INSTITUTIONAL AND POLICY MECHANISMS FOR ENHANCING ENERGY PERFORMANCE IN PRECONSTRUCTION AND CONSTRUCTION PHASES: EXPERT INSIGHTS FROM SRI LANKA

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Abstract. Energy performance in the built environment is a critical concern due to increased energy demand, particularly in developing countries such as Sri Lanka. Although operational stage energy consumption in projects has already gained considerable attention, limited focus has been given to improving energy performance during preconstruction and construction stages. This study examines the institutional and public-private collaborative mechanisms that enhance energy performance at preconstruction and construction stages within the Sri Lankan construction industry. A qualitative research approach was adopted, and data were collected through ten expert interviews with architects, engineers, and quantity surveyors involved in pre-construction and construction phases. The findings reveal eight institutional mechanisms, including lifecycle based guidelines, policy development, enforcement mechanisms, accountability, financial assistance, project specific policies, mandatory energy efficiency integration, and stable policies resistant to political transition. Additionally, five mechanisms related to public-private collaboration were identified, namely encouraging private sector investment, facilitating idea and technology exchange, minimizing regulatory barriers, establishing a unified sectoral vision, and promoting mutually beneficial partnerships. The study highlights the importance of strengthening governance structures and sectoral collaboration to improve energy performance during early decision making and construction practices rather than focusing solely on operational stages.

Keywords. *Energy Performance, Preconstruction Stage, Construction Practices, Institutional Mechanisms, Public-Private Partnership*

1. Introduction

The construction industry is one of the major contributors to Sri Lanka's national economy, accounting for a significant proportion of the industrial sector's GDP (Economic Indicators | Central Bank of Sri Lanka, 2022). However, industry is also a substantial consumer of non-renewable energy and natural resources throughout the lifecycle of construction projects, including preconstruction (planning and design), construction and post construction (operational) phases (Apandi et al., 2023). Energy performance in the built environment is influenced not only by operational consumption but also by preconstruction and construction stages (Manfren et al., 2020). Decisions taken at the preconstruction stage play a critical role in shaping long term energy outcomes, as early design choices and planning strategies directly affect overall project energy performance (Lima et al., 2020). Although Sri Lanka possesses renewable energy potential such as solar, wind and hydro power, the country continues to rely heavily on fossil fuels to meet national energy demands (Fernando et al., 2019). As a result, a substantial share of export income is allocated for fuel imports (Thiruchelvam & Uduwage, 2025). These conditions highlight the importance of improving energy performance through reduced energy consumption and enhanced energy efficiency within the built environment.

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Several approaches have been proposed to reduce energy consumption in construction and building operations. These include the use of bio composite materials (Lima et al., 2020), adoption of energy efficient standards (Wijewansha et al., 2021), advanced technology integration (Rajapaksha et al., 2024) and use of renewable energy sources (Yahanpath et al., 2024). Previous studies have identified regulatory gaps, geographical constraints, high initial investment requirements, and cybersecurity risks associated with smart technologies (Rajapaksha et al., 2024; Yahanpath et al., 2024). In addition, limited public awareness regarding energy costs and consumption patterns continues to affect behavioural change (Wijewansha et al., 2021). Ongoing economic pressures further restrict long-term investments in sustainable energy practices (Weerasooriya et al., 2023). These factors suggest that technological solutions alone may not be sufficient to enhance energy performance in the built environment.

