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SYSTEMATIC REVIEW OF THE FACTORS RELATED TO ENERGY SAVINGS THROUGHOUT THE TOTAL LIFECYCLE OF CONSTRUCTION PROJECTS

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ABSTRACT: The construction sector ranks among the most energy-intensive industries globally, making it essential to comprehend its energy demands, particularly as urbanisation accelerates across China, accompanied by the rapid expansion of building development. In light of this, conserving energy at all stages of construction has become increasingly critical to curtail consumption and promote sustainability. The present study seeks to systematically examine and synthesise the key factors that affect energy conservation across the entire lifecycle of construction projects. It further evaluates international and regional trends, with particular focus on China, and investigates the role of energy-efficient technologies, policy frameworks, and awareness initiatives in supporting the adoption of energy-saving practices. To achieve these objectives, the study employed the PRISMA checklist to guide a systematic literature review. Following rigorous application of inclusion and exclusion criteria, twelve relevant studies were selected for analysis. The thematic analysis of these studies facilitated the identification of recurrent concepts. The findings reveal that the integration of energy-efficient technologies, such as Building Information Modelling (BIM), Life Cycle Assessment (LCA), and smart building systems, can significantly lower energy usage across various construction phases. The implementation of these technologies has been driven by financial incentives and regulatory measures, with such influences being particularly notable in China. The research highlights that energy-efficient technologies can be effectively applied during construction, post-construction, and operational phases when supported by robust government policies and enhanced stakeholder awareness.

Keywords: Construction Management, Energy Saving, Government Policy, Lifecycle Construction Projects.

1. Introduction

In recent years, the swift pace of urbanisation and the expansion of the construction sector in China have led to a substantial rise in the demand for buildings and enhanced living standards, which in turn has significantly contributed to increased energy consumption. This trend highlights the critical need to adopt effective energy-saving strategies within the construction industry, particularly given that this sector accounted for nearly 20 percent of global energy consumption in 2021 (IEA, 2021). In response to these challenges, the promotion of green construction and sustainable building practices has gained prominence, aiming to address both environmental concerns and the growing requirements of modern infrastructure (Zhu et al., 2019). These approaches seek not only to improve the quality of construction materials and living conditions but also to reduce energy usage across the full lifecycle of construction projects, encompassing planning, design, construction, operation, maintenance, and demolition.

Energy conservation opportunities are present throughout each stage of a construction project's lifecycle. Achieving optimal energy efficiency demands specific attention to energy use patterns during the operational phase, which has often been overlooked within industry practices. Key elements in this regard include the adoption of energy-conscious design strategies during construction, careful selection of building materials, energy requirements for the construction and maintenance of facilities, and operational energy use (Oregi, Hernandez, & Hernandez, 2017). Research continues to demonstrate the steady advancement of innovative technologies and methods aimed at reducing energy consumption and enhancing sustainability. These innovations have contributed to improvements in building energy performance, although there remains a lack of comprehensive guidelines and standardised best practices for their application across different project stages (Smolina, 2024; Zhao, Zhang, & Wang, 2021).

This study undertakes a systematic review of the key dimensions of energy conservation throughout the complete lifecycle of construction projects. It examines the definition and significance of energy savings, explores global trends alongside specific developments in China, and assesses the implementation of various energy-saving measures, including government policies, technologies, and awareness initiatives. The research applies the PRISMA method to structure the review, detailing the research questions, inclusion and exclusion criteria, and the systematic review process, followed by data extraction and analysis. The concept of lifecycle energy conservation is then critically evaluated, with particular focus on implementation strategies at different project stages and comparative discussions of international and Chinese advancements (Zhao et al., 2021).

The study further investigates the economic and intrinsic drivers of energy savings and analyses the impact of government policies, including mandatory, economic, and voluntary approaches (Smolina, 2024). In addition, it considers the financial advantages of energy-saving technologies and examines the development and effects of stakeholder awareness (Giahchy et al., 2023; Zhao & Zhang, 2022). Lastly, the study analyses the interrelationship between policy frameworks, technological solutions, and awareness initiatives in advancing energy-saving efforts, thereby offering a theoretical and practical foundation for future research (Oregi et al., 2017).

1.1. Problem Statement

The construction sector is recognised as one of the largest consumers of energy on a global scale. At the same time, it faces considerable difficulties in embedding sustainable energy conservation practices across the entire lifecycle of construction projects. Although technological advancements have created opportunities to enhance energy efficiency, the industry continues to encounter numerous obstacles. These include policy-related challenges, high implementation costs, and limitations associated with technology. Furthermore, the lack of a cohesive framework that connects energy-saving initiatives from the planning phase through to the operational stage further compounds these challenges. While the necessary technologies are already accessible, the core issue lies in ensuring their effective application throughout all phases of construction (Górecki & Morales Calleja, 2019; Zaneldin et al., 2024). Overcoming these barriers requires the integration of well-designed policies, strategic use of available technologies, and the consistent application of energy conservation measures from initial construction to the final operational phase of buildings.

