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EVALUATION OF THE EDGE CERTIFICATION IN THE OPERATIONAL EFFICIENCY OF MULTIFAMILY BUILDINGS

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EVALUACIÓN DE LA CERTIFICACIÓN EDGE EN LA EFICIENCIA OPERATIVA DE EDIFICIOS MULTIFAMILIARES

AVALIAÇÃO DA CERTIFICAÇÃO EDGE NA EFICIÊNCIA OPERACIONAL DE EDIFÍCIOS MULTIFAMILIARES

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ABSTRACT

In the context of increasing urbanization and resource pressures, the EDGE certification is presented as a key strategy for promoting sustainable buildings in developing countries. This study evaluated the real impact of EDGE on the operational efficiency of multifamily buildings in Lima, focusing on water and energy consumption. Using a mixed approach, post-occupancy data from three buildings were analyzed: two certified (one new and one with 24 months of operation) and one uncertified. The newer EDGE building exceeded its projected energy savings (28% vs. 25%), while the older one achieved only 10.64%, indicating a performance gap. In contrast, water consumption increased by 14.89% in the older EDGE building, due to the removal of efficient devices and a lack of monitoring. These findings highlight the need for educational strategies, technical maintenance, and post-occupancy evaluation to optimize the impact of certification.

Keywords
EDGE, multifamily building, operating cost, operational sustainability

RESUMEN

En un contexto de creciente urbanización y presión sobre los recursos, la certificación EDGE se presenta como una estrategia clave para fomentar edificaciones sostenibles en países en desarrollo. Este estudio evaluó el impacto real de EDGE en la eficiencia operativa de edificios multifamiliares en Lima, Perú, enfocándose en el consumo de agua y energía. Mediante un enfoque mixto, se analizaron datos post-ocupacionales de tres edificios: dos certificados (uno nuevo y otro con 24 meses de operación) y uno sin certificación. El edificio EDGE más reciente superó su proyección de ahorro energético (28% frente a 25%), mientras que el más antiguo solo alcanzó un 10,64%, lo que evidenció la brecha de desempeño. En contraste, el consumo hídrico aumentó un 14,89 % en el edificio EDGE antiguo, debido a la remoción de dispositivos eficientes y a la falta de monitoreo. Estos hallazgos resaltan la necesidad de estrategias educativas, mantenimiento técnico y evaluación post-ocupacional para optimizar el impacto de la certificación.

Palabras clave
EDGE, edificación multifamiliar, costo operativo, sostenibilidad operativa

RESUMO

Em um contexto de crescente urbanização e pressão sobre os recursos, a certificação EDGE surge como uma estratégia fundamental para promover edifícios sustentáveis em países em desenvolvimento. Este estudo avaliou o impacto real da EDGE na eficiência operacional de edifícios multifamiliares em Lima, Peru, com foco no consumo de água e de energia. Por meio de uma abordagem mista, foram analisados dados pós-ocupacionais de três edifícios: dois certificados (um novo e outro com 24 meses de operação) e um sem certificação. O edifício EDGE mais recente superou sua projeção de economia de energia (28% contra 25%), enquanto o mais antigo atingiu apenas 10,64%, o que evidenciou a diferença de desempenho. Em contrapartida, o consumo de água aumentou 14,89% no edifício EDGE mais antigo, devido à remoção de dispositivos eficientes e à falta de monitoramento. Essas descobertas destacam a necessidade de estratégias educacionais, de manutenção técnica e de avaliação pós-ocupacional para otimizar o impacto da certificação.

Palavras-chave
EDGE, edifício multifamiliar, custo operacional, sustentabilidade operacional

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INTRODUCTION

In recent years, the accelerated urbanization and the growing demand for housing have driven the expansion of multifamily buildings as a solution to urban densification. This dynamic is especially evident in Lima, a metropolis characterized by high population density, pressure on urban land, and increasing verticalization in downtown districts, as well as greater residential consolidation, with the availability of land becoming increasingly limited. This multifamily model has become the predominant response to the need for housing. However, it substantially increases the consumption of critical resources such as energy, water, and sanitation systems due to the high density of users and the simultaneous use of infrastructure (Aini & Tarigan, 2023).

