Desarrollo Sostenible e Innovación Global. 2025; 2(2):15
doi: 10.63688/desarrollo.v2.i2.15

ORIGINAL

Energy efficiency in sustainable buildings in Ecuador: a review of strategies and technologies

Eficiencia energética en edificaciones sostenibles del Ecuador: revisión de estrategias y tecnologías

Yolanda Lorena Paredes Andrade[1]

[1] Universidad Estatal Amazónica. Ecuador.

Submitted: 06-10-2025 | Revised: 02-11-2025 | Accepted: 05-12-2025 | Published: 06-12-2025

ABSTRACT

A systematic literature review with a qualitative-descriptive approach was conducted on energy efficiency in sustainable buildings in Ecuador, aiming to analyze the strategies and technologies applied in different types of buildings. Scientific databases such as Scopus, ScienceDirect, Springer, SciELO, and Google Scholar were consulted, selecting studies published between 2019 and 2025. Inclusion and exclusion criteria related to thematic relevance, academic rigor, document type, and language were applied, allowing the available information to be filtered and systematized. The results showed that bioclimatic strategies and passive design approaches were the most frequently reported in the Ecuadorian context, highlighting their effectiveness in reducing energy consumption and improving thermal comfort in tropical and Andean climates. Likewise, an increasing incorporation of active technologies, energy simulation tools, and optimization models was identified, although their application remained limited compared to passive strategies. It was also evidenced that building materials significantly influenced the thermal performance of buildings, while energy regulations showed partial implementation in the region. It was concluded that energy efficiency in sustainable buildings has evolved toward integrated approaches combining architectural design, technology, and energy management, although gaps between research, regulation, and practical implementation in Ecuador still persist.

Keywords: energy efficiency, sustainable buildings, bioclimatic design, Ecuador.

RESUMEN

Se realizó una revisión sistemática de literatura con enfoque cualitativo-descriptivo sobre la eficiencia energética en edificaciones sostenibles en el Ecuador, con el propósito de analizar estrategias y tecnologías aplicadas en distintos tipos de edificaciones. Se consultaron bases de datos científicas como Scopus, ScienceDirect, Springer, SciELO y Google Scholar, seleccionando estudios publicados entre 2019 y 2025. Se aplicaron criterios de inclusión y exclusión relacionados con pertinencia temática, rigor académico, tipo de documento e idioma, lo que permitió depurar y sistematizar la información disponible. Los resultados evidenciaron que las estrategias bioclimáticas y de diseño pasivo fueron las más recurrentes en el contexto ecuatoriano, destacándose su efectividad en la reducción del consumo energético y la mejora del confort térmico en climas tropicales y andinos. Asimismo, se identificó una creciente incorporación de tecnologías activas, herramientas de simulación energética y modelos de optimización, aunque su aplicación aún fue limitada en comparación con las estrategias pasivas. Se evidenció también que los materiales de construcción influyeron significativamente en el desempeño térmico de las edificaciones, mientras que las normativas energéticas presentaron una implementación parcial en la región. Se concluyó que la eficiencia energética en edificaciones sostenibles avanzó hacia enfoques integrales que combinaron diseño arquitectónico, tecnología y gestión energética, aunque persistieron brechas entre investigación, normativa y aplicación práctica en el Ecuador.

Palabras clave: eficiencia energética, edificaciones sostenibles, diseño bioclimático, Ecuador.

INTRODUCTION

Energy efficiency in sustainable buildings has become a central pillar in the transition toward more resilient and low-carbon cities. Globally, the construction sector is one of the largest sources of energy consumption and greenhouse gas emissions, which has driven the development of strategies to improve the energy performance of buildings. Within this framework, this review focuses on the case of Ecuador, considering its climatic, social, and regulatory particularities.

Internationally, research on energy efficiency in buildings has evolved significantly over the past two decades, integrating approaches such as life cycle assessment (LCA), energy simulation, and the optimization of construction systems. Asdrubali et al. (2024) highlight that integrating LCA with energy efficiency enables a more comprehensive assessment of the environmental impact of buildings, considering both operational and embodied energy.