Institutional and policy mechanisms play a critical role in translating energy efficiency strategies into practice. Government interventions through regulations, enforcement mechanisms, and financial incentives can influence decision making within construction projects (Petkova-Chobanova et al., 2020). Similarly, public–private partnerships have the potential to facilitate energy performance improvements through financing arrangements, risk sharing mechanisms, and support for advanced technology integration (Joseph et al., 2025). Effective collaboration between public authorities and private sector stakeholders may strengthen the adoption of energy efficient practices across the lifecycle of built assets. Institutional mechanisms and public private partnerships can be examined together as they operate in a complementary manner within the built environment, where institutional mechanisms provide the regulatory and policy frameworks, while public–private partnerships enable the practical implementation of these frameworks through collaboration, resource sharing, and innovation. Existing literature has predominantly focused on technological innovations, performance modelling, and post construction (post-occupancy) evaluation. For instance, Kovalchuk and Shcherbakova (2024) examined passive design techniques and advanced insulation materials, while Grigorovitch et al. (2023) discussed energy consumption monitoring models. Andargie et al. (2020) emphasized the role of post-occupancy evaluation in assessing energy outcomes. However, comparatively less attention has been given to institutional and collaborative mechanisms during the preconstruction and construction phases. Although policy related studies have been conducted in certain contexts (Yuan et al., 2017; Tinarwo et al., 2025), limited empirical attention has been given to understanding institutional and collaborative mechanisms within the Sri Lankan construction sector, particularly during the preconstruction and construction phases.

Countries face unique challenges when adopting practices from other contexts due to differences in economic conditions, environmental priorities, and policy frameworks (Debnath et al., 2025). Therefore, there is a need to examine how institutional and policy mechanisms can support the enhancement of energy performance in the built environment within the Sri Lankan context. While existing studies have largely focused on operational stages, limited attention has been given to preconstruction and construction phases, where early decisions and implementation practices significantly influence long term energy performance. Accordingly, this study focuses on these preconstruction and construction phases and aims to examine institutional and collaborative mechanisms that enhance energy performance in the Sri Lankan construction industry. To achieve the aim, the following objectives were formulated.

1. To explore institutional mechanisms that influence energy performance during pre-construction and construction phases within the built environment.
2. To analyze collaborative mechanisms between public and private stakeholders that facilitate energy efficient implementation in construction projects.

2. Literature Review

2.1. ENERGY PERFORMANCE ACROSS PRECONSTRUCTION AND CONSTRUCTION STAGES

Built environment has the ability to influence global energy consumption through several phases of the project lifecycle, including planning, designing, construction and operation (Apandi et al., 2023). Operational stage energy consumption is particularly associated with heating, ventilation, air conditioning, and lighting systems, accounting for approximately 50% of total building energy consumption (Lima et al., 2020).

However, a substantial portion of energy is consumed during the construction phase through material production and on-site activities (Yüksek, 2015; Simeone et al., 2023). The production of construction materials such as cement, steel, and aluminium requires significant energy due to energy intensive manufacturing processes (Yüksek, 2015). In addition, the operation of heavy machinery, material transportation, and temporary lighting and site facilities contribute to increased energy demand during construction (Simeone et al., 2023).

Furthermore, energy performance within the built environment is shaped by decisions taken at the preconstruction stage of a project (Manfren et al., 2020). Factors such as building orientation, material selection, and envelope performance influence the energy performance of a project. (Çavuşoğlu & Çağdaş, 2018). Once construction has commenced, revising design strategies or integrating additional energy efficiency measures becomes costly and time consuming (Akpomiemie, 2016). Therefore, decision making at the preconstruction stage becomes critical, as many long-term energy outcomes are largely determined before construction progresses.

2.2. INSTITUTIONAL AND POLICY MECHANISMS FOR ENERGY PERFORMANCE

Institutional and policy mechanisms are crucial in converting energy efficient strategies into practical action within the built environment, where the government holds a central responsibility (Sheikh et al., 2024). Government policies provide formal frameworks that guide projects throughout their lifecycle and promote accountability in energy management (Petkova-Chobanova et al., 2020). Case studies from Germany and Romania indicate that effective communication between public authorities and private stakeholders can significantly improve energy efficiency outcomes (Murafa, 2017). Similarly, in South Africa, environmental policy implementation led by the government has been identified as a key mechanism in advancing energy efficiency practices (Ndou & Aigbavboa, 2023).

