Deheragoda, H., De Silva, G.H.S.P., and Jinthusan, M., 2026. Beyond the envelope: Examining project management as a catalyst for higher-performance building design. In: Waidyasekara, K.G.A.S., Jayasena, H.S., Chandanie, H. and Tennakoon, G.A. (eds). *Proceedings of the 14th World Construction Symposium*, 10-11 July 2026, Sri Lanka. pp. 320-333. DOI: https://doi.org/10.31705/WCS.2026.24. Available from: https://ciobwcs.com/papers/

BEYOND THE ENVELOPE: EXAMINING PROJECT MANAGEMENT AS A CATALYST FOR HIGHER-PERFORMANCE BUILDING DESIGN

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ABSTRACT

Improving energy efficiency in building design is increasingly vital as the global construction sector confronts rising energy demands and environmental challenges. In Sri Lanka, the early design phase often lacks strategic integration of energy considerations, limiting the effectiveness of sustainable outcomes. This research investigates how project management (PM) strategies (strategies and tools), influence energy-efficient decision-making of design teams during the pre-construction stage of building projects. The authors adopted a mixed-methods approach, combining qualitative insights from seven semi-structured interviews with architects, engineers, and project managers, followed by quantitative data collected via a questionnaire administered to 42 professionals. The study explored the implementation and impact of PM approaches including Building Information Modelling (BIM), Integrated Project Delivery (IPD), Value Engineering (VE), and Early Contractor Involvement (ECI). Data were analysed using descriptive statistics and thematic coding to uncover trends and relationships. The findings revealed that BIM and VE are the most influential approaches in guiding sustainable design decisions, particularly when applied early in the project lifecycle. Success factors included early stakeholder collaboration, clearly defined energy goals, and performance-based planning. However, key barriers such as limited awareness, high upfront costs, and weak communication persist. The study recommends aligning PM practices with sustainability targets and enhancing stakeholder engagement to promote energy-efficient design in Sri Lankan construction projects.

Keywords: *Building Projects; Decision-making; Design Stage; Energy Efficiency; Project Management.*

1. INTRODUCTION

The successful completion of a construction project involves effective PM. Effective PM depends on proper process integration and personnel coordination throughout construction projects. However, to coordinate processes and stakeholders throughout the construction project, the PM team must make a significant effort to make the right

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decisions at the right time, as decision-making has become increasingly important due to today's sustainability movements and global building practices (Bakht & El-Diraby, 2015). Given these sustainability concerns, modern building construction projects must focus on mitigating the significant environmental impacts they could create. With this rising global emphasis on sustainability, PM is found to be a key determinant of success, especially in energy efficiency initiatives with complex technical and environmental targets that require a robust management framework compared to conventional projects.

According to the growing body of knowledge, buildings account for nearly 40% of global energy consumption, which highlights the need to improve energy efficiency (Laustsen, 2008). In construction projects, energy efficiency focuses on reducing its consumption and carbon emissions in buildings, with building geometry, envelope elements, renewable energy integration, and regulations influencing performance (Shove, 2018). Despite the growing emphasis on energy efficiency in building projects, many projects continue to underperform due to the weak integration of PM approaches with design-stage decision-making processes. The poor practices of PM often fail to ensure early stakeholder collaboration, clear communication, and the timely incorporation of energy objectives, thereby limiting the adoption of effective passive and active design solutions within the project. In this regard, Project managers play a significant role in coordinating stakeholders and supporting energy-efficient design, using decision-making methods such as Value Engineering, BIM, and Building Energy Modelling (Lucas et al., 2025).

Among these solutions, one of the best moves would be to apply effective management approaches, such as IPD, lean construction, and agile project management, to support collaboration and decision-making, and to use technologies and techniques such as Multi-Criteria Decision Analysis (MCDA) (Ingrao et al., 2018). However, challenges remain in implementing energy-efficient construction projects, particularly in developing countries, due to limited resources, technological constraints, and organisational weaknesses (Yadollahi et al., 2014). This challenge is particularly significant in the Sri Lankan construction context. Despite the context, it is compounded by rising material costs (Carlander & Thollander, 2023), limited professional awareness (Palm & Bryngelson, 2023), and weak enforcement of sustainability regulations (Palm & Bryngelson, 2023), further constraining the implementation of energy-efficient measures.

Although previous studies have extensively explored building energy efficiency, sustainable construction practices, and stakeholder management, limited research has specifically examined how PM approaches influence design team decision-making toward energy efficiency during the building design phase, particularly in the Sri Lankan context. This lack of focused understanding, represents a significant empirical and contextual research gap. Therefore, this study aims to investigate how PM approaches influence the design team's energy efficiency decisions in building projects and the author, set the following objectives to bridge the research gap,

- Identify PM practices relevant to energy efficiency decisions in building design.
- Investigate the impact of PM practices on energy efficiency decisions taken by the design team.
- Explore effective PM practices that promote energy-efficient decisions in building construction projects.