The EDGE (Excellence in Design for Greater Efficiencies) certification, promoted by the International Finance Corporation [IFC] since 2014, has established itself as an international reference for promoting sustainable buildings in developing countries, which requires at least a 20% reduction in water, energy, and carbon embedded in materials compared to traditional methods (IFC, 2025).

EDGE evaluates three pillars (energy, water, and materials) through a credit structure that requires relative reductions compared to reference projects. This study considered said structure, summarized in Table 1, which includes criteria such as efficient insulation and lighting, low-consumption toilets and faucets, and materials with a lower carbon footprint. This is consistent with what was stated by Ibrahim et al. (2023), who highlight the integration of functional design required by sustainability.

Experiences in Indonesia, Egypt, and Mexico report significant reductions in energy and water consumption using EDGE simulations (Velázquez-Robles et al., 2022; Alsabry et al., 2024). However, in Latin America, 24% of the certified projects in Colombia do not meet energy-saving goals, and 12% do not meet water targets (Rodríguez et al., 2021), which evidences a performance gap between what has been projected and what has been executed. In Peru, the adoption of EDGE has been growing since 2016, in line with SDG 11, although empirical validation of its impact remains limited (Isimbi & Park, 2022). The literature indicates that the reports are based on simulations, without contrasting them with post-occupational data under real conditions (Reyes et al., 2022). This questions the effectiveness of technologies when they are not accompanied by user education or continuous monitoring (Cabeza et al., 2018). Similarly, Mannan & Safiri (2025) showed that even certified buildings depend on operational configuration, reinforcing the persistence of the performance. Filippini & Obrist (2022) point out that these homes do not necessarily have lower energy consumption, thus highlighting the influence of user behavior.

In this context, Agyekum et al. (2021) highlight that the post-occupancy assessment is decisive for understanding the actual performance. Condezo Solano et al. (2024) examine the operational behavior of EDGE buildings, while Mach et al. (2025) show that efficient buildings can exhibit notable deviations between actual and projected performance associated with everyday use. Marques et al. (2024) indicate that the perceived value does not always align with operational performance. In the same way, Marzouk (2023) identifies that the theoretical achievements of EDGE can be conditioned by use and maintenance practices, reinforcing the need for systematic post-occupancy assessments.

This work, like the current research, highlights the need to contrast certification goals with actual consumption. However, it differs in its methodological approach: it focuses on aggregate-level analysis at the case level, whereas this study uses a direct comparison between certified and non-certified buildings within the same urban context.

In order to analyze this situation, the research focused on three multifamily buildings located in the same residential sector of Lima Top, an area characterized by high urban consolidation and predominance of vertical projects: building A, newly built and EDGE certified; building B, with two years of operation under certification; and building C, without certification, with more than five years of use. The selection of cases was conducted using non-probabilistic convenience sampling; eight apartments, comparable in surface area, construction standards, and number of residents, were considered.

The information collection used a mixed approach, combining quantitative and qualitative methods. Utility bills, meter records, and financial statements were reviewed; semi-structured interviews were conducted with owners, complemented with direct observation, photographs, and plans. In the same way, tools such as Excel, Google Forms, AutoCAD, and EDGE software facilitated data systematization, thereby providing a comprehensive vision that combined user perception with technical evidence.

The results indicated that EDGE-certified buildings achieved a significant reduction in water consumption through double-flush toilets, efficient faucets, and optimized hydraulic design. However, energy consumption exceeded the projected level, mainly due to poorly configured or underutilized home automation systems. This finding is consistent with the results reported by Condezo-Solano et al. (2024) and with research in Colombia and Mexico, which document inconsistencies between initial simulation and actual operational performance.

Another relevant aspect was residents' behavior, which affected consumption through prolonged showers, improper faucet use, and limited knowledge of the equipment. The interviews showed a lack of awareness and post-occupancy accompaniment. Consistent with Gil-Ozoudeh et al. (2024), the study shows that certification performance depends on technology, satisfaction, and habits, confirming the performance gap and the need for educational processes to optimize results.