In the Sri Lankan context, the Energy Efficiency Building Code (EEBC) establishes minimum standards for the design, construction, and operation of buildings (Gajaba & Dissanayake, 2025). The Guidelines for Sustainable Energy Residences set limits for energy utilization in buildings (Sri Lanka Sustainable Energy Authority, 2020). The GREENSL® Rating System of the Green Building Council of Sri Lanka (GBCSL) provides energy performance benchmarks, particularly under the Energy and Atmosphere category (GBCSL, 2022). However, in the absence of strict enforcement mechanisms, improvements in energy performance remain limited (Withanaarachchi et al., 2014). In addition, government prioritization of energy performance has been relatively modest (Fasna & Gunatilake, 2019). Therefore, identifying and implementing appropriate policy interventions appears necessary to strengthen energy performance within Sri Lanka's built environment.

2.3. PUBLIC-PRIVATE COLLABORATION IN ENERGY EFFICIENT CONSTRUCTION

Public-Private Partnership (PPP) act as a pathway to enhance energy performance within the construction industry, as such arrangements enable collaboration between the public and private sectors (Joseph et al., 2025). Hajigholami (2024) emphasized that PPP arrangements help to overcome high capital costs and complex regulatory arrangements associated with energy efficiency projects. Similarly, Ugwu et al. (2024) conducted a study in Nigeria and highlighted that PPP mechanisms facilitate increased investment in energy related infrastructure development and enable risk sharing between both parties.

As a developing country experiencing economic constraints, Sri Lanka faces several challenges in investing in energy efficiency related projects, including renewable energy integration and the adoption of advanced construction technologies (Debnath et al., 2025). Although existing studies have examined PPP collaboration in energy efficient construction, their applicability to the Sri Lankan context remains largely unexplored.

Moreover, while prior research has addressed institutional and policy mechanisms as well as PPP collaboration in energy efficient construction, limited attention has been given to Sri Lanka's built environment. In addition, many studies are primarily focused on the operational phase of the project and comparatively less attention is given to preconstruction and construction phase practices. However, decisions taken during preconstruction and construction phases have significant potential to influence overall energy performance. Therefore, investigating institutional and collaborative mechanisms that can enhance energy performance in Sri Lanka's built environment, particularly with a focus on preconstruction and construction phases, would help to identify areas requiring improvement and support the advancement of energy performance in the construction industry.

3. Research Methodology

This study adopted a qualitative research method to explore institutional and collaborative mechanisms that enhance energy performance within Sri Lanka's built environment. Qualitative method was considered appropriate as the study obtain in depth insides from construction industry professionals regarding construction practices, institutional policies and collaborative arrangements influencing preconstruction and construction stage decisions (Taherdoost, 2022).

The target population of the study comprised construction industry professionals with knowledge and experience related to energy performance in the Sri Lankan built environment. The sampling frame included architects, engineers, and quantity surveyors (QS), as these stakeholders are actively involved in preconstruction and construction phases. A purposive sampling technique was adopted to select experts who met predefined selection criteria, ensuring the collection of data from the experts with the relevant expertise and experience to address the research objectives (Thiruchelvam & Uduwage, 2025).

Semi structured interviews were conducted with ten experts who satisfied the expert selection criteria. The interview guideline comprised three sections. The first section was designed to collect demographic information about the experts. The second and third sections focused on institutional mechanisms and public private collaborative mechanisms, respectively. The sample size was limited to ten interviews, as data saturation was reached after the seventh interview. Table 1 presents the expert's selection criteria and profile of experts.