1.2. Objectives

- To conduct a systematic review to identify the key factors that influence energy conservation throughout the full lifecycle of construction projects
- To examine global developments and regional patterns, with a specific focus on China, regarding the implementation of energy-saving practices and policies in the construction sector
- To analyse the role of energy-saving technologies, government policies, and stakeholder awareness in supporting the adoption of energy conservation measures in construction projects

1.3. Significance

The importance of this study lies in its contribution to addressing a research gap concerning the assessment of energy efficiency across the entire lifecycle of construction projects in China. It offers a systematic and in-depth examination of the factors that influence energy performance. From a practical perspective, the study delivers valuable guidance for construction firms by providing empirical insights based on Chinese companies within the sector. These findings aim to promote improvements in energy efficiency in construction activities across China and present a model of best practices that may serve as a reference for energy-saving efforts globally. The study is expected to advance both theoretical knowledge and practical approaches related to energy conservation in the context of the rapidly expanding construction industry. Additionally, the outcomes of this research hold the potential to inform strategies in other developing countries and regions, thereby contributing to broader international efforts in energy efficiency.

2. Literature Review

2.1. Factors Influencing Energy Savings throughout the Lifecycle of Construction Projects

The promotion of energy-efficient practices within the construction sector is frequently linked to the adoption of suitable policy interventions or incentive schemes. As highlighted by Tkachenko, Klymchuk and Ivakhnenko (2019), green leases and surveys represent valuable methods for formulating balanced energy-saving policies in construction projects. They introduced a Balanced Scorecard framework that integrates energy conservation not only as a functional concern but also through financial, customer, operational, and workforce dimensions, thereby supporting energy efficiency efforts. In addition, the deployment of building automation and control systems, alongside the enforcement of comprehensive energy regulations, has been recognised as a critical strategy in reducing energy consumption within buildings (Vandenbogaerde, Verbeke, & Audenaert, 2023).

The combined application of BIM and Life Cycle Assessment (LCA) tools is regarded as fundamental to attaining substantial energy conservation throughout the construction lifecycle. According to Lai (2020), expanding the use of green construction components and adopting carbon-reducing materials can significantly enhance energy efficiency and environmental sustainability. To ensure effective outcomes, such measures should be incorporated at each stage of the construction process. Furthermore, Karimpour et al. (2014) argued that tools based on Life Cycle Energy Analysis (LCEA) are effective for minimising overall building energy use, as they account for both embodied energy in materials and the energy demands of construction technologies. Their research underscores that considerable energy savings can be realised by employing innovative and energy-efficient materials in construction.

Cabeza et al. (2014) provided an overview of the application of LCA as a critical tool for assessing building energy performance over its lifecycle. They contended that this approach offers valuable insights, as it facilitates the estimation of both energy consumption and carbon emissions, which are central to energy conservation strategies. Their work proposed that integrating LCA within the design and construction phases enhances the sustainability of construction processes. Similarly, Chau, Leung and Ng (2015) stressed that evaluating lifecycle carbon emissions is an essential element of building energy efficiency assessments, as carbon output plays a decisive role in determining appropriate energy-saving measures.

2.2. Global and Regional (Specifically China) Trends, Practices, and Policies for Implementing Energy-Saving Measures

Progress towards sustainable construction in China has increasingly prioritised the management and reduction of energy consumption. According to Wang et al. (2018), although adjustments in the energy structure could substantially lower carbon intensity by 2030, achieving the full objectives necessitates broader policy interventions beyond what optimisation models alone can deliver. Sole reliance on energy restructuring has proven insufficient, highlighting the need for complementary measures such as technological integration and stronger enforcement mechanisms. Examining regional pathways, Li et al. (2021) investigated the carbon peaking patterns in Jiangsu Province through a scenario-based approach. Their findings emphasised that early transitions in industrial energy use and the strengthening of energy efficiency policies align with provincial carbon peaking targets. The study further indicated that provinces display differing levels of preparedness, suggesting that decentralised and locally tailored policy solutions are more appropriate than centrally imposed strategies.