2. LITERATURE REVIEW

Adopting energy-saving practices helps reduce environmental impacts, especially in developing economies (da Cunha & de Aguiar, 2020). Integrating passive designs and thermal optimisation strategies, through proper improvements in building orientation, materials, and integrated systems, can enhance the energy performance of a building (Abu Dabous & Hosny, 2025).

2.1 UNDERSTANDING THE CORE CONCEPTS

Successful completion of energy-efficient buildings requires integrating technical design strategies, adhering to proper PM practices, and collaborating with a multidisciplinary team throughout their lifecycles. These building designs also need to ensure occupant comfort, functional and operational performance, while minimising energy consumption and environmental impacts (Riabchuk et al., 2024). To meet these requirements, by reducing operational energy while contributing to sustainability and carbon reduction targets, designers frequently adopt a combination of active and passive strategies, such as natural ventilation, optimal building orientation, thermal insulation, high-performance HVAC systems, energy-efficient lighting, and renewable energy technologies (Iqbal et al., 2021).

Energy Efficiency in Building Design: Energy efficiency in building construction aims to reduce power consumption and minimise environmental impact through advanced materials and techniques (Riabchuk et al., 2024). Sustainable approaches, including energy-efficient operations, integrated heat exchangers, and intensified processes, support global carbon reduction goals while enhancing occupant comfort.

Key Energy Efficiency Strategies and Technologies: Building efficiency is achieved via passive design strategies, optimal orientation, insulation, and natural ventilation, combined with high-performance Heat Ventilation and Air Conditioning (HVAC) and lighting systems and renewable energy integration (Iqbal et al., 2021). These approaches improve building autonomy from fossil fuels and enhance overall operational performance.

PM in construction involves risk identification, prioritisation, and mitigation to manage complex schedules and multiple stakeholders. Traditional PM addresses linear project goals (Lalmi et al., 2025), while lean construction optimises value and reduces waste. Agile PM introduces flexibility to dynamic projects, minimising inefficiencies through performance-based planning (Frank et al., 2004).

The design process progresses from conceptual (vision and feasibility) to schematic (spatial layout), detailed (technical and system integration), and production (full documentation) stages (Svalestuen et al., 2015). Architects, Engineers, and Quantity Surveyors form core design teams, where architects lead design vision, engineers ensure technical feasibility, and quantity surveyors manage costs (Gunasekara et al., 2023). Effective collaboration and proactive leadership improve innovation and sustainable outcomes (Sagar et al., 2023). Effective PM practices strengthen collaboration, coordinate efforts among stakeholders, and incorporate sustainability considerations from inception through the completion of the building construction project (Meng, 2012). Energy-efficient building performance is also influenced by the PM practices used. Therefore, comprehending the role of PM in the building design process is timely to identifying approaches that can enhance the successful delivery of high-performance buildings.

2.2 PM Approaches Relevant to Energy Efficiency Decisions

The successful delivery of high-performance buildings relies on effective PM practices that promote collaboration, knowledge sharing, and informed decision-making. Through a comprehensive Literature review of sustainable construction, high-performance buildings, and PM. Three criteria guided the selection:

- Frequency of application of PM practices in sustainable and energy-efficient building projects,
- Its contribution in improving stakeholder collaboration and project performance, and
- Potential influence on energy-efficiency decisions during the building design process.

Accordingly, IPD, BIM, VE, ECI, Design Charrettes, Risk Management, and Communication Planning were identified as the most relevant PM for investigation. Since these are actively contribute to meeting energy-efficiency objectives by enhancing interdisciplinary collaboration, facilitating the evaluation of design options, minimising project risks, and integrating sustainability considerations throughout the design process, they provide an appropriate foundation for examining how PM can act as a motivator for high-performance building design.

Table 1: PM approaches relevant to energy efficiency decisions

PM Strategy	Description	Source
Integrated Project Delivery (IPD)	Encourages early involvement of all participants, promoting collaboration, sustainability, and energy-efficient outcomes	[1], [2], [3]
Building Information Modeling (BIM)	Integrates multidisciplinary data for energy-focused design decisions, reducing operational costs and environmental impacts	[4], [5],
Value Engineering (VE)	Balances cost, performance, and lifecycle considerations to enhance energy efficiency and resource utilization	[6], [7], [8]
Early Contractor Involvement (ECI)	Aligns design, cost, constructability, and sustainability, reducing redesign and energy waste	[9], [10], [11]
Design Charrettes	Collaborative workshops promote stakeholder alignment, resource optimization, and innovation in sustainable design	[12], [13], [14]
Risk Management	Risk Management: Identifies and mitigates environmental, technical, and project risks affecting energy efficiency	[15], [16], [17]
Communication Planning	Strengthens collaboration, reduces misunderstandings, and builds trust among stakeholders, critical for sustainable project delivery	[18], [19]