Table 1: Expert selection criteria and experts' profiles

Expert selection criteria									**Experts' profile**	
	Compulsory requirement (All three should be satisfied)			**Additional requirement (At least one should be satisfied)**						
	C1 or C2		**C3**	**C4**	**C5**	**C6**	**C7**			
Code of respondents	Possess a minimum of five years of experience in the construction industry	Possess a minimum of five years of experience in Academia	At least involved in one energy related project	Having a built environment related degree	Having a built environment related to professional qualification	Having certification or other recognized sustainability related credentials	Interest and knowledge on energy performance in construction industry		Profession	Years of experience
E1	✓	X	✓	✓	✓	X	✓		Architect	11
E2	✓	X	✓	✓	✓	X	✓		QS	11
E3	X	✓	✓	✓	✓	X	✓		Engineer	8
E4	✓	X	✓	✓	✓	X	✓		Architect	23
E5	✓	X	✓	✓	✓	✓	✓		QS	40
E6	✓	X	✓	✓	✓	✓	✓		Engineer	7
E7	✓	✓	✓	✓	✓	✓	✓		Architect	17
E8	✓	X	✓	✓	✓	X	✓		Engineer	9
E9	✓	X	✓	✓	✓	X	✓		QS	9
E10	✓	✓	✓	✓	✓	✓	✓		Engineer	11

The collected data were analysed using manual content analysis as this approach enables systematic identification, coding, categorization and interpretation of emerging themes within the textual data (Kleinheksel et al., 2020).

4. Research findings

Experts provided their opinions on industrial and policy mechanisms to enhance energy performance, as well as the expected public-private collaboration required to improve energy performance in the Sri Lankan built environment. The findings from experts' interviews were gathered and analysed using manual content analysis and are discussed as follows.

4.1 INSTITUTIONAL MECHANISMS INFLUENCING ENERGY PERFORMANCE IN PRECONSTRUCTION AND CONSTRUCTION STAGE PRACTICES

Experts were asked open ended qualitative questions regarding their opinion on improving energy performance during preconstruction and construction stages through government initiatives. The institutional mechanisms identified from expert interviews are presented in Table 2. Check marks (✓) represent the experts who referred to each mechanism. In this study, institutional mechanisms refer to the policies, regulations and governance processes that are initiated by the government to improve energy performance in the construction industry.

Table 2: Institutional mechanisms influencing energy performance

Institutional mechanisms influencing energy performance	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Comprehensive lifecycle-based guidelines	✓	X	X	X	X	X	X	X	X	✓
Speed up the policy development	✓	X	X	X	X	X	X	X	X	X
Enforcement and compliance mechanisms	X	✓	X	X	X	X	X	✓	X	X
Accountability in policy execution	X	✓	X	X	X	X	✓	✓	X	X
Provide financial assistance	X	X	✓	✓	X	X	✓	✓	✓	X
Develop project specific policies	X	X	X	X	✓	✓	X	X	X	X
Mandatory integration of energy efficiency measures in high-energy projects	X	X	X	X	✓	X	✓	✓	X	X
Formulation of stable energy policies resistant to political transition	X	X	X	X	X	X	✓	X	X	X

Experts identified **comprehensive lifecycle-based guidelines** as a mechanism influencing energy performance in the built environment in Sri Lanka. E1 highlighted the unavailability of properly developed efficiency codes covering preconstruction, construction, and post construction phases. According to E1, the development of a proper efficiency code is essential to establish a main guideline for each stage of the project lifecycle to systematically guide energy efficiency efforts. Similarly, E10 emphasized the importance of evaluating both initial and operational costs in energy efficient projects rather than focusing solely on initial investment costs.

Speeding up policy development related to energy efficiency was suggested by E1, who referred to the Energy Efficiency Building Code (EEBC), which guides the Sri Lankan construction industry in reducing building energy use. E1 stated that although Sri Lanka has the EEBC to guide energy performance, its promotion and implementation are not sufficiently effective and therefore need to be expedited.

Regarding **enforcement and compliance mechanisms**, E2 noted that merely developing policies is insufficient without enforceable mechanisms to ensure compliance. Supporting this view, E8 emphasized the importance of having a dedicated regulatory body to oversee the implementation of energy policies within the construction industry. In addition, **accountability in policy execution** was also identified by experts as a significant mechanism influencing energy performance.