Thus, the EDGE certification is a valuable tool for improving efficiency in multifamily buildings, especially in water conservation; however, its effectiveness depends on technical and behavioral factors. The study provides three main contributions: empirical evidence of Edge's actual performance in Peru, analysis of the variables that affect its results, and a proposal to integrate mandatory post-occupancy assessments into sustainable certifications. In this way, research reinforces the academic debate and provides practical inputs for more efficient and responsible urban project management.

METHODOLOGY

This study adopted a mixed-methods approach to objectively evaluate the impact of EDGE certification and analyze residents' perceptions of operating costs associated with water, energy, and maintenance consumption in multifamily buildings. The purpose was to identify relationships between certified sanitary technologies and the results in indicators of water consumption and monthly expenditure.

The scope was descriptive-correlational, analyzing the relationship between the independent (EDGE certification) and the dependent variables (operating costs and water consumption). Certified and non-certified buildings were compared to establish quantitative impact patterns. The population included three buildings in Surco: A (2023-2024, EDGE-certified), B (2022-2023, EDGE-certified), and C (over 10 years old, without certification). The cases were selected based on comparability criteria in multifamily typology, built area per apartment, and approximate value per square meter, as well as accessibility to information and authorization from owners. The sample was non-probabilistic for convenience and included eight apartments with diverse characteristics.

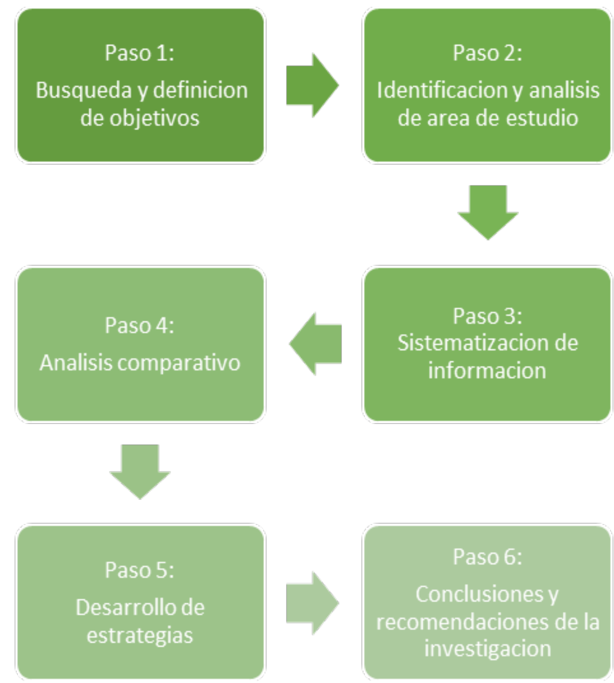

Figure 1. Methodological process diagram. Source: Prepared by the authors.

Tools such as Excel, Google Forms, AutoCAD, and EDGE were used. An interview guide was developed to contextualize the quantitative data and explore usage patterns and barriers in consumption, applied to owners of buildings A and B. The water and energy consumption data were obtained directly from the provider companies' bills, which guaranteed their reliability. The interviews allowed identifying variations in use, such as longer stays in Building B or modifications to saving devices, thereby determining consumption differences.

Fieldwork was carried out in the three buildings by direct observation of facilities, taking photographs, and comparing the plans. In the case of Building A, two months were recorded with atypically low consumption due to the temporary vacancy of units, and these were adjusted by replacing the monthly averages with the series median to avoid distortions. In Building B, the monthly variations were driven by minimal differences in the number of occupants, greater daily permanence, and the removal of aerators, which significantly increased the consumption flow. Also, secondary sources were reviewed, including plans, previous studies, and technical documents related to EDGE certification in multifamily buildings.

FIRST STAGE

Theoretical background information, previous studies, and technical documentation on EDGE in multifamily buildings were reviewed. The search allowed identifying gaps in water consumption, energy use, and operating

Table 1. EDGE certification credit structure. Source: Prepared by the authors.