Sources: [1] (Kahvandi et al., 2017), [2] (Jones, 2014), [3] (Yee, 2017), [4] (Azhar, Khalfan and Maqsood, 2012), [5] (Volk, Stengel and Schultmann, 2014), [6] (Ilayaraja and Zafar Eqyaabal, 2015), [7] (Chen et al., 2022), [8] (Rachwan, Abotaleb and Elgazouli, 2016), [9] (Walker and Lloyd-Walker, 2012), [10] (Wondimu et al., 2016), [11] (Wondimu, Klakegg and Lædre, 2020), [12] (Kilbane and Roös, 2022), [13] (Palmer, 2013), [14] (Bahadorestani, Naderpajouh and Sadiq, 2020), [15] (Chapman, 2001), [16] (Goral, 2007), [17] (Shang et al., 2005), [18] (Khoury, 2019), [19] (Whyte, 1996)

3. RESEARCH METHODOLOGY

In light of comprehensive literature review, authors selected a mixed method approach to achieve the set objectives.

In the phase I, Author administered a questionnaire survey among industry professionals and 33 complete responses were taken for analysis. The quantitative data were analysed using descriptive statistical tools, such as weighted averages, percentage counts, and means, using a 5-point Likert scale to assess the significance of factors influencing energy-efficiency decisions. Under phase II, Qualitative insights were obtained from seven semi-structured interviews conducted with architects, engineers, and project managers, through purposive sampling based on, direct involvement in building design or PM activities, experience working on projects incorporating sustainability or energy-efficiency objectives, a minimum of three years of professional experience in the construction industry and willingness to share professional insights regarding PM and energy-efficiency decision-making. Data collected were then analysed thematically using a deductive approach to identify key patterns, barriers, and improvement strategies. Integrating survey and interview findings enabled the identification of key obstacles, expert-proposed solutions, and practical recommendations for aligning PM approaches with energy-efficient design, providing both empirical evidence and actionable insights for sustainable construction practice.

Table 2: Likert scale.

Value	Range	Scale
1	1.00-1.08	Low
2	1.81-2.60	Very low
3	2.61-3.40	Moderate
4	3.41-4.20	High
5	4.21-5.00	Very high

Assumption made.

- The distance between “very high" and "high” is the same between “high” and “moderate”.
- A consequence of the above would be that the distance between “high” and “very high” is five times greater than that between “low” and “very low”.

4. DATA ANALYSIS AND DISCUSSION

4.1 QUALITATIVE DATA ANALYSIS

4.1.1 Respondent Profile

The interview participants included Architects, Engineers, Project Managers, and Quantity Surveyors. Their professional experience ranged from three to thirty-five years. This diverse group of professionals provided valuable perspectives on PM practices, design decision-making, and sustainability challenges within the construction industry. The following Table 3 summarises the Respondents demographic Information.

Table 3: Demographics details

Interview	Job Role	Years of Experience
Respondent 01 (R1)	Chartered Architect	7 years
Respondent 02 (R2)	Architect	5 years
Respondent 03 (R3)	Civil Engineer	35 years
Respondent 04 (R4)	Project Manager	6 years
Respondent 05 (R5)	Site Engineer	12 years
Respondent 06 (R6)	Assistant Quantity Surveyor	4 years
Respondent 07 (R7)	Site Quantity Surveyor	3 years

4.1.2 Qualitative Findings

Key PM Approaches Influencing Energy Efficiency: Qualitative findings highlighted the importance of early collaboration and integrated planning for achieving energy-efficient building outcomes. Participants (R_3, R_4, R_5, R_6 and R_7) emphasised that approaches such as IPD, BIM, VE, and ECI (R_1 and R_2) play an important role in supporting energy-efficient design decisions. Early stakeholder involvement enables project teams to establish sustainability objectives and integrate energy-saving measures during the design stage. Respondents explained that collaborative project environments encourage knowledge sharing and allow different professionals to contribute their expertise to design solutions. This collaborative approach helps ensure that sustainability considerations are incorporated into project planning and decision-making processes from the beginning of the project lifecycle.

Impact of PM Approaches on Design Phase Decisions: The participants (R_1, R_2, R_4, R_7) emphasised that PM approaches significantly influence energy-efficiency decisions during the design phase. The respondents also highlighted that early stakeholder involvement enables project teams to conduct energy performance analyses, evaluate design alternatives, and incorporate sustainability objectives into design solutions. Also, they noted that collaboration among design team professionals enables teams to balance energy performance with cost, constructability, and project constraints. Meanwhile, R_3, R_5, and R_6 highlighted the importance of balancing constructability, cost, and performance through effective team coordination, informed trade-offs, accurate cost estimation, and ongoing feedback from quantity surveyors. This integrated decision-making process helps ensure that sustainable solutions are both technically feasible and financially viable.

The respondent's opinion on the impact of PM approaches suggests that early stakeholder engagement and integrated decision-making are crucial to achieving energy performance goals in building projects. The reason behind their opinion may be that early engagement allows the design team to incorporate sustainability into core design at no cost during the design stage, resulting in savings of millions in the building's operational stage.