The most frequently identified mechanism among experts was **providing financial assistance**. For instance, E5 stated that "incorporation of energy-efficient design and materials within a project will lead to an increase in Mechanical Electrical Plumbing (MEP) costs by around 30%." E7 and E8 also acknowledged the high cost implications and suggested the need for tax benefits, subsidies, and financial incentives for developers who incorporate renewable energy solutions such as solar panels, wind power, and energy efficient systems into construction projects.

The **development of project specific government policie**s was highlighted by E5 and E6. E5 explained that small capacity machinery, such as generators, floodlights, and welding machines, can be powered by solar or similar renewable energy sources at construction sites. However, high-capacity equipment such as tower cranes cannot be powered in the same way. Furthermore, the feasibility of renewable energy applications varies depending on project location and duration. For example, recommending solar farming for a six-month project may not be economically feasible due to high initial costs. Therefore, the development of project-specific government policies was considered essential.

Finally, experts emphasized the **mandatory integration of energy efficiency measures in high-energy projects**. E4, E7, and E8 suggested identifying a threshold limit of energy usage for different types of projects. If a project exceeds the defined energy consumption limit, energy efficient design measures should be mandated. Additionally, E7 expressed the need for **stable energy policies resistant to political transitions**, noting that policy changes associated with government transitions often affect decisions related to energy efficient design implementation.

4.2. PUBLIC-PRIVATE COLLABORATIVE MECHANISMS FACILITATING ENERGY EFFICIENT IMPLEMENTATION IN CONSTRUCTION PROJECTS

Experts proposed several public-private collaborative mechanisms to facilitate energy efficient implementation in construction projects. The findings are summarized in Table 3.

Table 3: Public-private collaborative mechanisms that facilitate energy efficient implementation

Public-private collaborative mechanisms	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Encouraging private sector investment in energy efficient projects	✓	✓	✓	✓	X	X	X	✓	✓	X
Facilitation of idea and technology exchange between sectors	✓	X	X	✓	X	X	X	✓	X	✓
Policy reforms to minimize regulatory barriers	X	X	X	✓	X	X	X	X	X	X
Unified vision between public and private sectors for energy efficiency projects	X	X	X	X	✓	X	X	X	X	X
Establishment of mutual beneficial public-private partnership	X	X	X	X	X	✓	✓	X	X	X

The most frequently identified mechanism among experts was **encouraging private sector investment in energy-efficient projects**. E1 stated that the hierarchy of investment can be undertaken by the private sector, whereas the public sector does not have the same level of financial affordability. As a result, public sector projects often attempt to reduce costs, sometimes by compromising energy efficiency measures. E2 and E3 further highlighted that providing financial benefits and incentives to the private sector has strong potential to encourage greater private investment in energy efficient construction projects.

The **facilitation of idea and technology exchange between public and private sectors** was noted as another important mechanism. Experts stated that although Sri Lanka has several independent public and private sector projects, there is no significant linkage between the two sectors to exchange ideas and technological advancements due to the absence of collaborative programs. In addition, E4 suggested that **policy reforms** are necessary to minimize regulatory barriers that restrict effective public-private sector collaboration.

Furthermore, E5 emphasized the need for a **unified vision between the public and private sectors** to develop the country holistically while promoting energy performance. According to E5, the private sector's vision is largely profit oriented, whereas the public sector's vision focuses more on public welfare. However, aligning both sectors under a shared vision toward energy efficiency could produce more effective and sustainable outcomes.

Finally, E6 and E7 stressed the importance of **establishing mutually beneficial public-private partnerships**. For instance, E6 explained that if the private sector produces energy at Rs 10 per unit, the public sector must provide a reasonable return, such as Rs 12 per unit, to ensure profitability. If one party incurs losses, long term participation in the partnership becomes unlikely. Similarly, E7 referred to the successful implementation of the energy wheeling system in India, while noting that Sri Lanka still faces challenges in allowing energy generated at one location to offset consumption at another location through the CEB system. Therefore, maintaining a win-win situation for both public and private parties is essential for sustaining collaborative efforts in energy-efficient construction initiatives.

