarchy Process and Fuzzy Set Theory, identifying technical improvements for developing countries.

Findings:

Historical Context:Earlier sustainability efforts in construction were generic and did not account for specific construction methods like PESBs. However, with the rise in PESB adoption, the last decade has seen a shift towards tailored sustainability approaches.

Prevalence of PESBs:The literature consistently emphasizes the increasing adoption of PESBs due to their efficiency, cost-effectiveness, and speed of construction. There is a noted trend towards PESBs in industrial and commercial constructions, especially in developing economies.

Green Rating Adaptations:Several studies show that traditional green rating frameworks, while comprehensive, often lack specific criteria tailored to the nuances of PESBs. However, there have been adaptations and specialized modules in frameworks like LEED to better cater to steel constructions.

Key Sustainability Aspects:Energy efficiency is a recurring theme, especially concerning insulation and energy consumption in PESBs.Material sourcing and recyclability of steel play a central role in determining the green credentials of PESBs.Lifecycle assessments of PESBs, compared to traditional constructions, show promising results in terms of reduced environmental impact.

Stakeholder Perception:Industry stakeholders recognize the importance of green ratings, with many noting that such certifications can enhance brand reputation, drive customer trust, and even lead to economic benefits in the form of tax breaks or increased valuation.

Innovations & Future Outlook:Emerging research explores the integration of renewable energy systems within PESBs, such as solar rooftops, to further boost their sustainability.There's a growing trend towards combining PESBs with other sustainable construction methods, like green facades or rainwater harvesting, to create holistic eco-friendly structures.

Recommendations from Previous Studies:Several authors advocate for the development of a unified, specialized green rating framework for PESBs.Enhanced collaboration between academia, industry stakeholders, and green rating agencies is often cited as a necessary step towards refining sustainability criteria for PESBs.

Discussion:

Green Rating Frameworks:

Green ratings have changed the building business. They demonstrate the industry's awareness of construction practices' environmental implications and the need for sustainable growth. These frameworks provide stakeholders a clear path to eco-friendly project practices as objective evaluation tools. Early green rating systems' one-size-fits-all approach made them difficult to apply to different building methods. Due to changes in materials, construction procedures, and operating dynamics, a PESB may not be assessed using the same criteria as a standard concrete structure. The growth of various grading systems to fit particular construction types, such PESBs, shows sustainable building's maturity and complexity. The ongoing development of these frameworks is also important. Green grading systems are updated with new research, technology, and environmental situations. This flexibility makes it difficult for industry stakeholders to keep current and compliant.

Pre-engineered Steel Buildings (PESBs):

PESBs' cost-effectiveness, speed, and design flexibility have made them a popular building method. Their modularity and off-site component fabrication decrease waste and site footprint.

Recyclability is a major sustainability benefit of steel. Steel may be recycled forever without losing quality, making PESBs potentially very sustainable throughout a lifespan, particularly compared to degradable or landfill materials. However, PESBs have sustainability issues. Steel manufacturing is energy-intensive and carbon-intensive. PESBsreal sustainability has been debated in the literature. The carbon-intensive manufacture of steel is balanced against its long lifetime and recyclability. Green construction concepts might also enhance or diminish PESB advantages. PESBs may lose energy efficiency without sufficient insulation, undermining their ecological benefits. PESB interaction with green grading systems is key.

Interplay between Green Rating Frameworks and PESBs:

Applying green grading systems to PESBs is complicated due to their specific characteristics. Developing or adapting grading systems for PESBs guarantees thorough and meaningful evaluation. This symbiotic connection may innovate PESB building techniques and expand rating systems. This SLR shows that knowing green rating frameworks and PESBs is vital. Both organizations advance sustainable building, but their full potential is realized when they work together. This integration offers a sustainable future for the building industry and a model for other industries.

Limitations of Green Rating Frameworks for Pre-engineered Steel Buildings:

Although groundbreaking for the building sector, green grading frameworks restrict pre-engineered steel constructions (PESBs). First, many frameworks disregard PESBs because they use traditional construction methods. Steel production is energy-intensive, which may overshadow PESBs' long-term sustainability benefits including recyclability and durability. PESBs may not meet broader building rating system standards or reflect their eco-friendliness. This wide approach may skew PESB environmental footprint assessments. The rapid expansion of PESB materials and methods may outpace green rating framework update cycles, leaving assessment criteria outdated or incorrect.

Common Trends:

Green grading systems for PESBs have shown numerous patterns. PESBs are increasingly incorporating renewable energy sources like solar panels. Improved insulating methods for PESB energy efficiency are also growing. A growing trend is to use sustainable and recycled steel to reduce raw material production's carbon impact. Evaluations are increasingly using lifecycle assessments, which analyze a PESB's complete lifetime from material procurement through destruction or reuse, indicating a holistic approach to sustainability.