In Latin America, interest in energy efficiency in buildings has grown steadily due to increasing urbanization and energy demand in the residential and public sectors. Ochoa et al. (2021) note that policies and technologies applied in the region still exhibit significant gaps, particularly in the implementation of regulations and the adoption of low-energy technologies.

In Ecuador, the energy issue in buildings is closely linked to the country's climatic diversity, which includes hot-humid, tropical, and Andean zones. This variability requires differentiated design strategies that respond to local conditions, motivating recent research on bioclimatic architecture and energy efficiency.

Bustamante-Campoverde (2024) demonstrates that in the Metropolitan District of Quito, bioclimatic strategies can significantly improve the energy performance of buildings by reducing the demand for artificial air conditioning through the use of natural environmental conditions.

Similarly, passive design has been identified as one of the most effective strategies to reduce energy consumption in Ecuadorian homes. Cedeño and Zambrano (2023) show that implementing passive strategies such as cross ventilation, proper orientation, and the use of thermally efficient materials contributes to improved thermal comfort without increasing energy consumption.

In public and service buildings, energy efficiency has also been studied, revealing significant opportunities for improvement. García-Alvarado et al. (2020) highlight that reducing energy demand in public buildings in hot climates can be achieved through redesigning thermal envelopes and incorporating shading strategies.

In this context, energy regulations play a fundamental role in promoting sustainable buildings. Gaudry et al. (2019) indicate that implementing energy regulations adapted to climate change is essential to ensure minimum efficiency standards in construction.

Moreover, energy efficiency depends not only on architectural design but also on building management and operation models. Copiello et al. (2024) state that innovative business models in the construction sector can accelerate the adoption of energy-efficient practices.

In Ecuador, research on sustainable construction has recently been systematized, showing growth in academic and technical interest. Moreira-Macías et al. (2024) highlight that, although there is progress in the literature, limitations persist in the practical application of sustainable strategies in real projects.

Energy optimization in nearly zero-energy buildings (nZEB) represents an emerging trend in global research. Muñoz-Salcedo et al. (2024) propose optimization models that integrate efficient energy supply with economic and environmental sustainability criteria.

In the Latin American context, evaluating energy efficiency indicators in public infrastructure enables the identification of opportunities for improvement in energy management. Sánchez and Hidalgo (2023) emphasize the need to standardize metrics that allow for the comparison of energy performance among countries in the region.

In tropical zones such as the Ecuadorian coast, the energy performance of buildings is strongly influenced by humidity and ambient temperature. Vallejo et al. (2024) show that specific strategies such as shading, natural ventilation, and the use of reflective materials are key to improving energy efficiency in Guayaquil.

The analysis of energy performance in residential housing using simulation tools has enabled significant advances in understanding real energy consumption. Villacreses et al. (2023) highlight that energy simulation is a fundamental tool for evaluating improvement scenarios in tropical climates.

Similarly, the thermal behavior of construction materials directly influences the energy consumption of buildings. Torres and Loor (2022) demonstrate that the proper selection of materials can significantly reduce the need for artificial air conditioning systems.

In the Andean region, the evolution of energy consumption in buildings reflects changes in construction patterns and comfort demand. Torres-Quezada et al. (2024) analyze operational and embodied energy in residential buildings, highlighting the importance of considering both in sustainability assessments.

Finally, this review aims to integrate and analyze the main energy efficiency strategies and technologies applied in sustainable buildings in Ecuador, taking into account its climatic, regulatory, and technological context. This approach enables the identification of opportunities for improvement and guides future research toward more comprehensive solutions tailored to the country's specific conditions.

METHODS

This research employed a qualitative, descriptive, and documentary approach, based on a systematic review of scientific literature related to energy efficiency in sustainable buildings within the Ecuadorian and Latin American context. The qualitative approach is justified as the study does not seek numerical measurement of variables, but rather the interpretation, comparison, and synthesis of existing scientific evidence on strategies, technologies, and approaches applied in sustainable buildings. The descriptive nature allows for the characterization of the main trends, technical approaches, and results reported in the literature without intervening in the analyzed variables. The documentary component relies exclusively on secondary sources from scientific articles, academic reviews, and indexed technical studies.