Role of Specific PM Approaches in Energy-Efficient Design:

IPD: All the participants except R_6 emphasised that IPD promotes early collaboration among project stakeholders. Through integrated planning, teams can establish shared sustainability objectives and ensure that energy-efficiency considerations are incorporated into design decisions from the beginning of the project.

BIM: BIM was widely recognised as a critical tool for supporting energy-efficient design decisions. Participants (R_1, R_3, R_5) highlighted that BIM allows project teams to simulate building performance, test different design alternatives, and analyse energy consumption before construction begins. This enables more informed decision-making and improves coordination among project stakeholders.

VE: All the Respondents confirmed VE as an effective strategy for balancing cost control with sustainability objectives. By evaluating alternative materials, systems, and construction methods, VE allows project teams to identify solutions that maintain or improve energy performance while remaining cost-effective.

ECI: Participants expressed varying perspectives regarding ECI. While some respondents (R_3, R_4) believed that early contractor involvement may influence design decisions toward construction practicality, others (R_5, R_6, R_7) emphasised that contractor expertise can improve constructability and help identify practical energy-saving opportunities.

Sustainability Charrettes: Respondents (R_2, R_3, R_4) described Sustainability Charrettes as collaborative workshops that encourage interdisciplinary discussion and innovation. These sessions bring together professionals from different disciplines to explore sustainable design solutions and incorporate energy-efficiency considerations during early project planning. R_7 pointed out that charrettes encourage idea sharing and may bring about better sustainability results.

Adoption of Energy-Efficient Building Solutions: The findings revealed that PM approaches such as IPD, ECI, and BIM facilitate the adoption of energy-efficient building features. These approaches enable early collaboration and allow project teams to incorporate sustainable solutions such as improved building envelopes and daylight optimisation during the design stage. Respondents R_3, R_4, and R5 highlighted how IPD and ECI help prevent scheduling and budget issues by involving contractors early.

However, participants noted that traditional procurement methods, such as design–bid–build, often delay sustainability integration because contractors are involved only after the design stage is complete. It creates a knowledge gap, as the design is frozen when the contractor proposes a more efficient solution at the construction stage, and it may cost a considerable amount and delay progress in incorporating these solutions into the design. Therefore, opportunities to incorporate energy-efficient solutions may be missed. However, methods such as ECI and IPD can analyse real-time constructability, as contractors can confirm resource availability and labour costs, thereby avoiding cost overruns, as respondents mentioned. Also, the IPD creates a win-win solution by establishing a shared risk-and-reward concept. This may motivate stakeholders, as everyone's profit depends on the building's performance.

Early Planning and Goal Setting for Energy Efficiency: All respondents except R_5 emphasised the importance of establishing energy-efficiency targets early in project development. Clear sustainability objectives guide design decisions, influence material selection, and encourage environmentally responsible practices. R3 affirmed that early planning also helps project teams control costs and avoid expensive modifications later in the project lifecycle.

Role of Communication and Collaboration: Effective communication and collaboration among project stakeholders were identified as essential factors for achieving energy-efficient project outcomes by all the respondents. They all emphasised that project managers play a critical role in coordinating stakeholder activities and ensuring that sustainability objectives remain a priority throughout the project lifecycle. Strong leadership and open communication help maintain alignment between design objectives, budget constraints, and environmental performance goals.

Technological Tools Supporting Energy Efficiency: Participants highlighted the importance of digital tools for managing energy efficiency in building projects. BIM is integrated with energy simulation software such as Autodesk Insight, Green Building Studio, Energy Plus, DesignBuilder, and IES, enabling project teams to analyse building performance and evaluate design alternatives. These tools also support compliance with sustainability standards and allow quantity surveyors to integrate cost considerations with energy performance analysis.

Challenges in Implementing Energy-Efficient Design: Despite the benefits of PM approaches, participants identified several barriers to implementing energy-efficient design practices. Key challenges include budget limitations, limited stakeholder awareness, and resistance to change (R1, R2, R4, R5 and R7). Many respondents noted that clients often focus on initial construction costs rather than long-term operational benefits. To address these challenges, experts recommended early stakeholder education, lifecycle cost analysis, and clear energy-efficiency targets during project planning.

Integration of Energy Efficiency in Project Management: All participants emphasised that energy efficiency should be integrated into the core practices of PM and treated with the same level of importance as traditional project objectives such as time, cost, and quality. Regular monitoring of energy performance, sustainability cost analysis, and collaborative decision-making were identified as key practices for achieving energy-efficient project outcomes.