Chen et al. (2022) expanded on the theme of regional disparities through spatial and decoupling analyses. Their research identified a decline in energy consumption intensity across many provinces. However, overall consumption continues to increase, particularly in emerging high-growth areas along the Yangtze River. This points to a weakening link between economic expansion and energy use, although it persists in certain regions where it remains challenging to introduce and enforce energy efficiency standards effectively. Ren and Kim (2023) noted notable advances in energy-saving technologies for buildings but highlighted that Chinese research on green buildings often overlooks lifecycle operation and management aspects. This indicates that despite progress in technological innovation, the sustained management of energy use in operational buildings has received limited attention in efforts to achieve comprehensive energy conservation.

Addressing this shortfall, Kang et al. (2022) examined nearly zero-energy buildings (NZEBs) across various climate zones in China, incorporating both energy and economic analyses. Their study revealed that although NZEBs present significant opportunities for carbon reduction, challenges related to regional adaptability and high initial costs hinder broader implementation. The authors advocated for the introduction of region-specific subsidies and climate-adapted standards to promote NZEB uptake across different parts of China. On a global scale, Walczyk and Ożadowicz (2024) offered a cross-national perspective on the integration of BIM and digital twins in smart building design. While their work did not directly address China, it outlined how digital ecosystems could play a transformative role in energy monitoring and optimisation in construction, with potential applicability worldwide.

2.3. Energy-Saving Technologies, Government Policies, and Awareness of Energy-Saving Practices

Morshed and Manjur (2024) offered a comprehensive analysis of how various aspects of building design, such as insulation standards, the efficiency of HVAC systems, and the type of automation integrated into a structure, contribute to energy performance. Their research highlighted that the influence of existing technologies is both cumulative and transformative, as real-time data on energy consumption can guide more informed usage decisions. Nevertheless, their findings pointed to regional disparities in the extent of policy adherence and noted that societal concerns continue to limit the widespread adoption of these technologies. Building upon this, Cheng (2025) examined the environmental benefits of incorporating solar, wind, and geothermal energy technologies into building systems to reduce carbon emissions. However, the study also noted that economic constraints and administrative challenges often undermine the feasibility of these technological solutions. One conclusion drawn from this research was that even the most efficient renewable technologies may remain underutilised in the absence of strong political backing and regulatory support.

In relation to governance, Litvinova and Doroshenko (2019) investigated how federal, regional, and municipal levels of authority shape the implementation of energy conservation initiatives. Their study argued that the lack of alignment across regulatory structures and the diversity of control measures contribute to the limited effectiveness of these instruments. Furthermore, inadequate collaboration between public authorities, private individuals, and corporate actors weakens the coordinated execution of energy-saving strategies. In this context, Iqbal et al. (2021) emphasised that tailored financial mechanisms, tax incentives, and regulatory frameworks suited to local conditions are essential for advancing sustainable construction. Their research identified that in developing nations such as Pakistan, barriers to progress stem from both structural issues and gaps in stakeholder knowledge. The authors concluded that effective promotional approaches must incorporate capacity-building activities to raise awareness among key participants.

Xu (2024) extended this discussion by assessing how digital governance can improve energy efficiency through enhanced data transparency, citizen engagement, and the use of smart technologies. The study contended that transforming public institutions into digital entities strengthens their ability to oversee and deliver energy performance measures. Similarly, Kou (2022) argued that although energy-efficient technologies are available, their impact is limited due to low levels of awareness and insufficient promotion, particularly in the context of interior design and building refurbishment. This research highlighted the importance of expanding education and training initiatives to bolster technological capacity and encourage more widespread application in practice.

2.4. Literature Gap

The existing literature on energy conservation within construction projects offers substantial insights across various dimensions. Nonetheless, important gaps remain, particularly regarding long-term operational management and the influence of regional disparities on the effectiveness of energy-saving measures. While notable progress has been made in the development and application of BIM and LCA, limited attention has been given to their practical deployment during the operational stages that follow construction. This gap suggests that the role of these technologies in ongoing energy management remains underexplored. Supporting this view, Ren and Kim (2023) observed that the green building sector in China still lacks sufficient focus on lifecycle operation and management to substantiate claims that technological advancements have significantly enhanced energy management within the industry over time.

In relation to policy frameworks, it is apparent that existing research has yet to fully examine how policy interventions, along with regional variations in the implementation of both policies and technologies, affect energy-saving outcomes. Chen et al. (2022) highlighted that current policy studies and management approaches have largely overlooked the differences in energy consumption patterns across regions, including those characterised by rapid growth or higher levels of development. Additionally, while considerable work has been undertaken on raising awareness, there is still a need for further research into how international construction firms might more effectively embed educational initiatives aimed at promoting energy conservation, as suggested by Kou (2022).