CATEGORY	MAIN CRITERIA	PARAMETERS EVALUATED
ENERGY	Reduction of energy consumption in operation	- Insulation and thermal efficiency of walls and ceilings - Glazing and shading - Efficient lighting - Air conditioning and ventilation systems - Low consumption of elevators and household appliances.
WATER	Optimization of drinking consumption	- Low consumption toilets - Efficient showers and taps - Low consumption washing machines - Reuse of gray water - Rainwater harvesting
MATERIAL	Reduction of embedded carbon in building materials	- Walls, ceilings, and floors with a low carbon footprint - Sustainable finishes and carpentry - Use of recycled or recyclable materials - Industrialized construction systems

costs. Based on this, general and specific objectives were formulated, such as comparing the relationship between EDGE certification and the reduction of operating costs associated with water and energy consumption in Lima. In contrast, the specific objectives delimited measurable variables that guided the research process (Table 1).

SECOND STAGE

The analysis of buildings A and B, built by the same real estate company, and of building C, built by another construction company but located in the same urban environment, allowed evaluation of the benefits of the EDGE certification, with an emphasis on sanitary fittings. It focused on residents whose apartments had certified original sanitary appliances, and it also considered the diversity of household members to compare consumption and habits.

THIRD STAGE

The water and energy savings projected by the certification were verified. The actual consumption in both buildings A and B reflected the data obtained. To compensate for differences across apartments, a formula was applied to standardize amounts and facilitate comparison of water and electricity bills (Equation 1 and Equation 2).

$$\left(\frac{8}{18}\right) x \text{ Building A Amount}$$

$$\left(\frac{8}{14}\right) x \text{ Building B Amount} \qquad \text{(Equation 1)}$$

$$\left(\frac{\text{Cost of C-Adjusted Cost of A}}{\text{Cost of C}}\right) x\, 100 \qquad \text{(Equation 2)}$$

FOURTH STAGE

The comparative case approach analyzes the actual performance of multifamily buildings with and without EDGE certification in similar urban conditions. This methodology addressed the need to empirically validate EDGE's projected benefits in energy and water efficiency, thereby overcoming limitations of simulation-based studies (Reyes et al., 2022; EDGE, 2021). Several authors have noted a gap between estimated savings and actual building behavior during operation (Rodríguez et al., 2021; Whitehead et al., 2014). Therefore, a direct comparison of water and electricity consumption enabled the identification of efficiency indicators and the understanding of the impact of applied technologies, while also considering the user's role in achieving sustainable goals (Isimbi & Park, 2022; Defilippi-Shinzato et al., 2024). This approach provides quantitative and qualitative evidence to evaluate the effectiveness of certification in Latin American contexts.

FIFTH STAGE

The strategies included selecting controlled cases to understand variations in operational performance, conducting post-occupational data collection, evaluating sanitary technologies to identify the use and maintenance of efficient devices, applying structured surveys, and calculating efficiency indicators using relative formulas. All this facilitated comparison between buildings and helped identify gaps that highlight the performance gap.

SIXTH STAGE

Finally, the discussion was based on the systematized results. The analysis showed that although the EDGE certification encourages a reduction in water consumption through efficient technologies, its

Table 2. Comparative Table of EDGE Certification. Source: Prepared by the authors.

Criterion	Building A	Building B
N° Apartments	18	14
Certification Date	Certified in 2024	05/12/2022
Certifying Entity	GBCI (Green Business Certification Inc.)	GBCI (Green Business Certification Inc.)
Projected Energy Savings	24.95%	24%
Projected Water Savings	39.03%	34%
Reduction in materials (embedded carbon)	61.00%	62%
CO_2 avoided (tCO_2/year)	34.93	45.76
EDGE software used	EDGE v3.0.0	EDGE v3.0.0
Energy measures	- Efficient glazing - Reflective roofs - Submeters - Lighting control	- Reduced window-to-wall ratio - Insulated roof
Sanitary measures	- 6.79 L/min shower- Dual flush toilets- Efficient washing machines	- Efficient shower, taps, and toilets
Observations	Certificate for multiple typologies	Certificate for 14 units

effectiveness depends largely on user behavior and device maintenance. In some cases, the elimination of aerators or intensive use of the spaces counteracted the expected benefits. The information collected also identified the need to include user education processes and post-occupancy monitoring in the implementation of sustainable certifications.