5. Discussion

This study identifies institutional and collaborative mechanisms (Table 2 and Table 3) that enhance energy performance during preconstruction and construction stages of the built environment in Sri Lanka. The findings revealed eight institutional mechanisms influencing energy performance at these stages. These findings are consistent with existing research. For instance, Petkova-Chobanova et al. (2020) highlighted that accountability, enforcement, and compliance mechanisms imposed through government institutions have significant potential to enhance energy performance. The present study reinforces this argument by emphasizing the importance of structured regulatory mechanisms and policy execution within the Sri Lankan context, where the existing regulations, such as Energy Efficiency Building Code (EEBC), Guidelines for Sustainable Energy Residences and the GREENSL® Rating System of the Green Building Council of Sri Lanka (GBCSL), require greater emphasis and more effective implementation. Furthermore, the findings suggest that energy requirements in construction projects vary depending on project size, scale, and duration. This is supported by Lapidus et al. (2022), who noted that energy demands differ based on project characteristics. For example, mandating solar energy installations may not be practical or cost effective for small scale, short duration projects. Therefore, the development of project-specific policies appears essential to ensure flexibility and context-sensitive implementation of energy efficiency measures, particularly during early project decision making and construction stages.

In addition, the study identified five mechanisms related to public-private collaboration that facilitate energy performance improvements in the built environment. These findings are also supported by prior research. Ugwu et al. (2024) noted that public-private partnerships (PPP) can stimulate higher levels of investment in energy related infrastructure. Similarly, the present findings indicate that encouraging private sector investment in energy efficient projects can reduce the financial burden on the public sector while simultaneously promoting knowledge and technology exchange between sectors. Moreover, Sri Lankan specific mechanisms, such as establishing mutually beneficial partnerships and developing a unified vision between the public and private sectors, were emphasized by the experts. These findings highlight the importance of aligning economic objectives with national energy sustainability goals. Without mutual benefits and shared strategic direction, long term collaboration for energy efficient construction may remain limited.

Based on these findings, several practical implications emerge. Academia can play a role in facilitating structured collaboration programs between the public and private sectors to strengthen knowledge exchange. Additionally, short-term professional training programs can be introduced to industry practitioners to promote the integration of energy-efficient design strategies during preconstruction and construction stages, rather than focusing primarily on the operational stage of a project. At the policy level, the government can develop tailored policies aimed at enhancing energy performance in the built environment and ensure their strict implementation and monitoring to achieve long-term effectiveness.

6. Conclusion

This study examined the institutional and collaborative mechanisms (Table 2 and Table 3) that enhance energy performance during preconstruction and construction stages of the built environment in Sri Lanka. The findings revealed that comprehensive lifecycle based guidelines, speeding up policy development, enforcement and compliance mechanisms, accountability in policy execution, provision of financial assistance, development of project specific policies, mandatory integration of energy efficiency measures in high-energy projects, and formulation of stable energy policies resistant to political transition act as institutional mechanisms influencing energy performance in preconstruction and construction practices. At the same time, the findings further identified encouraging private sector investment in energy efficient projects, facilitation of idea and technology exchange between sectors, policy reforms to minimize regulatory barriers, development of a unified vision between public and private sectors for energy efficiency projects, and establishment of mutually beneficial public-private partnerships as important collaborative mechanisms that facilitate energy efficient implementation.

These findings can be useful for policymakers and industry professionals to understand the institutional and collaborative factors that support energy performance in the built environment. By focusing on both government support and public-private collaboration, energy efficiency can be improved during the preconstruction and construction stages rather than concentrating only on the operational stage of projects. Future research can be extended by testing these identified mechanisms using a larger sample within the construction industry in Sri Lanka. In addition, similar studies can be conducted in other developing countries to compare how institutional and collaborative mechanisms influence energy performance in different contexts.

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