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Energy Saving Opportunities at Rawa Bebek Rental Flats

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ABSTRACT

Jakarta's vision for sustainable urban development includes energy efficiency as a key component in its transformation into a global smart city. As part of this effort, the government has initiated energy audits to identify conservation opportunities in buildings. This study examines the energy, water, and material efficiency potential of Rawa Bebek Rental Flats using the EDGE application. Data collection focused on electronic appliance usage, water consumption patterns, building orientation, construction materials. The findings reveal that current energy savings stand at only 0.65%, requiring an additional 19.35% reduction to meet the EDGE standard of 20%. Water consumption has been reduced by 7.93%, necessitating further savings of 12.07%, while embodied carbon emissions have increased by 8%, requiring a 28% reduction.

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INTRODUCTION

Jakarta is a city with a vision that refers to the pillars of sustainable development (Drestalita & Saputra, 2019). Thus, the city of Jakarta adopts the concept of sustainable urban development, which emphasizes environmental sustainability (Rachmawati et al., 2024). Sustainable urban development takes several factors into account, including meeting the needs of the current population without negatively impacting the needs of future generations, minimizing environmental damage while preserving resources, reducing water consumption, and utilizing renewable resources (Bera, 2020). One of the practices of sustainable urban development is the construction of green buildings, such as energy-efficient designs, the use of sustainable materials, and the integration of green roofs and walls (Pavate et al., 2024).

To promote energy conservation, the Provincial Government of the Special Capital Region of Jakarta has partnered with the Ministry of Energy and Mineral Resources of the Republic of Indonesia to establish a cooperation agreement on building energy audits in efforts to implement optimal energy efficiency in buildings. Currently, energy evaluation or audits can be conducted using the EDGE Building application, which provides information about the surrounding environment as input for design and helps measure building performance related to design, construction, operation, and energy control (Kusuma et al., 2022).

In Jakarta, there is a rental flat building that applies an energy-saving concept. Rawa Bebek Rental Flats is one of the buildings in Jakarta designed with a green concept aimed at creating energy-saving opportunities. This study aims to assess energy-saving, water-saving, and material-saving potential using the EDGE Building application. To meet the EDGE savings standards in the categories of energy, water, and embodied energy in materials, a minimum standard of 20% must be achieved (Aini & Tarigan, 2023). Therefore, this study is necessary to determine the percentage of energy, water, and material consumption savings in the building. If the minimum standard of 20% is achieved in the categories of energy, water, and embodied energy in materials, the green design concept of Rawa Bebek Rental Flats can be recommended for other buildings in Indonesia, particularly rental flats. However, if the standard is not met, design recommendations or proposals will be needed to ensure compliance with the minimum requirements.

LITERATURE REVIEW

Rental Flats

A rental flat is a housing concept consisting of a multi-story building with separate yet functionally structured residential units, both horizontally and vertically. It is also equipped with shared facilities such as meeting rooms, playgrounds, or sports facilities. Additionally, there are other communal spaces, such as public areas or open spaces, that residents can enjoy together (Sudjito, 2020). The key distinction between regular apartments/flat and rental flats lies in the range of facilities provided. Rental flats are designed to be more functional and simplified in order to reduce construction and operational costs (Alief

Muzakkii Saliim, 2022). In general, rental flats located in Jakarta are leased to low-income communities (MZ et al., 2021).

Excellence in Design for Greater Efficiencies (EDGE)

The EDGE (Excellence in Design for Greater Efficiencies) Building application is an assessment tool focused on energy savings and the use of renewable energy sources, developed by the International Finance Corporation (IFC) (Kusuma et al., 2022). The use of the EDGE Building application has become a crucial tool in evaluating building sustainability. EDGE enables architects and engineers to analyze potential savings in energy use, water consumption, and embodied energy in materials while providing data-driven insights into green building performance (Salsabila & Prianto, 2020). When using the EDGE Building application, the savings standard in energy, water, and embodied energy in materials must meet a minimum threshold of 20% (Ramadhon, 2021).