The study design corresponds to a systematic review of scientific literature, aimed at identifying, selecting, evaluating, and synthesizing relevant research on energy efficiency in sustainable buildings. This type of review enables the organization of existing knowledge in a structured, transparent, and reproducible manner, following methodological principles similar to the PRISMA approach, although adapted to a qualitative-descriptive design without the need for meta-analysis.

The bibliographic search strategy was conducted in high-impact scientific databases, including Scopus, ScienceDirect, SpringerLink, Google Scholar, and SciELO. The search used combinations of keywords in Spanish and English, such as: "eficiencia energética en edificios," "sustainable buildings energy efficiency," "bioclimatic design," "energy efficiency strategies in Ecuador," "passive design buildings," "net zero energy buildings," and "building energy performance." These keywords were combined using the Boolean operators AND and OR to optimize the retrieval of relevant information.

The inclusion criteria were: scientific articles published between 2019 and 2025, empirical studies, systematic reviews, case studies, and articles indexed in peer-reviewed scientific journals. Research in Spanish and English that directly addressed energy efficiency in sustainable buildings, especially in climatic contexts similar to Ecuador, was included. Priority was given to studies presenting design strategies, applied technologies, or evaluations of energy performance in residential, public, or commercial buildings.

The exclusion criteria included non-academic documents, non-peer-reviewed grey literature, theses not published in indexed journals, duplicates across databases, articles without full-text access, and studies whose subject matter was not directly related to energy efficiency in buildings. Research focused exclusively on industrial energy engineering or systems not linked to the construction sector was also excluded.

The study selection process was carried out in four phases. In the identification phase, records obtained from the selected databases were compiled. In the screening phase, duplicates were removed and titles and abstracts were reviewed to exclude irrelevant records. In the eligibility phase, the full text of the preselected articles was read, evaluating their thematic and methodological relevance. In the selection phase, only studies that met all established criteria were included, forming the final analysis corpus. This procedure followed a logic equivalent to the PRISMA model, ensuring transparency and rigor in the selection of the literature.

Data analysis was performed using thematic content analysis, which enabled the identification, coding, and categorization of the main strategies and technologies related to energy efficiency in buildings. From this process, the main analytical categories were established, such as bioclimatic design, construction materials, energy regulations, active technologies, and passive technologies. These categories facilitated the organization of information and comparison among studies from different geographic and climatic contexts.

The variables or categories of analysis considered in the review were the climate of the study area, the type of building (residential, public, or commercial), the reported or estimated energy consumption, the applied energy efficiency strategies, and the results obtained in terms of consumption reduction or improvement of thermal comfort. These variables allowed for the structuring of the evidence synthesis and the identification of common patterns among the reviewed studies.

The methodological procedure was developed sequentially. First, the research question and objectives of the review were defined. Second, the databases were selected and search strategies were designed using keywords and Boolean operators. Third, inclusion and exclusion criteria were applied to refine the collected information. Fourth, a critical reading and eligibility analysis of the selected studies was conducted. Fifth, the information was organized into analysis matrices based on the defined categories. Finally, a qualitative synthesis of the findings was performed, integrating the results according to the most recurrent strategies and technologies in the reviewed scientific literature.

This methodological approach ensured rigor, traceability, and coherence in the review process, providing a solid foundation for the analysis of energy efficiency in sustainable buildings in Ecuador.

RESULTS

The results of the systematic literature review on energy efficiency in sustainable buildings in Ecuador reveal a convergence of technical, climatic, and regulatory approaches aimed at improving building energy performance. Analysis of the selected studies identified common patterns in the application of bioclimatic strategies, passive and active technologies, and an increasing integration of simulation and energy assessment tools across different building types. Overall, the reviewed literature shows a predominance of studies conducted in Latin American and tropical contexts, with particular emphasis on the Ecuadorian case.

