International Journal of Hydrological and Environmental for Sustainability
Volume 5, Issue 3, 214-224.
e_ISSN: 2828-5050
https://www.journal.foundae.com/index.php/ijhes

Assessment of Energy Efficiency and Conservation at the UNTAG Surabaya Rectorate Building Using EDGE and GREENSHIP

Kresna Gemilang
Sebelas Maret University, INDONESIA

Endah Safitri*
Sebelas Meret university, INDONESIA

Sholihin As'ad
Sebelas Maret University, INDONESIA

***Correspondence: E-mail:** endahsafitri@staff.uns.ac.id

Article Info

Article history:

Received: April 14, 2026
Revised: June 18, 2026
Accepted: July 30, 2026

Copyright : © 2026 Foundae (Foundation of Advanced Education). Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution - ShareAlike 4.0 International License (CC BY SA) license (https://creativecommons.org/licenses/by-sa/4.0/).

Abstract

The building subsector is the largest contributor to greenhouse gas emissions in Indonesia's energy sector, with approximately 90% of its emissions stemming from electricity consumption. The implementation of green building concepts is one of the efforts to improve energy efficiency and reduce these emissions. This study aims to evaluate the energy efficiency and conservation (EEC) score in the GREENSHIP rating system and compare it with energy savings estimates using the excellence in design for greater efficiencies (EDGE) Building App at the Rectorate Building of the University of 17 August 1945 in Surabaya. The study employed a quantitative descriptive method based on electricity consumption data and observations of electricity usage for the GREENSHIP evaluation, as well as calculations of the Window-to-Wall Ratio (WWR) and building characteristics for energy performance simulations using the EDGE Building App. The results show that the GREENSHIP EEC score reached only 7 out of a total of 36 points, while the EDGE simulation indicated a potential energy savings of 26.37%. These results indicate that EDGE focuses on the percentage of energy savings compared to a baseline building, whereas GREENSHIP evaluates the implementation of energy management, efficiency, and conservation strategies more comprehensively. Therefore, a high level of energy savings does not necessarily result in a high GREENSHIP score without the comprehensive application of energy efficiency criteria.

Keywords: green building, building energy performance, energy efficiency, energy conservation, greenship and edge assessment

To cite this article: Gemilang, K., Safitri, E. and As'ad, S. (2026). Assessment of Energy Efficiency and Conservation at the UNTAG Surabaya Rectorate Building Using EDGE and GREENSHIP. *International Journal of Hydrological and Environmental for Sustainability, 5*(3), 214-224. https://doi.org/10.58524/ijhes.v5i3.1410

INTRODUCTION

Global warming is the phenomenon of rising average surface temperatures on Earth due to the accumulation of greenhouse gases primarily carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) which intensify the greenhouse effect, causing heat to be trapped in the Earth's atmosphere. The increase in the concentration of these gases is largely driven by human activities, such as the use of fossil fuels, industrial processes, and changes in land use (Bilgili et al., 2024).

According to the Intergovernmental Panel on Climate Change (IPCC, 2023), the global surface temperature during 2011–2020 was approximately 1.1°C higher than during the pre-industrial period of 1850–1900 (Report, 2023). One of the factors contributing to rising global temperatures is increased construction activity. Development activities, accompanied by increased energy use in buildings and a reduction in land designated as green spaces, contribute to global warming (Alsulaili et al., 2020). The construction industry accounts for approximately 19% of global greenhouse gas emissions through energy use, material production, transportation, and construction activities (Labaran et al., 2021).

In Indonesia, the Building Construction subsector is the largest contributor to greenhouse gas emissions among all energy sectors, accounting for an average of 33% from 2011 to 2021. As much as 90% of greenhouse gas emissions from the building sector stem from electricity use. This can only be prevented if global emission levels are reduced to the lowest possible levels (Lintas et al., 2025).