4.2 QUANTITATIVE DATA ANALYSIS

4.2.1 Respondent Demographics

The questionnaire survey received 42 responses from Sri Lankan construction professionals, representing an 84% response rate. Respondents were predominantly Quantity Surveyors (38.1%), followed by Project Managers (19%), Engineers (19%), and Architects (14.3%), with smaller representation from Sustainability Consultants, Technical Managers, and Electrical Engineers. Most participants had less than five years of experience in the construction industry (52.4%) and in pre-contract stage involvement (71.4%), although some mid- and senior-level professionals were also included. Notably, 69% of respondents participated in projects focused on energy-efficiency goals, suggesting strong familiarity with sustainable design practices. Most current projects were residential (34.8%) and commercial (33.3%), with smaller numbers in mixed development, apartments, infrastructure, and government buildings.

4.2.2 Quantitative Findings

Experience and Implementation of PM Approaches

Table 3 presents the level of implementation of PM strategies for supporting energy-efficient design decisions.

Table 3: Project management approaches supporting energy-efficient design

PM Strategy	Mean Score	Rank	Interpretation
Value Engineering (VE)	3.52	1	High
Building Information Modelling (BIM)	3.50	2	High
Sustainability Charrettes	3.50	2	High
Integrated Project Delivery (IPD)	3.10	4	Moderate
Early Contractor Involvement (ECI)	2.98	5	Moderate

Analysis of PM approaches usage showed that VE (3.52), Building BIM (3.50), and Sustainability Charrettes (3.50) were the most highly applied approaches for supporting energy-efficient design decisions. IPD and ECI are being moderately used. These results suggest that professionals in Sri Lanka are actively adopting collaborative and technology-enabled PM approaches, with VE, BIM, and Sustainability Charrettes being the most practical tools for enhancing sustainability outcomes during design.

Impact of PM Approaches on Energy-Efficient Decisions

Table 1: Influence of PM strategies on energy-efficiency decisions

PM Strategy	Mean Score	Rank	Interpretation
Value Engineering (VE)	3.57	1	High
Building Information Modelling (BIM)	3.52	2	High
Sustainability Charrettes	3.31	3	Moderate
Integrated Project Delivery (IPD)	3.29	4	Moderate
Early Contractor Involvement (ECI)	3.02	5	Moderate

The study found that VE and BIM (3.52) had the high influence on design teams' energy-efficiency decisions, while Sustainability Charrettes, IPD and ECI had the moderate influence.

Critical Project Stages for Energy-Efficiency Decisions

The below Table 5 summarises the level of criticality of project stages for energy efficiency decisions.

Table 2: Critical project stages for energy-efficiency decisions

Project Stage	Mean Score	Rank	Interpretation
Conceptual Design	3.45	1	High
Detailed Design	3.43	2	High
Construction	3.36	3	Moderate
Post-Construction	3.31	4	Moderate
Schematic Design	3.26	5	Moderate

The findings demonstrate that energy-efficiency decisions are most strongly influenced during the conceptual and detailed design stages. Interviewees consistently emphasized the importance of establishing energy targets early to avoid costly redesign and missed opportunities later in the project lifecycle. It emphasises the importance of early-stage decisions.

Practices Encouraging Energy Efficiency

Table 3: Approaches encouraging energy-efficient design

Approaches	Mean Score	Rank	Interpretation
Sustainability Champion	3.74	1	High
Incentives for Sustainable Design	3.69	2	High
BIM for Energy Analysis	3.62	3	High
Energy Performance Reviews	3.60	4	High
Energy Goals in Project Brief	3.55	5	High
Training and Capacity Building	3.48	6	High
Early Energy Consultant Involvement	3.45	7	High

The appointment of sustainability champions and the use of incentives emerged as the most effective approaches for encouraging energy-efficient decision-making. Interviewees also stressed the importance of clear project objectives, stakeholder engagement, and leadership commitment.

Early Collaboration and Multidisciplinary Engagement: Early collaboration between project managers and design teams was universally recognised as critical for achieving energy-efficiency outcomes. Most respondents rated early collaboration as very important or highly important, reinforcing the need for multidisciplinary engagement. Including energy consultants and quantity surveyors from the outset ensures that energy-efficiency objectives are clearly communicated, properly integrated, and effectively implemented throughout the project lifecycle.

Barriers to Energy Efficiency: Several key barriers were identified that limit the effectiveness of PM approaches in promoting energy-efficient design. These included delayed integration of energy objectives, low stakeholder awareness, resistance to sustainability adoption, high upfront costs, limited technical expertise, poor interdisciplinary coordination, compressed project schedules, regulatory complexity, and uncertainty regarding emerging technologies. These barriers highlight that achieving energy efficiency in the Sri Lankan construction context requires early planning, education, financial justification, and clear policies.

Additional PM Practices Recommended: Respondents suggested additional approaches to strengthen energy efficiency, emphasising early stakeholder involvement, integrated design planning, and establishing clear energy goals at project inception. They recommended the use of Lifecycle Cost Analysis, BIM-enabled energy simulations, and thermal performance assessments, alongside sustainability audits, workshops, collaborative contracts, and adherence to green building standards. Innovative approaches, including AI and machine learning, were also noted as potential enablers. Collectively, these practices indicate that energy efficiency should be treated as a measurable, collaborative, and integrated objective throughout the project lifecycle.