Table 1. Characterization of the reviewed studies

Author and year	Country	Database	Type of study	Type of building	Objective
Asdrubali et al. (2024)	International	Scopus / arXiv	Bibliometric review	General buildings	Analyze 20 years of research in LCA and energy efficiency
Bustamante-Campoverde (2024)	Ecuador	Scopus	Case study	Urban buildings	Evaluate bioclimatic performance in Quito
Cedeño & Zambrano (2023)	Ecuador	ScienceDirect	Simulation	Housing	Analyze passive strategies in housing
Copiello et al. (2024)	Europe	ScienceDirect	Case study and analysis	Commercial buildings	Evaluate business models in energy efficiency
Moreira-Macías et al. (2024)	Ecuador	SciELO	Systematic review	General construction	Synthesize studies on sustainable construction
Villacreses et al. (2023)	Ecuador	Scopus	Simulation	Residential housing	Evaluate energy performance in tropical climate

Table 2. Identified energy efficiency strategies

Author and year	Strategy	Description	Climate	Main result
Cedeño & Zambrano (2023)	Passive design	Cross ventilation, solar orientation	Tropical	Reduction in energy demand
Bustamante-Campoverde (2024)	Bioclimatic	Adaptation to Andean climate	Andean	Improvement in thermal comfort
Espinoza & Pacheco (2022)	Bioclimatic architecture	Reduction of consumption in social housing	Tropical	Decrease in air conditioning use
Vallejo et al. (2024)	Climatic strategies	Shading and natural ventilation	Warm humid	Improvement in energy efficiency
García-Alvarado et al. (2020)	Thermal redesign	Envelope optimization	Warm	Energy demand reduction

Analysis of Table 1 shows a predominance of simulation and review studies, reflecting a methodological trend toward the indirect evaluation of energy performance due to limitations in field measurements. Ecuador is a relevant scenario within the regional literature, especially in studies of housing and urban buildings.

The results in Table 2 indicate that passive and bioclimatic strategies are the central focus of energy efficiency in the Ecuadorian context. These strategies are adapted to specific climatic conditions, demonstrating effectiveness in tropical and warm humid zones, where natural ventilation and solar control are decisive for thermal comfort.

Table 3. Technologies applied in sustainable buildings

Author and year	Technology	System	Application	Impact
Muñoz-Salcedo et al. (2024)	Energy optimization	Active	NZEB buildings	Total consumption reduction
Torres & Loor (2022)	Thermal materials	Passive	Housing	Enhanced insulation
Villacreses et al. (2023)	Energy simulation	Digital tool	Housing	Design optimization
Copiello et al. (2024)	Energy management	Active	Commercial	Operational efficiency improvement
Vallejo et al. (2024)	Natural ventilation	Passive	Public buildings	Thermal load reduction

Table 3 shows a balanced combination of active and passive technologies, although passive technologies predominate in the Ecuadorian context due to their low cost and climatic adaptability. Active technologies, such as energy optimization and intelligent systems, are mainly present in more recent studies focused on high-performance buildings.

Table 4 indicates that the studies agree that combining passive and bioclimatic strategies yields the greatest benefits in reducing energy consumption and improving thermal comfort. However, the levels of reduction vary according to building type and climate, reinforcing the need for contextualized solutions.

Table 4. Comparative synthesis of energy results

Author and year	Building type	Combined strategies	Consumption reduction	Thermal comfort	Conclusion
Bustamante-Campoverde (2024)	Urban building	Bioclimatic + passive design	Moderate	Significant improvement	High efficiency in Quito
Cedeño & Zambrano (2023)	Housing	Passive strategies	High	Improved	Significant energy reduction
Vallejo et al. (2024)	Public building	Shading + ventilation	High	Optimal	Appropriate for warm climates
Villacreses et al. (2023)	Housing	Simulation + design	Variable	Improved	Design optimization
García-Alvarado et al. (2020)	Public	Thermal envelope	Moderate	Improved	Energy demand reduction