The implementation of green building concepts is becoming increasingly important in Indonesia as energy consumption in the building sector rises. The growth in the construction of office, commercial, educational, and residential buildings has led to a continuous increase in electricity demand, particularly for air conditioning systems, lighting, and electrical equipment. In tropical regions like Indonesia, air conditioning systems account for the largest share of energy consumption in buildings; therefore, improving energy efficiency in this sector holds significant potential for reducing electricity usage and operational costs (Ramadhan et al., 2025).

In addition to increasing energy consumption, electricity use in buildings also contributes to greenhouse gas emissions because most power plants in Indonesia are still dominated by fossil fuels, particularly coal. Therefore, efforts to reduce energy consumption through the application of green building principles not only provide economic benefits but also support the achievement of national emission reduction targets (Farizal et al., 2024). Indonesia has committed to reducing greenhouse gas emissions through its Enhanced Nationally Determined Contribution (Enhanced NDC) document, with a target of reducing emissions by 31.89% through its own efforts and by up to 43.20% with international support by 2030 compared to a business-as-usual (BAU) scenario (INDC, 2022). The energy sector is one of the priority sectors for achieving these targets. Therefore, the implementation of green buildings through improved energy efficiency is a key strategy in supporting the transition toward low-carbon development in Indonesia.

In Indonesia, there are several green building certification systems used to evaluate a building's sustainability performance, including EDGE (Excellence in Design for Greater Efficiencies) and GREENSHIP. Although both aim to promote sustainable development, their assessment approaches differ fundamentally. EDGE, developed by the International Finance Corporation (IFC), is a performance-based tool that measures resource savings through three key indicators: energy savings, water savings, and reduced embodied energy in materials. A building is deemed to meet the EDGE standard if it achieves a minimum 20% reduction in all three aspects compared to a baseline building (International Finance Corporation, 2026). Unlike EDGE, GREENSHIP developed by the Green Building Council Indonesia (GBCI) uses a point-based rating system. The assessment is conducted more comprehensively across six main categories: Appropriate Site Development, Energy Efficiency and Conservation, Water Conservation, Material Resources and Cycle, Indoor Health and Comfort, and Building Environment Management. Each category consists of prerequisites and credits that must be demonstrated through documentation and on-site verification, which are then accumulated to determine a certification rating of Bronze, Silver, Gold, or Platinum. In assessing energy efficiency and conservation, EDGE focuses on the end result the amount of energy saved while GREENSHIP evaluates the efforts and strategies implemented to achieve energy efficiency.

Several studies have used the EDGE Building App to evaluate the energy efficiency of educational buildings in Indonesia. Evaluating the i-CELL building using EDGE to assess energy, water, and material savings as a basis for achieving the green building certification (Rahmasari et al., 2024). Evaluating an existing building at the University of Palangka Raya using EDGE and Climate Consultant to identify potential improvements in energy efficiency (Harysakti et al., 2025). Meanwhile, a systematic literature review indicates that research in Indonesia generally uses EDGE or GREENSHIP separately according to the specific evaluation objectives, so studies linking the two systems remain limited (Lendra et al., 2025).

Several previous studies have evaluated buildings using either EDGE or GREENSHIP separately, but have not explained how the differing assessment philosophies of the two systems affect the energy efficiency evaluation results for the same building. Therefore, a comparison of the two methods is essential to bridge the gap between energy performance measurements (performance outcomes) and the assessment of energy efficiency strategy implementation (implementation-based assessment). Consequently, this study was conducted to address this gap by comparing energy savings results based on the EDGE Building App with the Energy Efficiency and Conservation (EEC) category assessment under the GREENSHIP Existing Building framework for the UNTAG Surabaya Rectorate Building.

METHOD

This study employs a case study method with a quantitative descriptive approach to evaluate the performance of electrical energy efficiency and conservation based on the EDGE methodology, as well as its contribution to the GREENSHIP Energy Efficiency and Conservation (EEC) score for the UNTAG Surabaya Rectorate Building. Quantitative descriptive analysis is a research method used to systematically describe, explain, and interpret numerical data without testing cause-and-effect relationships or inferential hypotheses. This method aims to provide an objective picture of the condition of a research object based on the measurement results and calculations obtained. According to Moh. Nazir, the descriptive method is a method for investigating the current status of a group of people, an object, a condition, a system of thought, or an event, with the aim of creating a systematic, factual, and accurate description, portrayal, or depiction of the facts under study.