5. DISCUSSION

The findings demonstrate that PM strategies play a significant role in facilitating energy-efficient design decisions in Sri Lankan building projects. BIM and VE emerged as the most influential strategies due to their ability to support performance analysis, informed decision-making, and cost optimisations. Similarly, studies of Bangladesh and Sri Lankan SMEs highlighted that BIM assists in the proper communication of project decisions related to design, visualisation, collaboration, and simulation across many applications (Datta et al., 2023; Lukson et al., 2024). Moreover, researchers have identified the importance of employing VE during the design stage to optimise project costs (Nejatyan et al., 2023).

Additionally, interview participants highlighted the value of integrated collaboration through IPD and Sustainability Charrettes, particularly during the early design stages. At the same time, researchers recognise IPD as a unique and creative approach to project management for the Sri Lankan construction landscape (Lukson et al., 2024). The study further confirms that energy-efficiency outcomes are heavily dependent on early planning and stakeholder engagement. Both quantitative and qualitative findings indicate that the conceptual and detailed design stages offer the greatest opportunity to influence building performance. This finding aligns with previous studies that argue that early design decisions determine the majority of lifecycle energy performance.Despite the recognised benefits of energy-efficient design, several implementation barriers remain. High initial costs, limited awareness, and weak collaboration continue to restrict the adoption of sustainable solutions within the Sri Lankan construction sector. Project managers should adopt more proactive approaches, including early stakeholder involvement, sustainability champions, performance monitoring, and BIM-enabled energy analysis. Altogether, the results demonstrate that successful integration of energy efficiency requires a collaborative project environment, clear sustainability objectives, and the strategic application of PM practices throughout the design process.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

PM approaches strongly influence energy-efficiency decisions during the design phase of building projects. The findings show that structured approaches such as IPD, BIM, VE, and ECI help integrate sustainability into design by improving stakeholder coordination and ensuring that energy, cost, and constructability objectives are considered together. Early stakeholder involvement among architects, engineers, project managers, quantity surveyors, and sustainability consultants is essential for embedding energy goals from the planning stage and developing innovative design solutions. Digital technologies, particularly BIM integrated with tools such as Autodesk Insight, Energy Plus, and Design Builder, support evidence-based decision-making through energy simulations, performance evaluation, and design optimisation. In addition, VE and ECI improve the selection of cost-effective, feasible, and constructible energy-efficient solutions while minimising design changes.

Despite these benefits, several barriers limit implementation, including budget constraints, limited stakeholder awareness, resistance to change, and unclear energy-efficiency targets. Clients focus on high initial costs rather than long-term operational and environmental benefits, which further reduces the adoption of sustainable practices. Therefore, the study emphasises the need for early collaborative PM frameworks, BIM-based simulations, regular VE reviews, stronger contractor involvement, stakeholder training, and supportive environments.

These findings provide practical insights for project managers, architects, engineers, clients, and policymakers seeking to improve sustainability outcomes through more collaborative and structured project delivery approaches.

6.2 RECOMMENDATIONS

At the industry level, there is an alarming need for government policies, incentives, and regulatory frameworks to encourage and mandate energy-efficient design practices. It is the industry's responsibility to educate every Professional on various topics through training and awareness programmes on energy-efficient design principles and sustainable construction practices, while Construction organisations adopt integrated, collaborative PM approaches that foster early engagement of every responsible stakeholder throughout the design process. At the project level, energy-efficiency objectives should be clearly defined during project initiation and incorporated into project briefs, design reviews, and decision-making processes.

6.3 LIMITATIONS AND FURTHER RESEARCH

Although the study included professionals from several disciplines, only one interview participant held the role of Project Manager, and project managers represented 19% of the questionnaire respondents. Furthermore, a considerable proportion of survey respondents possessed fewer than five years of industry experience. Consequently, the findings should be interpreted as reflecting the collective perspectives of multidisciplinary project stakeholders rather than exclusively those of highly experienced project managers. Nevertheless, the inclusion of architects, engineers, quantity surveyors, and other professionals is justified because energy-efficiency decisions are inherently collaborative and require contributions from multiple stakeholders throughout the design process. The study is limited by its focus on project managers within formal construction organisations, excluding the perspectives of other stakeholders, smaller firms, and the informal sector, which may affect the generalizability of the findings. Additionally, reliance on self-reported data may introduce reporting bias; however, the study still provides valuable insights into how PM supports energy-efficiency decisions in building projects. Table 1 below presents the Likert scale used in data collection and analysis.

Future research could expand the sample of senior project managers and experienced practitioners to further validate and extend the findings. Further studies may also investigate the role of emerging technologies, such as artificial intelligence, advanced energy modelling tools, and digital PM platforms, in supporting energy-efficiency decision-making throughout the building lifecycle.