RESULTS

Three multifamily buildings in Lima were analyzed: building "A" (new with EDGE certification), building "B" (with EDGE certification and 24 months old), and building "C" (without certification, more than 24 months old). Buildings A and B, both from the same property developer, allowed the authors to evaluate the impact of the certification on energy consumption, water use, and operating costs in the post-occupancy stage.

Building C was included as a contrasting reference, presenting a real baseline of conventional practices in Lima's multifamily buildings. With 16 apartments of similar dimensions to those of buildings A and B, the design conforms to traditional standards and includes basic sanitary and electrical systems. Despite its age, it maintains adequate operating conditions, though without technological innovations to improve water or energy efficiency. This case allowed measuring the gap between EDGE projections and actual consumption in homogeneous urban environments.

In the EDGE certification comparative table (Table 2), Building B has 14 apartments and has been in operation for 2 years, while Building A, with 18 units, is about to

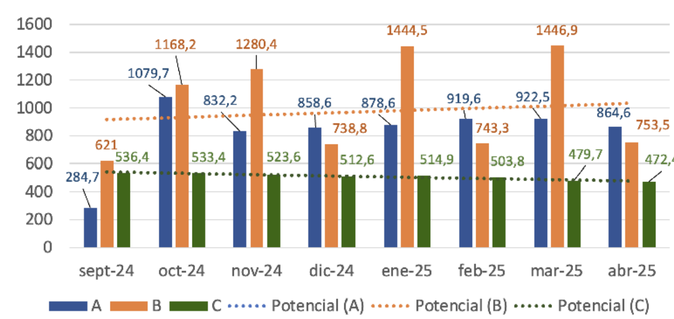

Figure 2. Electricity consumption in buildings A, B, and C from September 2024 to April 2025. Source: Prepared by the authors.

complete its first year. Both have EDGE certification, with projected energy, water, and materials savings of 24.95%, 39.03%, and 61.00%, respectively. Building C, uncertified, reinforced the methodological contrast by allowing the verification of operational differences compared to conventional buildings.

Figure 2 shows the electricity consumption costs collected in Southern Electricity bills for eight months (November 2024-April 2025). In building A, the trend remained stable; in B, it decreased by 8.5%; and in C, it decreased by 1.6%. These results show differential energy-efficiency behavior, with Building B standing out with the most significant percentage reduction.

Regarding water consumption (Figure 3), between September 2024 and April 2025, building A registered a 25.5% increase, peaking in March (27.2%); B grew 10% until January, then decreased by 8.5% in April;

while C showed a 1.6% decrease. These results reflect variable behaviors and suggest that users' consumption habits influence the effectiveness of the implemented technologies.

INTERVIEWS

Sixteen surveys were applied in buildings A and B. Nine owners were unaware that their property had EDGE certification, so this factor did not influence their purchase decision. According to Table 3, only one owner expressed dissatisfaction, while 11% of residents admitted to not checking their water bills. These findings show low user awareness of the added value of certification.

According to the EDGE certification, both buildings were certified for energy, water, and materials. However, actual consumption differed. According to Figure 2 and Table 3, building A maintained a stable energy consumption, while building B recorded a smaller reduction, with only 12.5% of residents reporting energy savings. For water, Figure 3 shows better performance for building A than for building B, with a 10% increase, consistent with the 68.8% of users who do not monitor their consumption. In CO_2 emissions, building B reported 45.76 tons per year, compared to 34.93 tons per year for A, confirming the latter's better environmental performance.