Table 5. Distribution of approaches by category

Category	Number of studies	Predominant region	Trend
Bioclimatic design	6	Ecuador / Andes	High relevance
Passive strategies	7	Tropical	Primary focus
Active technologies	4	Global	Growing
Sustainable materials	3	Latin America	Emerging
Energy regulations	2	Regional	Limited application

Analysis of Table 5 shows that bioclimatic design and passive strategies are the most established research lines in the field of building energy efficiency. In contrast, energy regulations and the use of sustainable materials still show limited development in the reviewed literature, suggesting the need to strengthen these areas in future research.

Taken together, the results demonstrate that energy efficiency in sustainable buildings in Ecuador is strongly determined by climatic adaptation and the use of passive design strategies. Nevertheless, there is a progressive transition toward the incorporation of active technologies and energy simulation tools, indicating an evolution toward more comprehensive and energy-optimized building models.

DISCUSSION

This review demonstrates that energy efficiency in sustainable buildings in Ecuador is influenced by a convergence of climatic, technological, regulatory, and architectural design factors. In this regard, the findings are consistent with the global trend identified by Asdrubali et al. (2024), who note that integrating life cycle analysis (LCA) with energy efficiency enables a comprehensive understanding of the environmental impact of buildings, including both operational and embodied energy. This perspective reinforces the need to address sustainability from a holistic approach.

In the Ecuadorian context, the reviewed studies demonstrate that bioclimatic strategies are central to building energy performance. Bustamante-Campoverde (2024) shows that adaptation to the Andean climate in Quito significantly improves thermal comfort and reduces energy demand, which is consistent with the results of this review. Additionally, Espinoza and Pacheco (2022) highlight that in Ecuadorian social housing, bioclimatic strategies reduce the use of artificial climate control, confirming their relevance in contexts of energy vulnerability.

Similarly, passive design is established as a fundamental strategy for reducing energy consumption in residential buildings. Cedeño and Zambrano (2023) indicate that elements such as cross ventilation, solar orientation, and the design of thermally efficient envelopes generate significant improvements in energy performance. These results are consistent with García-Alvarado et al. (2020), who, in warm climates, demonstrate that optimizing the thermal envelope in public buildings considerably reduces energy demand for cooling.

On the other hand, the reviewed literature indicates that Ecuador's climatic conditions are a determining factor in the energy design of buildings. Vallejo et al. (2024) emphasize that in hot and humid areas such as Guayaquil, shading strategies and natural ventilation are essential for improving energy efficiency. Additionally, Delgado et al. (2022) provide a broader environmental perspective by noting that extreme climatic conditions and precipitation variability also influence territorial planning, which indirectly affects the design of sustainable infrastructure.

Regarding construction materials, it is observed that they play a decisive role in the thermal performance of buildings. Torres and Loor (2022) demonstrate that selecting appropriate materials can significantly reduce energy consumption by improving thermal insulation and indoor comfort. This finding aligns with the results of Torres-Quezada et al. (2024), who emphasize the importance of considering both operational energy and embodied energy in materials, particularly in buildings in the Andean region.

From a technological perspective, the results indicate a transition toward the incorporation of simulation and energy optimization tools. Villacreses et al. (2023) highlight that simulation models enable the evaluation of energy performance in tropical climates and facilitate the anticipation of improvements in architectural design. Similarly, Muñoz-Salcedo et al. (2024) propose mathematical optimization models applied to nearly zero-energy buildings, reflecting a global trend toward the digitalization and automation of energy design.

With respect to energy policies and regulations, a significant gap is identified in their effective implementation in Latin America. Gaudry et al. (2019) point out that, although there have been regulatory advances regarding climate change, limitations persist in the application of energy standards in buildings. Additionally, Sánchez and Hidalgo (2023) highlight the need to standardize energy efficiency indicators in public infrastructure, which would enable a more objective evaluation of energy performance in the region.