Research Design

- Identification of the subject and location: UNTAG Surabaya Rectorate Building, Jl. Semolowaru No. 45, Surabaya.
- Electricity consumption data collection: January–December 2025.
- GREENSHIP assessment: using the Existing Building (EB) Version 1.1 from GBCI, specifically in the Energy Efficiency and Conservation (EEC) category.
- EDGE simulation: using the EDGE Building App version 2026 (IFC online platform).
- EDGE input variables: Window-to-Wall Ratio (WWR), Solar Reflectance Index (SRI) of facade materials, cooling system (split AC), lighting system, and actual electricity consumption data.
- Baseline assumptions: existing building conditions with standard AC and lighting.
- Efficiency Scenario: optimization of WWR, use of facade materials with high SRI, and replacement of the AC system with a more energy-efficient model.
- EEC GREENSHIP assessment procedure: completing nine assessment aspects (policy, minimum performance, optimized efficiency, commissioning, system performance, monitoring, O&M, renewable energy, emissions).
- Comparative analysis: comparing EDGE output (energy savings %) with EEC GREENSHIP scores to identify assessment gaps.

Data Collection

Primary data was obtained through direct observation at the UNTAG Surabaya Rectorate Building, including:

- Building area was measured from technical drawings and field verification.
- The inventory of lighting and air conditioning units was recorded through a room survey, including the number and capacity of each unit.
- AC capacity, COP, and EER were recorded from the AC unit nameplates.
- The building's operating hours were determined through daily observations and interviews with building management.

Secondary data is obtained from building documents and records, including:

- Monthly electricity data comes from building management calculations and electricity bills.
- Electricity data was verified by comparing internal records with building management records.
- GREENSHIP supporting documents are used to supplement the EEC assessment

GREENSHIP EEC Assessment

The building assessment in this study uses GREENSHIP Existing Building (EB) Version 1.1, developed by the Green Building Council Indonesia (GBC Indonesia). This rating system is designed to evaluate the performance of occupied buildings through six assessment categories: Appropriate Site Development (ASD), Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material Resources and Cycle (MRC), Indoor Health and Comfort (IHC), and Building Environment Management (BEM). This study focuses solely on the Energy Efficiency and Conservation (EEC)

category, as its objective is to compare energy efficiency assessment results with simulation results using the EDGE Building App. The following are the assessment aspects for the EEC category in GREENSHIP EB Version 1.1 (**Table 1**).

Table 1. GREENSHIP Assessment Aspects for the EEC Category

No	Assessment Aspect	Description	Evidence
1	Optimized Efficiency Building Energy Performance	Points are awarded based on the percentage reduction in EUI compared to the reference period. If the EUI is below the reference standard, each 3% reduction earns 1 point, up to a maximum of 16 points. If the EUI is above the reference standard but ≤120%, each 5% reduction earns 1 point. If the EUI is >120% of the standard, each 10% reduction earns 1 point (maximum 3 points).	Minimum 6 Months of PLN Bills and EUI Calculation
2	Testing, Recommisioning or Retrocomissioning	Points are awarded for commissioning, re commissioning, or retro-commissioning of building systems in accordance with the requirements.	Commissioning report, system test results.
3	System Energy Performances	Assessed based on the implementation of energy-efficient technologies in building systems (HVAC, lighting, elevators, pumps, motors, etc.). Each component that meets the requirements receives credits in accordance with the guidelines	Technical specifications for air conditioners, lights, motors, and pumps; inspection results.
4	energy Monitoring and Control	Assessed based on the presence of energy monitoring systems such as sub-metering, Building Management Systems (BMS), or energy monitoring systems that enable the evaluation of energy consumption.	Images of meter installations, monitoring data, BMS, and energy reports.
5	Operation and Maintenance	Assessed based on the implementation of energy system operation and maintenance procedures, maintenance schedules, routine inspections, and documentation of implementation.	Standard Operating Procedure, maintenance schedules, logbooks, and service reports.
6	On Site Renewable Energy	Points are awarded based on the use of renewable energy at the building site (e.g., rooftop solar power systems), with the number of points determined by the contribution to the building's energy needs.	PV system capacity data, installation drawings, and energy production data.
7	Less energy emission	A bonus is awarded if the building is able to reduce carbon emissions through the use of clean energy or emission reduction strategies in accordance with GREENSHIP regulations.	Emissions calculations, renewable energy usage data, emission factors