The data in Table 4 indicate that building A registered an average monthly cost per apartment of S/490.50, higher than expected for a certified project, which could be explained by higher administration expenses or differences in their distribution. In this case, the average water and electricity consumption was S/701.02. Building B, also certified, presented the highest average cost, at S/597.24 per dwelling, along with water and electricity consumption of S/170.94, positioning itself as the least efficient operationally. In contrast, building C,

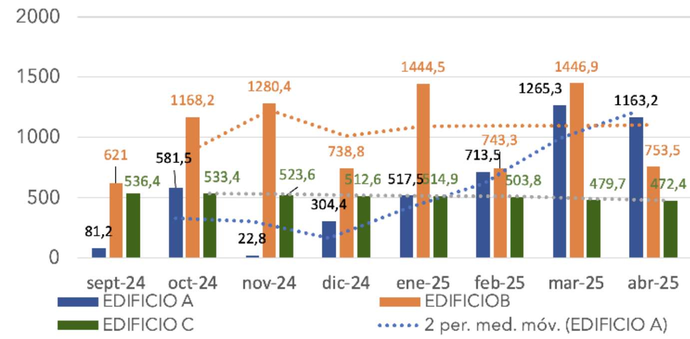

Figure 3. Water consumption in buildings A, B, and C from September 2024 to April 2025. Source: Prepared by the authors.

Table 3: Results of resident surveys of EDGE buildings. Source: Prepared by the authors.

INDICATOR	OPTION	NUMBER	%
Knowledge about the EDGE certification	Yes	7	43.8
	No	9	56.3
Perception of the benefits of EDGE	Water savings	5	31.3
	Higher property value	4	25.0
	Energy savings	2	12.5
	Does not know	5	31.3
Satisfaction with sanitary functioning.	Not satisfied	1	6.3
	Satisfied with no remarks	15	93.8
Monitoring of water consumption	Never	11	68.8
	Rarely	2	12.5
	Usually/almost always	3	18.7

Table 4: Comparative Table of Operating Costs - May 2025. Source: Prepared by the authors

CATEGORY	Building A (EDGE)	Building B (EDGE)	Building C (without EDGE)
Total number of apartments	18	14	8
Total monthly expenditure (S/)	8829.03	8361.41	3011.55
Monthly average per apartment (S/)	490.50	597.24	376.44
Monthly expenditure (8 comparable apartments)	3924.01	4777.95	3011.55
Average per apartment (8) (S/)	490.50	597.24	376.44
Average water consumption (S/)	332.10	597.24	291.20
Average electricity consumption (S/)	368.92	585.47	509.60
Other expenses	Included	Common + provisional expenses	Detailed

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Table 5. Electricity costs. Source: Prepared by the authors.

Building	kWh/month adjusted	Adjusted cost (S/.)	% of EDGE certification	Smart appliances	LED Lighting	Observations
A (EDGE)	531.66	2951.33	25	Yes	Yes	Intensive use of smart devices
B (EDGE)	461.26	3642.26	24	Partial	Yes	Partial use
C (without EDGE)	317.6	4076.80	0	No	No	Little use

without certification, had the lowest cost at S/376.44, with average water and electricity consumption of S/800.80, indicating greater economic efficiency, although it lacked support for sustainability criteria.

DISCUSSION

To compare results, equation (1) was used to calculate the actual percentage of savings that building C considers as a base, since it does not have EDGE certification. In this way, the performance of buildings A and B, both certified, was evaluated against that of the conventional building.

ANALYSIS OF ELECTRICITY:

The results obtained by equation (1) show discrepancies between projected and actual savings in EDGE buildings. In the case of electricity consumption (Table 5), building A exceeded its certified goal (28% real savings compared to the projected 25%), while B barely achieved 10.64%, confirming a performance gap (Whitehead et al., 2014). This phenomenon was mainly explained by two factors: partial implementation of intelligent systems in B, which reduced its efficiency potential (Cabeza et al., 2028), and modification of the lighting system by users, which increased consumption, reinforcing the hypothesis of Aini and Tarigan (2023) on the influence of the human factor.