7. ACKNOWLEDGEMENTS

The authors extend sincere appreciation to the Sri Lanka Institute of Information Technology (SLIIT) and the Liverpool John Moores University, UK (LJMU) for their continuous support and for providing the institutional resources required to successfully conduct this research.

8. REFERENCES

Abu Dabous, S. and Hosny, F. (2025) 'A review of building envelope retrofitting methods for improving energy efficiency, aesthetic, and indoor environmental quality', *Energy Nexus*, *18*, 100407. https://doi.org/10.1016/j.nexus.2025.100407.

Aga, D.A., Noorderhaven, N. and Vallejo, B. (2016) 'Transformational leadership and project success: The mediating role of team-building', *International Journal of Project Management*, 34(5), pp. 806–818. https://doi.org/10.1016/j.ijproman.2016.02.012.

Bahadorestani, A., Naderpajouh, N. and Sadiq, R. (2020) 'Planning for sustainable 55 stakeholder engagement based on the assessment of conflicting interests in projects', *Journal of Cleaner Production*, 242, 118402. https://doi.org/10.1016/j.jclepro.2019.118402.

Bakht, M. N., & El-Diraby, T. E. (2015). Synthesis of decision-making research in construction. *Journal of Construction Engineering and Management*, *141(9)*, 04015027. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001016

Carlander, J., & Thollander, P. (2023). Barriers to implementation of energy-efficient technologies in building construction projects — Results from a Swedish case study. *Resources, Environment and Sustainability*, *11*, 100097. https://doi.org/10.1016/j.resenv.2022.100097

Chapman, R.J. (2001) 'The controlling influences on effective risk identification and assessment for construction design management', *International Journal of Project Management*, 19(3), pp. 147–160. https://doi.org/10.1016/S0263-7863(99)00070-8.

Chen, W.T., Merrett, H. C., Liu, S., Fauzia & N, Liem, F. D, (2022) 'A Decade of Value Engineering in Construction Projects', *Advances in Civil Engineering, 2022*, 2324277. https://doi.org/10.1155/2022/2324277.

da Cunha, S.R.L. and de Aguiar, J.L.B. (2020) 'Phase change materials and energy efficiency of buildings: A review of knowledge', *Journal of Energy Storage, 27*, 101083. https://doi.org/10.1016/j.est.2019.101083.

Datta, S. D., Sobuz, M. H. R., Mim, N. J., & Nath, A. D. (2023). Investigation on the effectiveness of using building information modeling (BIM) tools in project management: a case study. *Revista de La Construccion*, *22*(2), 306–320. https://doi.org/10.7764/RDLC.22.2.306

Demirkesen, S., & Ozorhon, B. (2017). Impact of integration management on construction project management performance. *International Journal of Project Management*, 35(8), 1639–1654. https://doi.org/10.1016/j.ijproman.2017.02.004

Gunasekara, D., Indikatiya, I., Perera, B., & Senaratne, S., (2023) 'Managing intragroup conflicts within project design teams during pre-contract stage that effect the project deliverables in Sri Lanka', *Construction Innovation*, 23(2), pp. 406–424. https://doi.org/10.1108/CI 05-2020-0078.

Hettiarachchi, I., Rotimi, J. O. B., Shahzad, W. M., & Kahandawa, R. (2025). Bridging sustainability and performance: Conceptualizing net-zero integration in construction supply chain evaluations. *Sustainability*, 17(13), 5814. https://doi.org/10.3390/su17135814

Ingrao, C., Messineo, A., Beltramo, R., Yigitcanlar, T., & Ioppolo, G. (2018). How can life cycle thinking support sustainability of buildings? Investigating life cycle assessment applications for energy efficiency and environmental performance. *Journal of Cleaner Production*, 201, 556–569. https://doi.org/10.1016/j.jclepro.2018.08.080

Ilayaraja, K. and Zafar Eqyaabal, M. (2015) 'Value Engineering in Construction', *Indian Journal of Science and Technology,* 8(32), pp. 3–10. https://doi.org/10.17485/ijst/2015/v8i32/87285.

Iqbal, M., Ma, J., Ahmad, N., Hussain, K., & Usmani, M.S., (2021) 'Promoting sustainable construction through energy-efficient technologies: an analysis of promotional strategies using interpretive structural modeling', *International Journal of Environmental Science and Technology*, 18(11), pp. 3479–3502. https://doi.org/10.1007/s13762-020-03082-4.

Jones, B. (2014) 'Integrated project delivery (IPD) for maximizing design and construction considerations regarding sustainability', *Procedia Engineering*, 95(Scescm), pp. 528–538. https://doi.org/10.1016/j.proeng.2014.12.214.

Azhar, S., Khalfan, M. and Maqsood, T. (2012) 'Building information modeling (BIM): Now and beyond', *Australasian Journal of Construction Economics and Building*, 12(4), pp. 15–28. https://doi.org/10.5130/ajceb.v12i4.3032.