EDGE Building App Simulation

EDGE (Excellence in Design for Greater Efficiencies) is software developed by the International Finance Corporation (IFC) to evaluate the performance of green buildings based on three main aspects: energy efficiency (energy savings), water efficiency (water savings), and the reduction of embodied energy in materials. However, this study focuses solely on the analysis of energy efficiency (energy savings) because its primary objective is to compare the energy savings evaluation results obtained from the EDGE Building App with the Energy Efficiency and Conservation (EEC) category assessment in GREENSHIP Existing Building Version 1.1. Therefore, simulations related to water savings and embodied energy in materials are neither analyzed nor discussed in this study. The following are the parameters that must be entered during the simulation process using the EDGE Building App (**Table 2**).

Table 2. Assessment Criteria for EDGE Building APP

No	Parameter	Input
1	Building Type	Education Building
2	Location	Surabaya, Indonesia
3	Climate Zone	Tropical Warm Humid
4	Total floor area	5712 m^2
6	Air-conditioned area	4708,36 m^2
7	Number of floors	6 floors
8	Hours of Operation	8 hours/day
9	Window Wall Ratio (WWR)	21,35 %
11	SHGC of glass	0,32
12	Roof type	White UPVC
13	Cooling system	Air cooled DX Split System
14	Lighting Type	Luminous Efficacy
15	Reflective Roof: Solar Reflectance Index (SRI)	64
16	Reflective Exterior Wall: Solar Reflectance Index (SRI)	78

WWR and SRI Calculations

The window-to-wall ratio represents the ratio of the total window area to the total area of the building envelope that is, the outer layer that separates the thermally conditioned interior space from the exterior. The benefit of using exterior windows is to reduce the consumption of artificial lighting; however, this can lead to increased heat gain inside the room. Therefore, energy-efficient glass is required to reduce the amount of heat and UV radiation entering the room. The window to wall ratio (WWR) can be calculated using the following formula. **Table 3** below presents data on the total external glazing area and the total exposed gross facade area of the Untag Surabaya Building.

Table 3. Existing Window and Wall Areas.

	Overall Externall Glazing Area (m^2)	Overall Exposed Gross Facade Area (m^2)
North	247,76	557,5
South	247,76	557,5
West	35.56	850
East	69.9	850
Total	600,98	2815

$$WWR = \frac{\sum \text{Overall External Glazing Area (m2)}}{\sum \text{Overall Exposed Gross Facade Area (m2)}} \text{ x } 100\% \quad (1)$$

$$WWR = \frac{600,98}{2.815} \text{ x } 100\%$$

$$WWR = 21,35\ \%$$

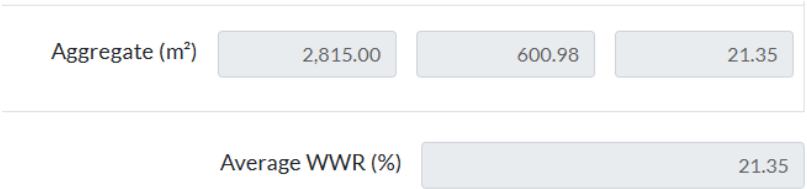

Figure 1. WWR Calculator Results

The Solar Reflectance Index (SRI) is a measure of a material's ability to reflect solar heat. Its value ranges from 0 to 100 (International Finance Corporation, 2026), the higher the value, the greater the material's ability to reflect solar radiation. the higher the value, the greater the material's ability to reflect solar radiation. At the UNTAG Surabaya Rectorate Building, the actual roofing material used is white UPVC with an SRI value of 100, in accordance with the EDGE user guide. This

value indicates very high reflectance performance, enabling the roof to function optimally in reducing the urban heat island effect and supporting energy efficiency goals. In addition, the exterior wall facade currently uses gray ACP material with an SRI value of 78, as listed in the official Alucubond Plus 2019 product catalog. The window-to-wall ratio can influence cooling, lighting, and ventilation energy demand, although its effect on total building energy consumption also depends on climatic and operational variables (Troup et al., 2019).