Energy

Energy availability is classified into two categories: non-renewable energy and renewable energy (Ali et al., 2022). Non-renewable energy is an energy source that exists in limited quantities in nature and will be depleted over time, whereas renewable energy is an energy source that can be replenished and is generally unlimited (Islamiyah, 2022). The benefits of renewable energy include energy savings, especially in buildings, reducing air pollution, and supporting sustainable urban development (Kusmana, 2019). In the context of sustainable architecture, a building must use energy wisely in its design to ensure occupant comfort. The energy needs of a building vary depending on its design, surrounding environment, operational methods, and intended use. Building design and its environment should be directed toward minimizing energy consumption to achieve thermal comfort, ensure healthy lighting, and provide water efficiently. Energy efficiency is also influenced by factors such as the size of the space, its orientation, the materials used in construction, and the building's capacity to store thermal energy. (Shaza Liyana Shamri, 2022)

Natural Lighting

Natural lighting is a crucial aspect of green building design, offering opportunities for energy savings, enhancing visual quality, and providing positive health benefits for occupants (Yousuf et al., 2017). Improper lighting design can negatively impact user productivity and comfort. Therefore, an appropriate lighting design is essential to enhance both aspects. Natural lighting plays a crucial role, as it directly affects the visual comfort of occupants in their daily activities and indirectly influences energy consumption for artificial lighting (Lasty Dinulfy Risfawany KS, Ramli Rahim, 2015).

The basic strategy for designing openings to optimize natural lighting in a building is to orient the building in a way that avoids direct sunlight from the west and east while still allowing sufficient light to prevent indoor spaces from becoming too dark (Avesta et al., 2017). If a room has optimal natural lighting from morning to evening, artificial lighting such as lamps will not be necessary during that period, reducing energy waste.

Water

Water efficiency is one of the solutions to address challenges in clean water supply, water scarcity, and environmental protection, allowing for water conservation through the following methods (Rizki, 2022):

1. Using a shower while bathing can save approximately 60% more water compared to using a dipper, which consumes around 15 liters of water.
2. Implementing a rainwater harvesting system with an underground storage system.
3. Creating green spaces such as grass and plants to help filter and absorb water into the ground, allowing it to be recycled into clean water.
4. Additionally, using a dual-flush toilet system can save up to 68% more water compared to squat toilets or conventional flush systems (Gong et al., 2020).

Embodied Energy in Materials

Sustainable construction materials contribute to energy savings by minimizing the embodied energy and reducing carbon emissions. The use of eco-friendly materials, such as recycled steel, bamboo, and insulated concrete forms, enhances building sustainability (Szymczak-Graczyk et al., 2024). The adoption of these materials reduces environmental impact and enhances building performance in terms of energy retention and thermal comfort.

A case study on energy-saving opportunities in government buildings found that energy audits combined with EDGE analysis improved efficiency by identifying key areas for energy consumption reduction (Sujatmiko, 2010). Similarly, a study on the New Dean's Office Building at Diponegoro University demonstrated the effectiveness of EDGE-based evaluation in achieving green building certification (Salsabila & Prianto, 2020)

METHODOLOGY

Rawa Bebek Rental Flats is a government-owned rental flats located in the Cakung area of East Jakarta.

Figure 1. Rawa Bebek Rental Flats Building

This rental flat is built on 17.65 hectares of land. Each unit in Rawa Bebek Rental Flats is equipped with several pieces of furniture, such as a wardrobe, spring bed, sofa, toilet, living room, and kitchen. As for public facilities, Rawa Bebek Rental Flats provide a convenience store, elevators, CCTV, security personnel, and free TransJakarta feeder buses for residents. All towers are equipped with smoke detectors, alarms, and automatic fire extinguishers. Rawa Bebek Rental Flats site plan was obtained by submitting a formal request to the relevant authorities, the DKI Provincial Government.

Rawa Bebek Rental Flats is divided into three categories:

1. For relocated residents (program-based): Based on DKI Jakarta Governor Regulation No. 11 of 2014, Article 3, program-based residents include those affected by public development programs, natural disasters, urban space regulation, and/or similar conditions. This category consists of 8 blocks.
2. For applicants who are married residents: These units are in a 16-story tower.
3. For applicants who are unmarried worker residents in Jakarta: These units are divided into two separate blocks for male and female residents.

Figure 2. Site Plan of Rawa Bebek Rental Flats

Due to time constraints in completing the research, the researcher has set a limitation to focus on the main research problem. Therefore, this study is specifically focused on the rental flats category for relocated residents (program-based) in Blocks 1-8.

Figure 3. Study area of Rawa Bebek Rental Flats Block Mass

From Blocks 1-8, two units from each block will be surveyed and interviewed regarding energy usage, water consumption, and embodied energy in materials.

Figure 4. Typical Foor Plan of Study Object Mass Block

The residential units studied are two units located on the 2nd and 6th floors of Blocks 1-8.