Kahvandi, Z., Saghatforoush, E., Alinezhad, M., & Noghli, F., (2017) 'Integrated Project Delivery (IPD) Research Trends.', *Journal of Engineering, Project, and Production Management,* 7(2), pp. 99–114. https://doi.org/10.32738/jeppm.201707.0006.

Khoury, K.B. (2019) 'Effective communication processes for building design, construction, and management. *Buildings, 9(5), 112*. https://doi.org/10.3390/buildings9050112.

Kilbane, S. and Roös, P.B. (2022) Charrette! An urgent response toward resilient and sustainable cities and landscapes, *Resilient and Sustainable Cities: Research, Policy and Practice*. Elsevier Inc. https://doi.org/10.1016/B978-0-323-91718 6.00015-3.

Laustsen, J. (2008). Energy efficiency requirements in building codes: Energy efficiency policies for new buildings. International Energy Agency (IEA)

Lalmi, A., Boumali, B., Fernandes, B., & Boudemagh, S.S., (2025) 'Identifying the most used traditional PM practices in construction industry', *Procedia Computer Science*, 256, pp. 1756–1763. https://doi.org/10.1016/j.procs.2025.02.315.

Lucas, S., Koukou, M. K., Aleksiejuk-Gawron, J., Justino, J., Rafael, S., Livieratos, A. D., Tourou, P. (2025). Training for sustainable and healthy building for 2050 Part 2: Incorporation of new knowledge and dissemination for the sustainability of the trans-European training experience. *Buildings*, 15(9), 1512. https://doi.org/10.3390/buildings15091512

Lucas, H., Berdahl, S., Chernyakhovskiy, I., Gokhale-Welch, C., Cox, S., & Hecht, A. (2024). *Strategies and good practices to support robust stakeholder engagement in multi-sector energy transition planning*. National Renewable Energy Laboratory (NREL). https://www.nrel.gov/docs/fy24osti/88389.pdf

Lukson, E. E., Ranadewa, K. A. T. O., Parameswaran, A., Wijerathna, M. R. D. P., & Kodituwakku, D. (2024). Integrated Project Delivery Implementation Among Construction SMEs in Sri Lanka: Barriers and Strategies. *World Construction Symposium*, 619–633. https://doi.org/10.31705/WCS.2024.49

Meng, X. (2012) 'The effect of relationship management on project performance in construction', *International Journal of Project Management*, 30(2), pp. 188–198. https://doi.org/10.1016/j.ijproman.2011.04.002.

Nejatyan, E., Sarvari, H., Hosseini, S. A., & Javanshir, H. (2023). Determining the Factors Influencing Construction Project Management Performance Improvement through Earned Value-Based Value Engineering Strategy: A Delphi-Based Survey. *Buildings*, *13*(8), *1964*. https://doi.org/10.3390/buildings13081964

Palm, J., & Bryngelson, E. (2023). Energy efficiency at building sites: barriers and drivers. *Energy Efficiency*, *16*(2), 18. https://doi.org/10.1007/s12053-023-10088-7

Riabchuk, V., Hagel, L., Germaine, F., & Zharova, A., (2024) 'Utility-based context-aware multi-agent recommendation system for energy efficiency in residential buildings', *Information Fusion*, *112*, 102559. https://doi.org/10.1016/j.inffus.2024.102559.

Shove, E. (2018). What is wrong with energy efficiency? *Building Research & Information*, 46(7), 779–789. https://doi.org/10.1080/09613218.2017.1361746

Svalestuen, F., Frøystad, K., Drevland, F., Ahmad, S., Lohne, J., & Lædre, O., (2015) 'Key Elements to an Effective Building Design Team', *Procedia Computer Science, 64*, 247–254. https://doi.org/10.1016/j.procs.2015.08.636.

Volk, R., Stengel, J. and Schultmann, F. (2014) 'Building Information Modeling (BIM) for existing buildings - Literature review and future needs', *Automation in Construction*, 38, pp. 109–127. https://doi.org/10.1016/j.autcon.2013.10.023.

Walker, D.H.T. and Lloyd-Walker, B. (2012) 'Understanding early contractor involvement (ECI) procurement forms', Association of Researchers in Construction Management, *ARCOM 2012 – Proceedings of the 28th Annual Conference*, 2, 877–887.

Wondimu, P.A., Hailemichael, E., Hosseini, A., Lohne, J., Torp, O., Lædre, O., (2016) 'Success Factors for Early Contractor Involvement (ECI) in Public Infrastructure Projects', *Energy Procedia, 96*, 845–854. https://doi.org/10.1016/j.egypro.2016.09.146.

Yadollahi, M., Mirghasemi, M., Zin, R.M., & Singh, B., (2014) 'Architect critical challenges as a project manager in construction projects: A case study', *Advances in Civil Engineering, 2014*, 205310. https://doi.org/10.1155/2014/205310.