RESULTS AND DISCUSSION

Overview of the UNTAG Surabaya Rectorate Building

The subject of this study is the Rectorate Building of the University of 17 Agustus 1945, located at Jl. Semolowaru No. 45, Menur Pumpungan, Sukolilo District, Surabaya, East Java. This Rectorate Building consists of six floors housing the offices of the rector and vice rectors, the foundation's administrative offices, offices for professors and doctors, and an auditorium. The first floor of this building serves as a lobby and garden, intended to provide greenery for the building. The building's characteristics are presented in **Table 4** below.

Table 4. Building Characteristics

No	Parameter	Value
1	Building Area	5.712 m2
2	Number of Rooms	36
3	Roof material	White UPVC
4	Type of Glass	Stopsol
5	Lighting system	Artificial and natural
6	Building Function	Office and Education Building
7	Energy Source	PLN
8	Cooling System	Split AC
9	Building Orientation	East

Electricity Consumption and Energy Use Intensity (EUI)

Electricity is one of the main forms of energy consumed in a building; it supports most activities within the building, including transportation, lighting, cooling, and heating. The following **Table 5** shows the electricity consumption of the Surabaya Rectorate Building over the past year.

Table 5. Electricity Usage at the Rectorate Building Over the Past Year

No	Month	KWh/month
1	January	27177
2	February	30037
3	March	22886
4	April	34328
5	May	24316
6	June	27177
7	July	34328
8	August	27177
9	September	31468
10	October	32898
11	November	30037
12	December	22886
Monthly Average1-6		27653
Monthly Average7- 12		29799
EUI 1		4,84
EUI 2		5,22
Percentage increase		7,85 %

Energy use intensity (EUI) is calculated using the following formula.

$$\text{EUI} = \frac{energy\ consumption(\frac{KwH}{month})}{Building\ Area\ (m2)} \quad (2)$$

Based on data on electricity usage at the UNTAG Surabaya Rectorate Building, there was a 7.85% increase in ECI compared to the previous 6 months. Therefore, the ECI for electricity usage does not comply with GREENSHIP regulations, which require a decrease.

GREENSHIP EEC Score

Based on field observations conducted through data collection, interviews, and calculations, the scores for the EEC category are as follows **Table 6**.

Table 6. Energy, Efficiency, and Conservation (EEC) Assessment Score

No	Assessment Aspect	Field Observations	Score
1	Optimized Building Energy Efficiency Performance	Based on changes in the Energy Use Intensity (EUI) value compared to the reference period, as specified in GREENSHIP Existing Building v1.1. The data used consisted of 12 months of PLN electricity bills and ECI calculations. In this study, there was no decrease in ECI compared to the reference period	0
2	Testing, Recommisioning or Retrocomissioning	No commissioning, recommissioning, or retro commissioning of the building systems was performed in accordance with the requirements.	0
3	System Energy Performances	LED lights are used in every room, and a split-type air conditioning system is used	5
4	energy Monitoring and Control	There is no energy monitoring system, such as sub-metering or a Building Management System.	0
5	Operation and Maintenance	Monthly reports on system operations and maintenance are provided	2
6	On Site Renewable Energy	No renewable energy	0
7	Less energy emission	There are no efforts to reduce carbon emissions	0
		Total	7
		Maximum Points	36

Based on the results of the EEC assessment using the GBCI form, the Untag Surabaya Rectorate Building received a score of only 7 out of a maximum of 36 points. Further evaluation is needed to improve the score. To improve energy performance ratings in accordance with the GREENSHIP Existing Building v1.1 guidelines, several improvement measures can be considered. First, commissioning, re commissioning, or retro-commissioning of mechanical, electrical, and HVAC systems should be conducted to ensure that all equipment operates as designed and achieves optimal efficiency. These activities have the potential to identify energy waste that goes unnoticed through routine monitoring (GBCI, 2016).