Figure 5. Typical Flats Unit Floor Plan

There is only one type of residential unit in Blocks 1-8, a unit that consists of two bedrooms, one living room, one dining area, one kitchen, one laundry and ironing area, a balcony, and one bathroom/toilet.

Figure 6. Window Opening in the Flats Unit

About 20% of the unit's surface area consists of openings. The interior walls are made of brick with a white paint finish, while the exterior walls have a green paint finish.

Figure 7. Water Faucet in the Bathroom

The residential units use water faucets with an average bathroom faucet water usage of 4 liters per minute. These faucets are available in both the bathroom and kitchen. There are no bidets or urinals in the residential units studied. Before conducting the research, the researcher first carried out a preliminary approach by reviewing several national journal articles from three similar studies. This review was necessary to determine which research methods had been used previously. From this analysis, the most suitable research method could be selected.

The first research article was titled "Energy Audit and Analysis of Energy Consumption Savings Opportunities at PT. Harmoni Putra Solusindo," (Ramadhon, 2021). This research used the energy audit method. The second research article, titled "Application and Evaluation Using EDGE Software in the New Dean's Building of the Faculty of Engineering, Diponegoro University," (Salsabila & Prianto, 2020). This article discusses energy efficiency standards based on the EDGE software in the case study of the new Faculty of Engineering Dean's Building at Diponegoro University. The third research article, titled "Study on Energy Consumption Savings Opportunities at the Secretariat General of Public Works Building," (Sujatmiko, 2010). The study clarifies the classification of the Secretariat General of Public Works Building as an efficient building. However, not all occupants agreed with this assessment, as many preferred lower indoor temperatures. Based on the analysis, it was recommended that energy savings could be achieved by reducing air conditioning leakage and improving current lighting levels, ensuring that energy savings would be experienced throughout the entire building.

These three studies demonstrate the applicability of energy-saving assessments in public buildings. While the contexts vary, they adopt a similar strategy to enhance energy efficiency by using the EDGE building application. Based on these insights, a descriptive quantitative methodology utilizing the EDGE building application was considered the most appropriate approach for this research. This approach allows for an analysis of savings opportunities in energy, water, and embodied energy in materials at Rawa Bebek Rental Flats, assessing whether they meet the minimum standard of 20% efficiency or not.

The steps involved in the descriptive quantitative research method are as follows:

1. Collecting data through direct field surveys and interviews with 16 respondents from Rawa Bebek Rental Flats residents. The 16 respondents from 16 apartment units were selected based on the distribution across the 8 building blocks within the complex. Samples were taken from 1 unit located on the lowest floors and and 1 unit on the highest floors of each block, representing areas with contrasting indoor temperature conditions, to capture a comprehensive range of thermal variations for analysis. The collected data includes types of electronic devices used in each unit and their usage duration, water consumption in each residential unit, types of toilets and faucets installed in the units, and dimensions of openings in each residential unit, floor slab thickness, building mass orientation, and materials used for walls, floors, windows, doors, and roofs.
2. Gathering literature studies related to energy savings and rental flats, sourced from journals, books, and relevant regulations.
3. Using the EDGE building application with a base case that meets EDGE standards at the research location while the existing building conditions from the survey are input as the improved case.
4. Analyzing the output of the EDGE building calculations to determine whether it meets the standards. The results will conclude whether the building meets the minimum standard or requires recommendations or design proposals.

RESEARCH RESULT

Energy Usage Analysis

In the residential units of the Rawa Bebek Rental Flats designated for relocated residents (programmed), the researcher conducted a survey and analysis regarding electronic appliances, lighting, and air conditioning used by the occupants. Based on the data collected on usage duration and power rating (in watts) of each electronic appliance, the average daily energy consumption in watt-hours (Wh) for each device was calculated. The study examined the duration of usage, the number of units, and the wattage consumed. Table 1 below represents the total electricity consumption in watt-hours along with the electronic devices from the 16 surveyed and interviewed units.

Table 1. Total Electricity Consumption for 16 Sample Units

No.	Electronics Type	Total Items	Total kWh/day
1	Lamp	58	16,73
2	AC	3	10,8
3	Fan	33	28,7
4	TV	13	7,92
5	Refrigerator	13	27
6	Wi-Fi	9	2,16
7	Washing Machine	14	3,95
8	Rice Cooker	12	59,17
9	Blender	1	2,1

10	Aquarium Pump	3	1,44
11	Exhaust	2	1,28
12	Clothes Iron	11	0,93
13	Sound System	2	0,38

Source: Research Result, 2024

Figure 8. Energy Savings Achievement

The Energy Saving bar chart above is derived from the EDGE application, indicating an energy savings of 0.65% based on the comparison between the Base Case and the Improved Case. In the context of this study, the Base Case data by EDGE represents standard construction practices commonly used in the Jakarta area, while the Improved Case reflects the existing building, namely Rawa Bebek Rental Flats.