In the field of energy planning, Ochoa et al. (2021) show that policies and technologies in Latin America still exhibit significant inequalities in their adoption, especially in the residential sector. This finding is consistent with the results of the present review, which observes a greater concentration of studies on passive strategies, while advanced technologies have a lower presence in the Ecuadorian context. This suggests a gap between academic research and practical implementation.

Furthermore, business models and energy management approaches also emerge as relevant factors in building efficiency. Copiello et al. (2024) highlight that innovative business models can accelerate the adoption of sustainable practices in the construction sector. Additionally, Velepucha Sánchez et al. (2024) demonstrate through a techno-economic analysis that implementing energy efficiency measures in university buildings can be economically viable, reinforcing the relationship between sustainability and profitability.

Finally, the review identifies a progressive evolution toward nearly zero-energy buildings and integrated energy efficiency strategies. Pacheco et al. (2024) indicate that the design of NZEB buildings in developing countries requires the integration of passive, active, and regulatory strategies adapted to the local context. This approach is complemented by the findings of Moreira-Macías et al. (2024), who highlight the need to strengthen applied research in Ecuador to bridge the gap between theory and practice in sustainable construction. Overall, the results suggest that energy efficiency in sustainable buildings in Ecuador is advancing toward a more comprehensive model, although significant challenges remain in its implementation and scaling.

CONCLUSIONS

The systematic review determined that energy efficiency in sustainable buildings in Ecuador is mainly influenced by bioclimatic and passive strategies. These strategies constitute the central axis of energy performance in different types of buildings, demonstrating their effectiveness in tropical and Andean climates. Based on the general objective, it is concluded that climate-adapted architectural design is the most significant factor in reducing energy consumption.

It is concluded that construction materials play a significant role in the energy efficiency of buildings, as they directly influence thermal comfort and air conditioning demand. The analyzed studies show that the appropriate selection of materials contributes to improving overall energy performance, especially in homes and public buildings located in areas with high temperature and humidity.

Likewise, it is identified that active technologies and energy simulation tools are growing, although their application remains limited in the Ecuadorian context. These technologies enable the optimization of building design and operation, facilitating the transition toward nearly zero-energy consumption models. However, their implementation is still constrained by economic and technical factors.

With respect to the regulatory framework, it is concluded that there is a gap in the effective application of energy efficiency policies in buildings in Latin America and Ecuador. Although there have been regulatory advances, their implementation remains incipient, which limits the standardization of sustainable practices. There is a need to strengthen indicators and regulations adapted to the local climatic context.

In conclusion, energy efficiency in sustainable buildings in Ecuador is advancing toward a comprehensive approach that integrates bioclimatic design, efficient materials, and emerging technologies. However, challenges persist in the coordination among research, regulations, and practical implementation. Greater integration among academia, the public sector, and the private sector is necessary to achieve truly sustainable buildings.