Second, an energy monitoring system should be implemented by installing sub-meters on major load groups such as air conditioning systems, lighting, and outlet loads, or by integrating them

with a Building Management System (BMS). This system allows for a more detailed analysis of energy consumption, enabling targeted efficiency measures to be implemented.

Third, although monthly reports on building system operations and maintenance are already available, these reports need to be supplemented with an analysis of energy consumption trends, periodic evaluations of the EUI score, and the setting of annual energy-saving targets so that maintenance activities are not merely administrative but also support improved energy performance. Fourth, the building has not yet utilized renewable energy, so the installation of a rooftop solar power generation system could be an alternative to reduce electricity consumption from the PLN grid while simultaneously improving the GREENSHIP assessment score in the areas of energy efficiency and sustainability. Previous studies have demonstrated that improvements in operational settings, lighting systems, glazing, and cooling equipment can substantially improve the energy performance and GREENSHIP scores of existing office buildings (Anisah et al., 2017)

Energy Conservation and Efficiency Simulation Using EDGE

After entering all required categories into the EDGE Building App, the final energy use was calculated at 391.6 kWh/year. The baseline energy use can then be calculated using the following formula:

$$\text{Baseline Energy Use} = \frac{Final\ Energy\ use}{1-Energy\ saving} \quad (3)$$

$$\text{Baseline Energy Use} = \frac{391{,}6}{1-0{,}2637}$$

$$\text{Baseline Energy Use} = 531{,}8\ \text{kWh/year}$$

The results of the EDGE Building App simulation are shown in the following **Table 7**.

Table 7. Energy, Efficiency, and Conservation (EEC) Assessment Scores

Parameter	Value
Baseline energy use	531,8 kWh/year
Final energy use	391,6 kWh/year
Energy Saving	140,2 kWh/year or 26,37%

The complete results of the EDGE Building App simulation for the UNTAG Surabaya Rectorate Building can be seen in the following **Figure 2**.

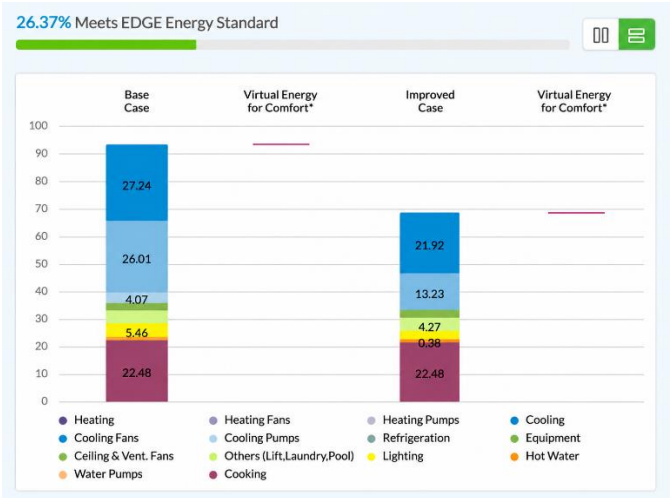

Figure 2. EDGE Building App Simulation Results

Based on the simulation results using the EDGE Building App, the UNTAG Surabaya Rectorate Building achieved an Energy Savings value of 26.37%. This value indicates that the building is capable

of reducing energy consumption by 26.37% compared to the baseline building, thereby meeting the minimum EDGE certification requirement of 20%. According to the EDGE simulation results, air conditioning systems account for the largest share of energy consumption. Strategies to reduce cooling loads should be a priority. Measures that can be taken include setting the air conditioning temperature between 24–26 °C, scheduling air conditioning operation according to the building's operating hours, performing routine maintenance on air conditioning units, reducing outdoor air infiltration, and improving the building envelope's performance through the use of high-performance glass, shading devices, or roof and wall insulation to reduce the heat load. The difference between simulated and actual building energy use should be considered because operational conditions and management practices may create a substantial building energy performance gap (Brady & Abdellatif, 2017).