Conclusion:

The inexorable march towards sustainability in the construction sector has brought to the fore the critical role of green rating frameworks. This systematic literature review has shed light on the intricate relationship between these frameworks and the burgeoning world of pre-engineered steel buildings (PESBs). PESBs, with their promise of efficiency, speed, and adaptability, represent the future of modern construction. Yet, their true sustainability potential hinges on a symbiotic relationship with green rating systems. These frameworks, while transformative, have limitations when directly applied to PESBs, underscoring the need for evolution and adaptation. By examining the current literature, it becomes evident that the future of eco-conscious construction lies in a tailored, nuanced approach that recognizes the unique attributes and challenges of PESBs. As the construction industry continues its journey towards a greener future, the harmonization of PESBs and green rating frameworks emerges as a lynchpin for sustainable progress.

Potential Improvements:

To maximize PESBs' sustainability potential, green grading systems must be improved. Develop PESB-specific criteria to handle their particular characteristics and issues. This may include establishing PESB-specific subcategories or modules in existing frameworks. Assessment criteria should be updated frequently to reflect

PESB building techniques and materials. A more accurate evaluation system may result from PESB producers, sustainability specialists, and green rating organizations working together. Finally, post-construction assessments and feedback loops may verify that graded PESBs live up to their green credentials by stressing real-world performance criteria over theoretical ones.

Future Research Directions:

Further study should focus on PESB-specific green grading standards. The real-world performance of rated PESBs after construction may be insightful. Under green grading systems, integrating developing sustainable technologies like advanced renewable energy solutions or bio-based insulating materials into PESBs might lead to next-generation sustainable architecture.

Ethical Considerations:

This comprehensive literature study followed strict ethical guidelines. Transparency was maintained throughout the research, from book selection through data analysis. Avoiding plagiarism required properly crediting all referenced material. Clear inclusion and exclusion criteria were used to reduce biases. To ensure review rigor and authenticity, only peer-reviewed and academic sources were evaluated. The intellectual property of writers and researchers was respected at all times.

Originality:

This systematic literature evaluation combines green rating frameworks with pre-engineered steel structures for a new viewpoint. Many researches have touched on this nexus, but this SLR gives a unified, thorough analysis, filling information gaps. The unique way this study consolidates material makes it a summary and a springboard for further research. This study adds originality to sustainable building discourse by emphasizing trends and ideas from multiple sources.

References:

[1] Bernardi, E., Carlucci, S., Cornaro, C., &Bohne, R. (2017). An Analysis of the Most Adopted Rating Systems for Assessing the Environmental Impact of Buildings. Sustainability, 9(7), 1226. https://doi.org/10.3390/su9071226

[2] Delavar, M. (2017). BIM Assisted Design Process Automation for Pre-Engineered Buildings (PEB). Western University Western University.

[3] Dong, Y., &Frangopol, D. M. (2016). Performance-based seismic assessment of conventional and base-isolated steel buildings including environmental impact and resilience. Earthquake Engineering & Structural Dynamics, 45(5), 739–756. https://doi.org/10.1002/eqe.2682

[4] Ferrari, S., Zoghi, M., Blázquez, T., &Dall'O', G. (2022). New Level(s) framework: Assessing the affinity between the main international Green Building Rating Systems and the european scheme. Renewable and Sustainable Energy Reviews, 155, 111924. https://doi.org/10.1016/j.rser.2021.111924

[5] Fowler, K. M., & Rauch, E. M. (2006). Sustainable Building Rating Systems Summary (PNNL-15858, 926974; p. PNNL-15858, 926974). https://doi.org/10.2172/926974

[6] Gorgolewski, M. (2006). The implications of reuse and recycling for the design of steel buildings. Canadian Journal of Civil Engineering, 33(4), 489–496. https://doi.org/10.1139/l06-006

[7] Haddaway, N. R., Page, M. J., Pritchard, C. C., & McGuinness, L. A. (2022). PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis Campbell Systematic Reviews, 18, e1230. https://doi.org/10.1002/cl2.1230

[8] JIM LISOWSKI. (2006). USING THE LEED® GREEN BUILDING RATING SYSTEM FOR SMALL TO MEDIUM-SIZED ENTERPRISES. ROYAL ROADS UNIVERSITY.

[9] Kabirifar, K., Mojtahedi, M., Wang, C., & Tam, V. W. Y. (2020). Construction and demolition waste management contributing factors coupled with reduce, reuse, and recycle strategies for effective waste

management: A review. Journal of Cleaner Production, 263, 121265. https://doi.org/10.1016/j.jclepro.2020.121265

[10] Khan, M. A., Wang, C. C., & Lee, C. L. (2021). A Framework for Developing Green Building Rating Tools Based on Pakistan's Local Context. Buildings, 11(5), 202. https://doi.org/10.3390/buildings11050202

[11] Kubba, S. (2012). Handbook of green building design and construction: LEED, BREEAM, and Green Globes. Elsevier, B-H.