ANALYSIS OF WATER CONSUMPTION:

In the case of water (Table 6), a more pronounced pattern was identified: building A exceeded the goal (49% vs. 39%), while building B showed an overconsumption of 14.89%. This finding is consistent with that of Rodriguez et al. (2021), who reported that 12% of EDGE projects in Colombia failed to meet savings goals. A critical aspect was residents' removal of aerators from faucets, which nullified the benefits of efficient technologies and underscored the importance of permanent educational programs (Isimbi & Park, 2022).

Table 6. Water costs. Source: Prepared by the authors.

APT	Building	m3/ month	Cost (S/.)	% of EDGE certification
Apt. A1	A (EDGE)	90.22	2066.40	39
Apt. B2	B (EDGE)	109.21	4683.77	34
Apt. C3	C (without EDGE)	102.3	4076.80	0

The comprehensive analysis (Table 7) showed that building A increased its maintenance expenses by 26.44% compared to the uncertified building (C), while building B increased them by 53.95%. EDGE does not set goals in this area, as it lacks certified references. Building C, although it registered a lower absolute cost, does not include sanitary provisions or equipment replacement, which explains its low proportion in the total expenditure. These differences were associated with residents' higher daily stay in B (Table 3), a variable usually excluded from projections (EDGE, 2021). Failures in operational management were also identified, such as hiring cheaper suppliers, which led to the breakdown of water pumps. These facts support the need for stricter post-occupancy verification protocols (Defilippi-Shinzato et al., 2024).

Although the EDGE certification showed potential in energy and water optimization, its effectiveness depends on three key dimensions: (1) comprehensive implementation of efficient technologies, (2) management of occupant behavior through continuous education, and (3) regulatory frameworks that require periodic post-occupancy evaluations. These results constitute relevant empirical evidence to strengthen the implementation of sustainable certifications and urban policies aligned with SDG 11 in Latin American contexts.

Table 7. Comparative summary of estimated EDGE savings vs. without certification. Source: Prepared by the authors

Building	Average monthly maintenance (S/.)	% representing the total cost of services	Includes sanitary maintenance	Observations
A (EDGE)	S/3,924.01	44%	Yes	This was adjusted to the value of 8 apartments
B (EDGE)	S/ 4,777.95	57%	Partial	
C (without EDGE)	S/ 3,011.55	100%	No	Total apartments

Table 8. Comparison between buildings. Source: Prepared by the authors.

Item	Certified Savings Building A (%)	Certified Savings Building B (%)	Savings A vs C (%)	Savings B vs C (%)
Water (S/.)	39	34	49	-14.89
Electricity	25	24	28	10.64
Maintenance	Does not specify	Does not specify	-26.44	-53.95

CONCLUSIONS

The results showed that the EDGE certification demonstrated differentiated effectiveness across application scopes. In Building A, favorable performance was verified by exceeding its certified goal by three percentage points (28% vs. 25% in energy savings) and achieving 49% water savings compared to the conventional building, which also exceeded the projected goal of 39%. These results confirmed the potential of certification to optimize water-energy performance.

However, the most critical finding was Building B, which, after two years of occupation, recorded a water consumption 14.89% higher than that of the conventional building with more than ten years of use. This result reflected an important vulnerability of the certification, since the overconsumption could not be attributed solely to residents' lack of awareness, but also to structural factors related to the implementation (removal of aerators) and the operation of the EDGE measures.

The comparison with Building C was particularly relevant, as its conventional nature offered an empirical reference point to validate the impact of EDGE certification on A and B. This contrast allowed demonstrating that the savings observed in building A were not circumstantial, but attributable to the measures implemented, and that the deficiencies of B did not represent the average of the Lima real estate park. In this sense, the inclusion of Building C reinforced the study's methodological soundness. It ensured that the results obtained had greater external validity, becoming a key reference for future comparative research on water and energy efficiency in multifamily housing.

In conclusion, the effectiveness of EDGE depended on three technical conditions: (1) Comprehensive implementation of the projected systems, (2) Operation according to the design, and (3) Automated monitoring with real-time feedback. Only under these conditions was it possible to sustain long-term savings, thereby consolidating EDGE as a valuable instrument for urban sustainability.

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