3. Methodology

3.1. Research Methods and Design

This study employed a qualitative research design to explore and evaluate the factors that influence energy conservation during the construction stage of a building. To address the research aims in a structured and rigorous manner, a Systematic Literature Review (SLR) was undertaken. The use of the SLR approach was selected due to its clarity and consistency in guiding literature reviews and synthesising findings within a particular research domain. This method involves the application of specific criteria to facilitate the identification of the most relevant and insightful articles for inclusion in the study, while also determining those that should be excluded. In alignment with the central objective of this research, which was to assess the existing body of knowledge on energy conservation in construction, the following research question was developed.

3.2. Data Collection Methods

3.2.1. Searching Technique

The literature search was guided by targeted themes associated with energy conservation within construction projects. A set of keywords, including energy savings, construction lifecycle, energy-efficient technologies, government policies, and energy-saving practices, was applied to identify studies that addressed energy efficiency across the various phases of construction. The use of these search terms ensured that the selected literature was closely aligned with the research objectives and directly contributed to answering the study's core questions.

3.3. Databases

The selection of databases for this study was informed by their relevance and prominence as sources of peer-reviewed publications within the fields of construction and energy efficiency. The databases utilised included JSTOR, Web of Science (WOS), Google Scholar, ResearchGate, and ScienceDirect. These platforms were chosen primarily due to their extensive coverage and accessibility to high-quality scholarly works, which facilitated the identification of pertinent and reliable studies. As a result, the systematic review was grounded in a broad and diverse collection of literature, thereby enhancing the robustness and credibility of the findings.

3.4. Boolean Operators

To enhance the precision and effectiveness of the search process, Boolean operators (AND, OR, NOT) were applied in structuring the queries. The operator AND was utilised to link distinct keywords, such as in the combination "energy savings AND construction lifecycle," ensuring that retrieved articles addressed both areas of interest simultaneously. The OR operator served to expand the search scope by incorporating alternative terms or related concepts, for example, "energy-saving technologies OR energy-efficient materials." Meanwhile, the NOT operator was used strategically to filter out studies unrelated to the core themes, thereby excluding works that focused on industries outside the construction sector or did not pertain to energy conservation.

3.5. Inclusion and Exclusion Criteria

A clear set of inclusion and exclusion criteria was defined to guarantee that the studies chosen for review were closely aligned with the research aims (Table 1).

Table 1: Inclusion and Exclusion Criteria.

Criteria	Inclusion	Exclusion
Publications	Peer-Reviewed Articles, Journals, Books, and Conference Papers After 2017.	Non-Peer-Reviewed Articles, Opinion Pieces, and Non-Academic Sources Before 2017.
Research Type	Empirical Studies, Theoretical Articles, and Case Studies.	Opinion-Based Articles, Non-Research Publications.
Language	English	Non-English Publications.
Focus	Studies on Energy-Saving Technologies, Lifecycle Management, and Policy Implementation in Construction Projects.	Studies Outside the Scope of Energy Savings or Construction Lifecycle.

3.6. Selection of Papers through PRISMA Framework

In accordance with the PRISMA guidelines, a total of 104 articles were initially identified that satisfied the defined inclusion and exclusion criteria. The abstracts and full texts of these publications were examined thoroughly on multiple occasions to ensure alignment with the objectives set out in this study. This rigorous review enabled the authors to carefully assess all identified works and ultimately select twelve articles deemed most suitable for the data analysis phase. The selection process was designed to ensure that only studies offering significant insights into energy-saving issues within construction projects were incorporated. Through purposive sampling, the research focused exclusively on articles that were directly relevant to the study's aims and provided meaningful contributions to the analysis.

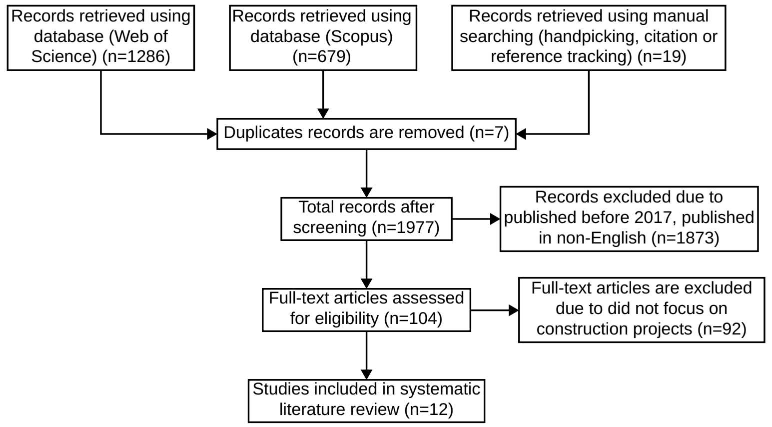

Figure 1: PRISMA Framework.