Comparison of EDGE and GREENSHIP

Based on the analysis results, there is a discrepancy in energy assessment results between the GBCI assessment and the EDGE simulation. This demonstrates that the relationship between the EEC GREENSHIP assessment and the energy simulation from the EDGE Building App is not linear. The following **Table 8** shows the differences between EDGE and GREENSHIP. Green building rating systems may produce different assessment results because they apply different indicators, weighting systems, and performance- or implementation-based evaluation approaches (He et al., 2018; Zhang et al., 2019).

Table 8. Comparison of EDGE and GREENSHIP.

Aspect	EDGE	GREENSHIP
Energy Focus	Percentage of energy savings relative to the baseline	Points based on energy efficiency strategy and performance.
Results	Energy Saving (%)	EEC Category Score/Points.
Method	Parameter-based simulation	Criteria and evidence based assessment.
Required evidence/documentation	Building model, design data, material specifications, equipment specifications, EDGE Building App simulation results, technical drawings, and supporting verification documents	At least 12 months of PLN electricity bills, EUI calculations, operation and maintenance reports, commissioning/re commissioning results (if any), energy monitoring system documentation, energy management policies, and evidence of energy conservation implementation.
Relevance to building operations	More focused on efficiency potential based on design or renovation simulations	Highly focused on the building's actual performance during its operational period, as it uses real energy consumption data and building management practices.
Implications of certification	Demonstrates that the building's design or renovation meets international resource efficiency standards and has the potential to reduce energy and water consumption, carbon emissions, and operating costs	Demonstrates that the building has consistently implemented sustainable operational management, including energy efficiency, environmental management, indoor air quality, water conservation, and building management aspects.

Research results indicate that improvements in energy performance based on EDGE simulations do not always correlate directly with EEC GREENSHIP point scores. The energy savings rate of 26.37% indicates efforts toward energy conservation in the building; however, its contribution to the GREENSHIP assessment is limited because the GREENSHIP system evaluates not only the results of energy savings but also the comprehensiveness of energy management implementation and other supporting technologies. Thus, energy conservation has contributed to the achievement of EEC points, but has not been significant enough to result in a high point total.

CONCLUSION

Based on the research results, the simulation using the EDGE Building App shows that the UNTAG Surabaya Rectorate Building achieved energy savings of 26.37%, thereby meeting the minimum requirement for EDGE certification, which is 20% energy savings compared to a reference building. However, based on the GREENSHIP Existing Building v1.1 assessment, the Energy Efficiency and Conservation (EEC) category scored only 7 out of 36 points. This discrepancy indicates that GREENSHIP not only evaluates energy savings through simulation but also considers the building's operational performance, including energy management, monitoring systems, commissioning/re commissioning, the use of renewable energy, and emissions control. Therefore, improving a building's energy performance requires more than just relying on simulation results; it necessitates the implementation of comprehensive energy conservation strategies. Recommendations that can be implemented include installing energy monitoring systems (sub-metering or Building Management Systems), conducting re-commissioning, optimizing air conditioning systems, replacing inefficient equipment, and utilizing renewable energy such rooftop solar power systems to improve energy performance and achieve a higher GREENSHIP score in the future.

AUTHOR CONTRIBUTIONS

Conceptualization, KG and ES; methodology, KG and ES; software, KG; validation, ES and SA; formal analysis, KG and ES; investigation, KG; resources, KG and ES; data curation, KG; writing—original draft preparation, KG; writing—review and editing, ES and SA; visualization, KG; supervision, ES and SA; project administration, KG. All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to the management of the Rectorate Building of Universitas 17 Agustus 1945 Surabaya for granting permission to conduct the study and for providing access to building documents, electricity consumption records, and other relevant technical information. The authors also acknowledge the support of Sebelas Maret University in facilitating the preparation and completion of this research. Appreciation is extended to all staff members and respondents who assisted during the field observations, data collection, and building energy assessment.