In the graph, annual energy consumption is expressed in kWh/m²/year for various energy usage categories. In the Base Case, total energy consumption comes from several main categories: cooking (0.53 kWh/m²/year), water pumps (1.65 kWh/m²/year), lighting (1.74 kWh/m²/year), common amenities (1.07 kWh/m²/year), ventilation and ceiling fans (2.32 kWh/m²/year), and household appliances (0.42 kWh/m²/year). Meanwhile, in the Improved Case (Existing), most categories have the same consumption as the Base Case, except for the water pump category, which experienced a slight decrease from 1.65 to 1.6 kWh/m²/year.

The reduction in energy consumption in the water pump category is the sole contributing factor to the 0.65% energy savings, which is still relatively low. The figure indicates that the existing Rawa Bebek Rental Flats building has not yet implemented significant energy efficiency strategies compared to standard construction practices in Jakarta. To achieve greater energy savings, additional measures are needed, such as adopting SMART Lighting along with LED lamps in the buildings and also applying renewable energy sources such as solar panels (Fatiha et al., 2025).

Water Consumption Analysis

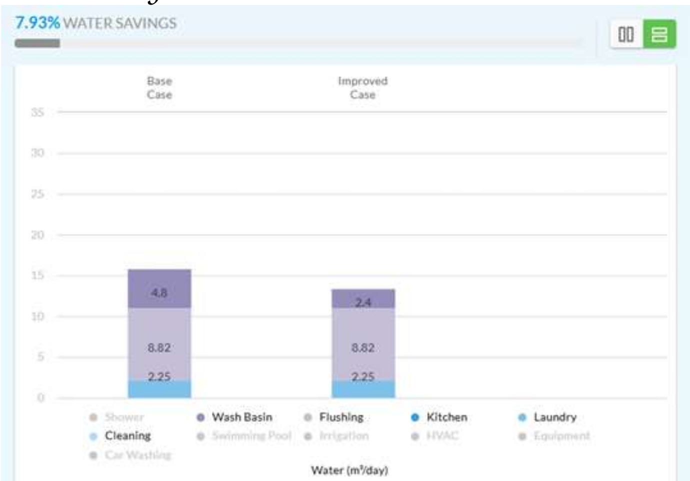

Figure 9. Water Savings Achievement

The bar chart from the EDGE application indicates a water savings of 7.93% based on a comparison between the Base Case and the Improved Case. In this study, the Base Case represents standard construction practices commonly used in the Jakarta area, while the Improved Case reflects the existing building, Rawa Bebek Rental Flats.

In the chart, daily water consumption is expressed in cubic meters per day (m^3/day) across various water usage categories. In the Base Case, total water consumption comes from several main categories: laundry (2.25 m^3/day), flushing (8.82 m^3/day), and washbasins (4.8 m^3/day). Meanwhile, in the Improved Case (Existing), water consumption remains the same for laundry (2.25 m^3/day) and flushing (8.82 m^3/day) but decreases in the washbasin category from 4.8 m^3/day to 2.4 m^3/day.

The reduction in water consumption in the washbasin category is the primary factor contributing to a 7.93% water savings compared to standard construction conditions in Jakarta. This indicates that the existing Rawa Bebek Rental Flats building has implemented an effective water efficiency strategy for washbasin usage, while other categories still maintain the same consumption as the standard condition.

Embodied Carbon Savings Analysis

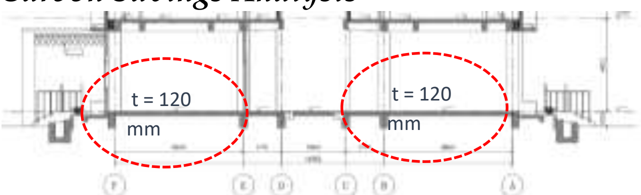

Figure. 10. 1st Floor Section Plan of Rawa Bebek Rental Flats

The researcher conducted a survey and analysis regarding the materials used in the flat's units. The flooring area (ground floor) has a thickness of 120mm. The typical floor area of the building per level also has a thickness of 120mm. The roof partially uses a concrete slab with the same thickness of 120mm. However, neither the roof nor the floors have insulation.