3.7. Data Analysis Methods

The information gathered from the chosen studies was examined through thematic analysis, a qualitative approach used to detect, analyse, and interpret recurring patterns and themes present within the data.

Table 2: Data Analysis Methods.

Step	Description
Familiarization with Data	Initial reading and re-reading of the selected papers to understand the context and identify potential themes.
Generating Initial Codes	Identifying meaningful segments of the text that relate to the research objectives.
Searching for Themes	Organizing codes into broader themes that capture recurring patterns across the studies.
Reviewing Themes	Refining themes by cross-checking them with the data to ensure they represent the findings accurately.
Defining and Naming Themes	Finalizing the themes and labelling them with clear definitions to guide the analysis.

3.8. Ethical Considerations

Ethical standards were maintained rigorously throughout the research process. As the study was grounded entirely in a review of existing literature, it did not involve direct interaction with human participants or the conduct of experimental procedures. Proper attribution was given to the original authors of all sources reviewed in order to ensure the avoidance of plagiarism. Furthermore, the selection of articles was guided solely by their scientific merit and their direct relevance to the research objectives. The study adhered to ethical principles not only by ensuring the originality of the work but also by providing a transparent account of the research methodology.

4. Results

This section provides a structured presentation of the data collected in the study, including its organisation in tabular format and a discussion of how the findings relate to each research objective. Table 3 outlines the key themes identified for analysis. The data were examined using NVivo software, which supported the systematic interpretation of the information gathered.

Table 3: Theme Extraction.

Theme	Description
Energy Savings in Construction	Focuses on identifying and understanding the factors that influence energy-saving measures across the entire lifecycle of construction projects.
Lifecycle of Construction Projects	Examines how energy savings can be integrated throughout the various stages of construction, including planning, design, construction, and operation.
Global and Regional Trends	Investigates the current trends and practices related to energy savings in construction at both global and regional (especially China) levels.
Energy-Saving Technologies	Analyses the role and impact of various energy-saving technologies that are used in construction projects to reduce energy consumption.
Government Policies	Assesses the influence of government regulations, incentives, and policies on promoting energy-saving practices within the construction industry.
Awareness of Energy Savings	Explores how awareness of energy-saving practices among stakeholders (such as project managers, contractors, and policymakers) impacts the implementation of energy efficiency measures.

Theme 1: Energy Savings in Construction

Table 4 displays the detailed analysis of the principal studies that focus on energy conservation within the construction sector. Enshassi, Ayash and Arain (2018) present an overview of the factors, technological solutions, management strategies, and policy measures that must be combined to implement energy efficiency initiatives aimed at achieving substantial savings. Similarly, Ma et al. (2015) explore opportunities for enhancing energy efficiency within China's urban civil construction sector, highlighting the importance of technological advancement, supportive policy frameworks, and improvements in construction quality. Both studies stress that effective policy implementation and the integration of technology are essential for addressing energy challenges in the construction industry.

Table 4: Energy Savings in Construction.

Authors	Objectives	Methods	Findings	Conclusion
Enshassi, Ayash, and Arain (2018)	To investigate and evaluate the key elements that support energy conservation efforts in construction projects	A qualitative examination and review of literature addressing the factors that promote energy conservation in construction projects	Recognised essential elements including energy-efficient technologies, management approaches, and policy measures that enhance energy performance in construction	The study highlights that achieving notable energy savings in construction projects depends on the effective combination of integrated management approaches and technological innovations.
Ma et al. (2015)	To examine essential factors and policy measures that could facilitate reductions in energy use within China's urban civil construction sector	A review and critical analysis of existing policies aimed at lowering energy consumption within China's construction sector	Concluded that regulatory frameworks, advancements in technology, and effective construction methods play a crucial role in lowering energy use in urban buildings	The study indicates that lowering energy consumption in China's urban building sector relies on the successful enforcement of appropriate policies combined with the widespread adoption of modern technological solutions.

Theme 2: Lifecycle of Construction Projects

Table 5 presents an analysis of how BIM and LCA are incorporated across the various stages of construction project lifecycles. Jin et al. (2019) emphasise that incorporating BIM into construction projects facilitates energy performance assessments and supports construction management across various stages, thereby enhancing the energy-saving outcomes of the projects. Similarly, Li et al. (2022) demonstrate that applying BIM together with LCA in prefabricated buildings provides a combined strategy that effectively reduces both energy consumption and carbon emissions. Both studies underline the significant contribution of BIM throughout the lifecycle of construction projects.