CONFLICTS OF INTEREST

The authors declare no conflict of interest concerning the publication of this article. The authors also confirm that the data and the article are free of plagiarism.

REFERENCES

Alsulaili, A. D., Al-Matrouk, M. F., Al-Baghli, R. A., & Al-Enezi, A. F. (2020). Environmental and economic benefits of applying green building concepts in Kuwait. Environment, Development and Sustainability, 22(4), 3371–3387. https://doi.org/10.1007/s10668-019-00352-1

Anisah, Inayati, I., Soelami, F. X. N., & Triyogo, R. (2017). Identification of existing office buildings potential to become green buildings in energy efficiency aspect. Procedia Engineering, 170, 320–324. https://doi.org/10.1016/j.proeng.2017.03.040

Bilgili, M., Tumse, S., & Nar, S. (2024). Comprehensive Overview on the Present State and Evolution of Global Warming , Climate Change , Greenhouse Gasses and Renewable Energy. Arabian Journal for Science and Engineering, 49(11), 14503–14531. https://doi.org/10.1007/s13369-024-09390-y

Brady, L., & Abdellatif, M. (2017). Assessment of energy consumption in existing buildings. Energy and Buildings, 149, 142–150. https://doi.org/10.1016/j.enbuild.2017.05.051

Farizal, F., Noviandri, M. A., & Hamdani, H. (2024). Sustainability Development through a Nearly Zero Energy Building Implementation Case : An Office Building in South Jakarta.

Green Building Council Indonesia. (2016). GREENSHIP Existing Building Version 1.1: Summary of Criteria and Benchmarks. Green Building Council Indonesia.

Harysakti, A., Permana, I., Segah, H., Sutrisno, H., & Sanitha, O. D. (2025). Evaluation of Existing Green Buildings on UPR Campus Using EDGE Application and Climate Consultant Software. 13, 2587–2600. https://doi.org/10.13189/cea.2025.131329

He, Y., Kvan, T., Liu, M., & Li, B. (2018). How green building rating systems affect designing green. Building and Environment, 133, 19–31. https://doi.org/10.1016/j.buildenv.2018.02.007

INDC. (2022). Enhanced Nationally Determined Contribution.

Intergovernmental Panel on Climate Change. (2023). Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC. https://doi.org/10.59327/IPCC/AR6-9789291691647

International Finance Corporation, O. (2026). - Energy Measures.

Labaran, Y. H., Mathur, V. S., & Farouq, M. M. (2021). The carbon footprint of construction industry : A review of direct and indirect emission. 6(September), 101–115. https://doi.org/10.29187/jscmt.2021.66

Lendra, L., Jesica, J., Wibowo, M. A., Utomo, J., & Hatmoko, D. (2025). Green building assessment tools in Indonesia : a systematic literature review and comparative analysis. 03023, 1–10.

Lintas, K., Bidang, I., Arsitektur, R., Penggunaan, M., & Ramah, M. (2025). Jurnal KaLIBRASI Upaya Peningkatan Efisiensi Energi Bangunan Berkonsep Berkelanjutan. 8(2), 113–124.

Rahmasari, K., Dewi, O. C., Salsabila, N. D., & Danusastro, Y. (2024). Green Building Certification in Educational Facility Green Building Certification in Educational Facility. https://doi.org/10.1088/1755-1315/1395/1/012024

Ramadhan, G. A., Anshori, M., Sulistiawan, A., Mesin, T., Nahdlatul, U., & Sunan, U. (2025). Evaluasi Efisiensi Energi Pada Sistem Green Building : 11(02), 10268–10274.

Troup, L., Phillips, R., Eckelman, M. J., & Fannon, D. (2019). Effect of window-to-wall ratio on measured energy consumption in US office buildings. Energy and Buildings, 203, 109434. https://doi.org/10.1016/j.enbuild.2019.109434

Zhang, C., Cui, C., Zhang, Y., Yuan, J., Luo, Y., & Gang, W. (2019). A review of renewable energy assessment methods in green building and green neighborhood rating systems. Energy and Buildings, 195, 68–81. https://doi.org/10.1016/j.enbuild.2019.04.040