REFERENCES

1. Asdrubali, F., Fronzetti Colladon, A., Segneri, L., & Gandola, D. M. (2024). LCA and energy efficiency in buildings: Mapping more than twenty years of research. https://arxiv.org/abs/2409.00065
2. Bustamante-Campoverde, A. (2024). Bioclimatic and energy performance by eco-efficiency in buildings of the Metropolitan District of Quito, Ecuador. Future Cities and Environment, 10(1). https://doi.org/10.5334/fce.263
3. Cedeño, D., & Zambrano, L. (2023). Evaluation of passive design strategies in Ecuadorian housing projects. Journal of Building Engineering, 66, 105987. https://doi.org/10.1016/j.jobe.2023.105987
4. Copiello, S., Donati, E., & Bonifaci, P. (2024). Energy efficiency practices: A case study analysis of innovative business models in buildings. Energy and Buildings, 114223. https://doi.org/10.1016/j.enbuild.2024.114223
5. Delgado, D., Sadaoui, M., & Ludwig, W. (2022). Spatio-temporal assessment of rainfall erosivity in Ecuador based on GPM-IMERG precipitation data. Catena. https://doi.org/10.1016/j.catena.2022.106597
6. Espinoza, J., & Pacheco, J. (2022). Bioclimatic strategies for reducing energy consumption in social housing in Ecuador. Revista de Arquitectura (Bogotá), 24(2), 45–58. https://doi.org/10.14718/RevArq.2022.24.2.3124
7. Gaudry, K. H., Godoy-Vaca, L., Espinoza, V. S., & Fernández, G. (2019). Normativas de energía en edificaciones ante el cambio climático. ACI Avances en Ciencias e Ingenierías, 11(2). https://doi.org/10.18272/aci.v11i2.1285
8. García-Alvarado, R., Soto, C., & Solar, A. (2020). Thermal performance and energy demand reduction in public buildings in warm climates. Renewable Energy, 160, 1338–1349. https://doi.org/10.1016/j.renene.2020.06.143
9. Moreira-Macías, E., Cobeña-Loor, W., & Ríos-Mera, N. (2024). Sustainable construction and energy efficiency in Ecuador: A systematic review. Revista Arquitectura +, 10(19), 1–18. https://doi.org/10.5377/arquitectura.v10i19.20561
10. Muñoz-Salcedo, M., Ruiz de Adana, M., & Peci-López, F. (2024). Mixed-integer disciplined convex programming approach applied to the optimal energy supply of near-zero energy buildings. Heliyon, 10(17), e36873. https://doi.org/10.1016/j.heliyon.2024.e36873
11. Ochoa, C., Correa, M., & Hernández, P. (2021). Energy efficiency in Latin American residential buildings: A review of policies and technologies. Sustainable Cities and Society, 74, 103178. https://doi.org/10.1016/j.scs.2021.103178
12. Pacheco, A., León, M., & Torres, F. (2024). Net zero energy building design strategies for developing countries. Energy Policy, 185, 113892. https://doi.org/10.1016/j.enpol.2024.113892
13. Sánchez, F., & Hidalgo, R. (2023). Energy efficiency indicators in public infrastructure in Latin America. Journal of Cleaner Production, 389, 135987. https://doi.org/10.1016/j.jclepro.2023.135987
14. Torres-Quezada, J., Isalgue-Buxeda, A., Pages-Ramon, A., & Lopez-Besora, J. (2024). Operational and embodied energy of residential buildings in the Andean region between 1980 and 2020. Energy and Buildings, 325, 114982. https://doi.org/10.1016/j.enbuild.2024.114982
15. Torres, M., & Loor, J. (2022). Impact of building materials on thermal comfort and energy consumption in tropical climates. Materials Today: Proceedings, 49, 2100–2107. https://doi.org/10.1016/j.matpr.2021.08.178
16. Vallejo, C., Godoy, L., Vásquez, F., Villacreses, G., Orozco, M., & Navarro, S. (2024). Strategies for enhancing energy efficiency in public service buildings within a hot and humid climatic zone: Case study in Guayaquil, Ecuador. Revista Técnica Energía, 21(1), 133–142. https://doi.org/10.37116/revistaenergia.v21.n1.2024.651
17. Velepucha Sánchez, J. M., Panchana, R., Arteaga Linzan, Á. R., Zevallos Cobeña, J. G., & Delgado, D. (2024). Techno-economic assessment of energy efficiency in a building at the Technical University of Manabí. In Green Energy and Technology: Towards Low and Positive Energy Buildings. https://doi.org/10.1007/978-3-031-70851-0_3
18. Villacreses, G., Martínez-Gordón, R., Gutiérrez, S. M., & Toledo, E. (2023). Energy performance assessment of residential buildings in tropical climates using simulation tools. Energy and Buildings, 279, 112685. https://doi.org/10.1016/j.enbuild.2023.112685

FUNDING

None.

CONFLICT OF INTEREST

None.

AUTHORSHIP CONTRIBUTIONS

Drafting – original draft: Yolanda Lorena Paredes Andrade.
Writing–review and editing: Yolanda Lorena Paredes Andrade.