Table 5: Lifecycle of Construction Projects.

Authors	Objectives	Methods	Findings	Conclusion
Jin et al. (2019)	To explore the integration of BIM with building performance analysis throughout the construction lifecycle in order to enhance energy efficiency.	Application of BIM alongside building performance analysis at the planning, design, and construction phases.	The integration of BIM supported improved energy analysis, informed design choices, and more effective management during construction.	Incorporating BIM into all stages of construction projects enables more accurate monitoring and supports efforts to optimise energy savings.
Li et al. (2022)	To assess the carbon emissions and energy usage of prefabricated structures over their entire lifecycle through the combined use of LCA and BIM.	Use of LCA in conjunction with BIM to evaluate carbon output and energy conservation potential in prefabricated construction.	The findings showed that prefabricated buildings achieved lower carbon emissions and energy consumption, with BIM contributing to enhanced lifecycle oversight.	The joint application of LCA and BIM offers a comprehensive method for cutting energy use and carbon emissions across the lifecycle of prefabricated buildings.

Theme 3: Global and Regional Trends

Table 6 presents an analysis of both global and regional developments relating to patterns of energy use and improvements in energy efficiency. Berardi (2017) undertakes a comparison of building energy consumption across various countries and concludes that energy conservation tends to be achieved in nations that have adopted stringent regulatory frameworks, whereas others continue to struggle with improving energy efficiency. In a related context, Wen et al. (2023) analyse research on construction supply chains and highlight energy efficiency as a major theme within this body of work. Both studies point to energy efficiency as a vital element in shaping future progress, emphasising that policy measures and regulatory action are central to advancing these efforts.

Table 6: Global and Regional Trends.

Authors	Objectives	Methods	Findings	Conclusion
Berardi (2017)	To examine and compare building energy consumption patterns across multiple nations and assess international variations in energy use.	Comparative analysis of building energy consumption data from several countries.	The study identified notable differences in energy use patterns between nations, influenced by differences in technology adoption and policy frameworks.	The findings suggest that countries enforcing stricter regulations are achieving reductions in building energy consumption, whereas other regions continue to encounter challenges in enhancing energy efficiency.
Wen et al. (2023)	To investigate global research developments in supply chain management for construction through bibliometric techniques.	Bibliometric review of international research trends in construction project supply chain management	The research revealed growing attention to energy efficiency within supply chain management, alongside other emerging themes.	Energy efficiency and sustainable practices are gaining prominence as key considerations in global supply chain management for the construction sector.

Theme 4: Energy-Saving Technologies

Table 7 presents an evaluation of technologies designed to promote energy conservation within the construction sector. Kwasnowski, Fedorczak-Cisak and Knap (2017) underline that the use of insulation and intelligent energy systems contributes notably to enhancing building efficiency. In a similar context, Guo, Wang and Dong (2022) report that, in China, the adoption of smart city technologies, including energy-efficient building methods and precise smart grid applications, has played an essential role in managing energy-related pollution and cutting CO2 emissions. Both studies stress the significant impact of advanced technologies in strengthening energy conservation and management efforts while mitigating environmental harm.

Table 7: Energy-Saving Technologies.

Authors	Objectives	Methods	Findings	Conclusion
Kwasnowski et al. (2017)	To investigate the challenges associated with energy-saving technologies in building construction and assess their contribution to energy efficiency.	Review and assessment of various technologies applied in building projects to enhance energy conservation.	The study highlighted major energy-saving measures, including insulation techniques and smart energy management systems, and evaluated their effectiveness in improving efficiency.	The research confirmed that technologies such as advanced insulation and intelligent systems play a crucial role in enhancing the energy performance of buildings.
Guo, Wang and Dong, (2022)	To examine the influence of smart city development on energy savings and carbon emissions reductions, focusing on examples from China.	Case-based study and evaluation of smart city projects in China, assessing the role of energy-saving technologies in reducing emissions.	Findings demonstrated that smart city technologies, such as efficient infrastructure and smart grids, have led to notable reductions in both energy use and CO2 emissions.	The study concluded that smart city developments incorporating advanced technologies make a significant contribution to cutting energy consumption and emissions in the construction sector.

Theme 5: Government Policies

Table 8 presents an analysis of government policy measures that support energy conservation within the construction sector. Wang et al. (2024) demonstrate that government regulations, together with financial incentives, are key factors in advancing the use of regulatory approaches aimed at lowering carbon emissions within the building sector. Similarly, Iqbal et al. (2021) utilised structural modelling to identify government-led incentives and policy measures that support the adoption of energy-efficient technologies in construction. Both studies confirm that government intervention through appropriate policies is fundamental to promoting sustainable practices in construction management.