The exterior wall material consists of brick masonry with a plaster finish, painted in dark green and yellow. The interior walls are also made of brick masonry with a plaster finish. The window frames are made of aluminum, and the windows use clear glass with a thickness of 5mm.

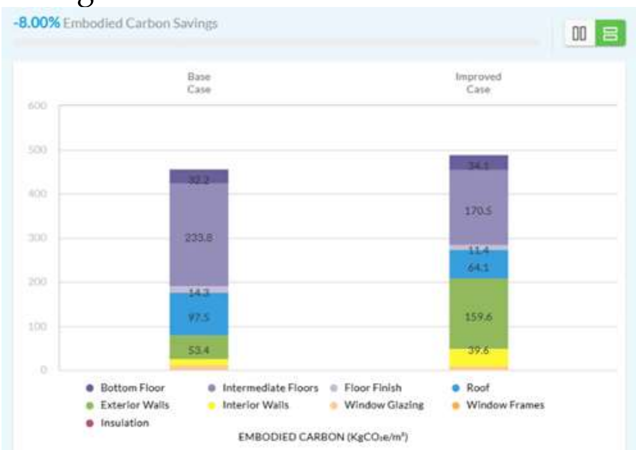

Figure 11. Material Usage Savings Achievements

The final bar chart from the EDGE application presents a comparison of embodied carbon between the Base Case and the Improved Case. The Base Case represents standard construction practices commonly used in the Jakarta area, while the Improved Case reflects the carbon emissions of the existing building, Rawa Bebek Rental Flats.

From the graph, it can be seen that the total embodied carbon in the Base Case is primarily contributed by several building elements, such as the intermediate floors (233.8 $kgCO_2e/m^2$), roof (97.5 $kgCO_2e/m^2$), exterior walls (53.4 $kgCO_2e/m^2$), and interior walls (13.0 $kgCO_2e/m^2$). Meanwhile, in the Improved Case (Existing), significant changes occur in some elements, with a decrease in the intermediate floors (170.5 $kgCO_2e/m^2$) and roof (64.1 $kgCO_2e/m^2$), but a significant increase in the exterior walls (159.6 $kgCO_2e/m^2$) and interior walls (39.6 $kgCO_2e/m^2$).

Overall, the difference between the two cases results in a -8.00% embodied carbon savings, meaning there is still room for improvement in reducing the building's embodied carbon footprint. While reductions were achieved in certain elements, such as the intermediate floors and roof, the significant rise in exterior and interior walls increased the total carbon emissions. Therefore, to achieve more optimal carbon savings some strategies can be applied to the materials such as using tempered glass, floor-to-ceiling window, low volatile organic compound (VOC) coating (Mustapa et al., 2024)

DISCUSSION

Based on EDGE standards, for Rawa Bebek Rental Flats to achieve the 20% energy savings target, efficiency improvements are required in several key categories. Currently, energy savings are only at 0.65%, meaning an additional 19.35% reduction in energy consumption is still needed. Since Rawa Bebek Rental Flats does not use water heating energy from the start, the strategy for achieving the 20% energy savings target should focus on other key areas. This includes implementing energy-efficient LED lighting, which can reduce lighting consumption by 30-40%; optimizing the efficiency of household appliances such as ventilation and ceiling fans to lower energy use by at least 25%; and exploring improvements in insulation or passive cooling strategies to minimize reliance on electrical cooling systems.

CONCLUSIONS AND RECOMMENDATIONS

Rawa Bebek has achieved a 7.93% reduction in water consumption; therefore, an additional 12.07% reduction is required to meet EDGE standards. This can be achieved by installing aerators on faucets and showers, which can reduce water consumption by up to 30%, and implementing dual-flush toilets, which can save up to 20% of water usage.

In terms of embodied carbon, it is currently experiencing an increase of 8%, meaning an additional 28% reduction is required to reach the 20% carbon reduction target. This can be achieved by replacing exterior and interior wall materials with low-carbon alternatives such as lightweight bricks or prefabricated panels, which can reduce carbon emissions by 30-40%. Additionally, optimizing the use of recycled materials in construction can further lower total carbon emissions. Implementing these measures will bring Rawa Bebek Rental Flats closer to the green building standards as claimed by EDGE.

ADVANCED RESEARCH

The results of this study were obtained from the results of a survey at the Rawa Bebek flats using Edge software. The EDGE application enables sustainable building design through energy, water and embodied carbon.

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