[12] Lee, B., Trcka, M., &Hensen, J. L. M. (2011). Embodied energy of building materials and green building rating systems—A case study for industrial halls. Sustainable Cities and Society, 1(2), 67–71. https://doi.org/10.1016/j.scs.2011.02.002

[13] Libby Dunne. (2020, June 1). Top 12 Green Building Rating Systems [Sustainable Investment Group (SIG)]. https://sigearth.com/top-12-green-building-rating-systems/

[14] Nguyen, T. H., Toroghi, Sh. H., & Jacobs, F. (2016). Automated Green Building Rating System for Building Designs. Journal of Architectural Engineering, 22(4), A4015001. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000168

[15] RajnandanVerma&Raghvendra Singh. (2020). COMPARATIVE ANALYSIS OF PRE-ENGINEERED STEEL BUILDING AND CONVENTIONAL STEEL BUILDING USING ETAB-A REVIEW. International Research Journal of Modernization in Engineering Technology and Science.

[16] Ramkumar, S. (2020). Why Green Ratings for Buildings Matter? The energy and resource institute. https://www.teriin.org/article/why-green-ratings-buildings-matter#:~:text=Green%20ratings%20assess%20a%20building,visual%20comfort%20of%20its%20occupants.

[17] Rating System & Addendum for New Construction & Major Renovations. (2004).

[18] Reeder, L. (2010). Guide to Green Building Rating Systems: Understanding LEED, Green Globes, Energy Star, the National Green Building Standard, and More (1st ed.). Wiley. https://doi.org/10.1002/9781118259894

[19] Saade, M. R. M., Guest, G., & Amor, B. (2020). Comparative whole building LCAs: How far are our expectations from the documented evidence? Building and Environment, 167, 106449. https://doi.org/10.1016/j.buildenv.2019.106449

[20] Sánchez Cordero, A., Gómez Melgar, S., &AndújarMárquez, J. M. (2019). Green Building Rating Systems and the New Framework Level(s): A Critical Review of Sustainability Certification within Europe. Energies, 13(1), 66. https://doi.org/10.3390/en13010066

[21] Sartori, T., Drogemuller, R., Omrani, S., &Lamari, F. (2021). A schematic framework for Life Cycle Assessment (LCA) and Green Building Rating System (GBRS). Journal of Building Engineering, 38, 102180. https://doi.org/10.1016/j.jobe.2021.102180

[22] Schafer, B. W. (2011). Cold-formed steel structures around the world: A review of recent advances in applications, analysis and design. Steel Construction, 4(3), 141–149. https://doi.org/10.1002/stco.201110019

[23] Shahana Y. Janjua, Prabir K. Sarker, &Wahidul K. Biswas. (2019). A Review of Residential Buildings' Sustainability Performance Using a Life Cycle Assessment Approach. Journal of Sustainability Research, 1(1). https://doi.org/10.20900/jsr20190006

[24] Shrivastava, S., & Shrivastava, G. (2022). Pre Engineered Structure study: A review. 09(12).

[25] Stephanie Vierra. (2023, March 23). Green Building Standards And Certification Systems [Whole building design guide]. https://www.wbdg.org/resources/green-building-standards-and-certification-systems

[26] Šuman, N., Marinič, M., &Kuhta, M. (2020). A Methodological Framework for Sustainable Office Building Renovation Using Green Building Rating Systems and Cost-Benefit Analysis. Sustainability, 12(15), 6156. https://doi.org/10.3390/su12156156

[27] Uher, T. E., & Lawson, W. (n.d.). Sustainable development in construction.

[28] Wasim, M., Wang, K., Yuan, Z., Jin, M., Abadel, A., &Nehdi, M. L. (2023). An optimized energy efficient design of a light gauge steel building. Case Studies in Construction Materials, 19, e02398. https://doi.org/10.1016/j.cscm.2023.e02398

[29] Wen, B., Liang, L., Xu, F., Yan, J., Yan, X., & Ramesh, S. (2022). FRAMEWORK FOR UPDATING GREEN BUILDING RATING TOOLS FOR DEVELOPING COUNTRIES. Journal of Green Building, 17(4), 41–77. https://doi.org/10.3992/jgb.17.4.41

[30] Yu, S., Liu, Y., Wang, D., Bahaj, A. S., Wu, Y., & Liu, J. (2021). Review of thermal and environmental performance of prefabricated buildings: Implications to emission reductions in China. Renewable and Sustainable Energy Reviews, 137, 110472. https://doi.org/10.1016/j.rser.2020.110472