Table 8: Government Policies.

Authors	Objectives	Methods	Findings	Conclusion
Wang et al. (2024)	To examine how government interventions and financial support contribute to reducing carbon emissions in the building sector.	Evolutionary analysis of regulatory policies and investment measures within the construction industry.	The study found that government interventions, particularly regulatory frameworks and financial incentives, are vital in advancing carbon reduction efforts in buildings.	The research concluded that well-designed government policies and focused investments are essential in driving energy-saving practices and lowering carbon emissions in construction.
Iqbal et al. (2021)	To investigate how government-led promotional schemes support the adoption of energy-efficient technologies in construction.	Application of interpretive structural modelling (ISM) to assess government strategies for encouraging sustainable construction practices.	The study identified important policies and incentive structures that foster the integration of energy-efficient technologies within construction projects.	The findings suggest that government measures, including both incentives and regulatory actions, are central to advancing sustainable building practices and energy efficiency.

Theme 6: Awareness of Energy Savings

Table 9 presents an examination of how awareness of energy conservation influences energy efficiency within the construction sector. Liu et al. (2017) investigate energy performance contracts and stakeholder perceptions within the Chinese context, concluding that greater awareness of energy-saving technologies has a positive and significant influence on the adoption of energy-efficient measures among SMEs. Similarly, Zedan and Miller (2018) apply a four-stage approach to evaluate stakeholder impact, demonstrating that both active stakeholder participation and awareness of energy efficiency practices are essential for the successful implementation of energy-saving strategies in residential construction. Both studies emphasise that awareness plays a critical role in advancing energy efficiency initiatives.

Table 9: Awareness of Energy Savings.

Authors	Objectives	Methods	Findings	Conclusion
Liu et al. (2017)	To assess how green manufacturing technologies spread in China, with a particular focus on energy performance contracts and stakeholder views.	Stakeholder-focused analysis using energy performance contract models, with attention to the perspectives of small and medium-sized enterprises (SMEs).	The study found that the level of awareness among SMEs and other stakeholders regarding energy-saving technologies plays a major role in encouraging the adoption of energy-efficient practices.	The research concludes that raising awareness of available technologies and financial support is vital for the broader application of green manufacturing technologies in China's construction sector.
Zedan and Miller (2018)	To measure the extent of stakeholder influence on housing energy efficiency and develop a method for evaluating their impact.	Four-stage framework designed to assess how stakeholders affect the energy performance of housing projects.	The findings highlighted that both stakeholder engagement and their understanding of energy efficiency practices significantly contribute to the adoption of energy-saving measures in housing.	The study suggests that strengthening stakeholder knowledge and participation can increase the success of energy efficiency initiatives in residential construction.

5. Discussion

5.1. Interpretation of the Findings

5.1.1. Factors Influencing Energy Savings throughout the Lifecycle of Construction Projects

Enshassi et al. (2018) and Ma et al. (2015) demonstrate that various elements significantly impact energy efficiency within the construction sector, and these factors should not be disregarded. Their research identifies technologies, operational practices and policy frameworks as central to achieving effective energy use. Both studies acknowledge that notable improvements in energy efficiency are only attainable through the adoption of technological innovations, structured methodologies and supportive legislation. Ma et al. (2015) in particular emphasise that regulatory measures and advancements in technology are vital for promoting energy conservation in the urban building sector of China, aligning with the objective of recognising the key influences on energy savings across all phases of construction projects.

5.2. Global and Regional (Specifically China) Trends, Practices and Policies for Implementing Energy-Saving Measures

Berardi (2017) provides a global and regional analysis of energy efficiency trends, noting that nations with rigorous regulatory frameworks tend to report reductions in energy use, while others continue to face obstacles in achieving efficiency targets. Similarly, Wen et al. (2023) highlight that energy efficiency is becoming an increasingly prominent theme within global construction supply chain management, particularly as policies and regulations are being designed to encourage energy-saving practices. These findings support the study's aim of assessing regional and international initiatives, with a specific focus on China's energy-saving efforts.

5.3. Energy-Saving Technologies, Government Policies and Awareness of Energy-Saving Practices

Research by Kwasnowski et al. (2017), Guo et al. (2022), and Iqbal et al. (2021) explores the contributions of technological innovation, government intervention and awareness in promoting energy conservation. Kwasnowski et al. (2017) highlight the value of insulation and intelligent systems in improving energy performance in buildings. Guo et al. (2022) examine how smart city technologies in China have contributed to reducing both energy use and CO2 emissions. Iqbal et al. (2021) point out the importance of government incentives and regulatory support in advancing energy-efficient technologies in construction. In addition, Liu et al. (2017) and Zedan and Miller (2018) emphasise that stakeholder awareness significantly influences the successful implementation of energy conservation measures. Together, these studies reflect the central role of technology, policy and awareness in driving energy efficiency across the sector.

5.4. Comparison with the Previous Studies

The results of this study reinforce earlier research findings that highlight the critical importance of technology and policy in achieving energy efficiency at all stages of construction. Enshassi et al. (2018) and Ma et al. (2015) identified the deployment of BIM, LCA and automation systems as essential to improving energy use in construction. However, this study extends prior conclusions by stressing the need for more comprehensive frameworks that integrate policies and educational initiatives. Smolina (2024) and Tkachenko et al. (2019) also argue that energy efficiency requires more than technological solutions and legal frameworks; stakeholder involvement and community engagement are equally important. The present study supports this view, noting that existing technologies are often underutilised due to weak law enforcement and limited stakeholder participation.

This research aligns with the life cycle management principles advanced by Lai (2020) and Karimpour et al. (2014), which advocate for the inclusion of green construction components and low-carbon resources to ensure long-term energy management. The need to address energy consumption and carbon emissions at the design stage is supported by Cabeza et al. (2014) and Chau et al. (2015), as LCA can assist in reducing energy use throughout the building's lifecycle. However, this study advances these insights by arguing that energy conservation strategies should also encompass the operational and maintenance phases. Karimpour et al. (2014) highlight that embodied energy in materials is often neglected, with most research focusing solely on operational energy.

Regarding regional challenges, the study's findings align with those of Wang et al. (2018) and Li et al. (2021), who examine the difficulties in meeting China's carbon intensity reduction goals. Building on Berardi (2017), this study illustrates the complexities of implementing energy-saving policies across diverse regions within a rapidly developing economy like China. The importance of considering spatial variations in energy use and policy enforcement, as noted by Chen et al. (2022), is also reinforced. The study advocates for localised policy measures that consider economic development levels and energy consumption patterns, as argued by Li et al. (2021) and Chen et al. (2022).

The research further supports the view, reflected in Morshed and Manjur (2024) and Cheng (2025), that technological innovation in areas such as smart grids and solar systems enhances energy efficiency. Nonetheless, the role of government policy in ensuring the success of these technologies remains vital. Wang et al. (2024) and Iqbal et al. (2021) highlight the influence of government regulation and financial incentives in promoting energy efficiency within the construction sector. This study advocates for regionalised public-private partnerships to strengthen the adoption of energy-saving technologies. Moreover, the study stresses the importance of stakeholder awareness, echoing the conclusions of Liu et al. (2017) and Zedan and Miller (2018). The findings suggest that raising awareness about the long-term benefits of energy-efficient technologies is essential for broader acceptance. Kou (2022) supports this view by indicating that training and education equip stakeholders with the necessary knowledge to enhance energy-saving efforts.

5.5. Theoretical Implications

This research offers valuable theoretical contributions by demonstrating how technological, policy and awareness-based interventions can be integrated across all phases of construction projects. While BIM and LCA are vital for improving energy efficiency in the built environment, the study highlights that these technologies achieve their full potential only when combined with effective policies and active stakeholder engagement. The importance of extending energy-saving strategies beyond the design and construction phases to include maintenance and operation is another key contribution. Overall, the research advances the theoretical discourse on the interplay between technology, policy and awareness in promoting energy conservation.

6. Conclusion

This review identifies the primary factors influencing energy efficiency across the lifecycle of construction projects. The study highlights the essential role of BIM and LCA throughout construction phases in improving energy performance. It concludes that while technological measures are important, they must be supported by well-designed policies, local implementation strategies and enhanced stakeholder awareness to maximise energy savings. The findings stress the need for collaboration among stakeholders at every stage, from design and construction to operation and maintenance. The research provides a sound theoretical foundation and practical guidance for promoting energy-saving practices in China and beyond.

6.1. Limitations of the Study

A limitation of the study is its reliance on secondary data, which may not reflect the most recent technological developments or policy updates. The focus on China limits the generalisability of findings to other regions, as global variations in energy-saving practices were not fully explored. Additionally, the absence of primary data means that the real-world applicability of the reviewed measures could not be directly evaluated.

6.2. Future Work

Future research should incorporate primary data collection to provide empirical evidence on the actual impact of energy-saving technologies in construction. Investigating the use of digital technologies and intelligent building systems in other regional contexts would also be valuable. Further exploration of the relationship between local policies, adaptability and stakeholder participation under varying climatic and economic conditions is recommended.

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