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ASSESSMENT AND OPTIMIZATION OF GREEN BUILDINGS IN INPATIENT BUILDINGS USING EDGE BUILDING RATING (Case Study: Graha Amarilis of Karsa Husada Batu Academic Hospital)

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Abstract
The Graha Amarilis inpatient building has high Energy, Water, and material consumption because it operates 24 hours daily. The building's performance must be evaluated based on green building standards to ensure the sustainability of the building and the environment surrounding it. This study aims to determine the performance of green buildings and optimize the Graha Amarilis inpatient building. A combined strategy of case studies with simulations is used as research methodology. Field surveys and measurements were carried out on research cases and digitally modeled using Autodesk REVIT. Then, building performance analysis calculations are carried out using the EDGE Building application simulation method, which presents data on green rating of Energy, Water, and Material saving in buildings. The results of this study were obtained on energy and water items that had not reached green building rating in EDGE Building by 20%. So, optimizing energy items at points EEM 18, EEM 07, and EEM 33 and Water at points WEM 01, WEM 02, WEM 14, and WEM 15 is necessary. Finally, after several simulations on that item, Energy saving consumption becomes 20.07 %, Water 34.69%, and Material 23.00%. With these adjustments, the Graha Amarilis inpatient Building can reach the green building standards and become more sustainable and environmentally friendly.

Keywords: EDGE Building, Green Building Assessment, Inpatient Building, Sustainable Building

INTRODUCTION

In this modern era, human sensitivity to the importance of environmental sustainability is a necessity for the sustainability of human civilization. Therefore, many innovations and ideas are developing to improve the quality of environmental sustainability. The United Nations (UN), through the Sustainable Development Goals (SDGs) program, has become a pioneer in maintaining the sustainability of human civilization, which can be in harmony with the natural environment and socio-cultural environment. Many sustainability parameters must be met through SDGs to create a sustainable life. In the health sector, the implementation of SDGs is realized in sustainable and green hospital concepts. The Green Hospital concept is developing rapidly, so many hospitals are adopting it. Hospitals themselves have many specialties and levels of service. Therefore, applying the green building concept to each type and differentiation of hospital will also be different (Muir, Stucki, & Keller, 2018). Each level of hospital service has a different level of complexity and activity, so different development and implementation strategies are required. This also has an impact on the application of the green hospital concept, which can be applied to certain hospitals. Teaching hospitals also have different services and activities from general hospitals, where additional academic activities are integrated into hospital services, requiring different spaces and facilities (Marshal et al., 2021).

Under the latest decree of the Minister of Health of the Republic of Indonesia, Karsa Husada Batu Hospital has met the criteria as a Type B hospital with a regional health service scale. Type B hospitals have complex and massive types of services, making the hospital operate with non-stop services. Type B hospitals have a relatively high service capacity, namely 400-1000 beds. Type B general hospitals are under the provincial government. In this case, Karsa Husada Batu Hospital is under the East Java Provincial Government. In 2022, besides being a type B regional general hospital, Karsa Husada Batu Hospital is the primary academic hospital of UIN Maulana Malik Ibrahim Malang. The development of Karsa Husada Hospital as an educational hospital for UIN Maulana Malik Ibrahim Malang is supported by a Memorandum of Agreement between the East Java Provincial Government (Number 120.23/235/NK/011.3/2021) and Maulana Malik Ibrahim State Islamic University Malang (Number 3318/Un.3/ HM.01/09/2021). That will transform Karsa Husada Batu into an academic hospital where teaching and learning activities occur, especially for medical professional study program students. The many types of services make the operational level in the hospital very high. This will affect many things, including resource consumption to support hospital operations (Azar, Farzianpour, Foroushani, Badpa, & Azmal, 2015).

The green hospital concept for academic hospitals still needs to be studied further because two main functions are accommodated in one room and an integrated area of the academic hospital (Arzemani, Sedghi, & Nasiripour, 2017). However, a hospital that applies the green hospital concept and its infrastructure must also meet the criteria for a sustainable green building (Mayangkusuma, 2017). Research on assessing the performance of green buildings in hospital case studies has been conducted in various locations. Still, of course, each location has its unique values and problems, so assessing the level of green building performance in hospital objects will produce differences in each case study (Astuti, 2016). Many previous research studies have discussed hospital green building assessments in general (Sunarto, 2018). Still, few have studied specific objects such as the inpatient building, the hospital's main building that operates 24 hours a day and seven days a week. This will indicate a very high level of building operations and needs special attention because the burden on hospital resources will be drained for inpatient building operations.

Many previous studies, such as those conducted by Amran & Muhtazaruddin, (2018), only revealed assessments of green building performance without carrying out a building optimization strategy so that the green level of the building can increase. In research conducted by ADHIM, 2015; Aripin, Othman, & Nawawi, 2015; Azar et al., 2015; Dhillon & Kaur, 2015; Khoirina, (2016) an assessment was carried out using the EDGE Building analysis method, one of the mandatory applications of GBCI to assess the level of green rating in buildings. In this application, we are asked to enter data related to buildings. We need an integrated method to make measurements more accurate and effective (Tanner, 1997). Modeling using BIM-based applications is also a solution to increase accuracy and effectiveness in calculating parameters in EDGE buildings. This is also done by many researchers, such as (Pham, Shin, & Ahn, 2019).

For this reason, modeling was carried out using BIM, specifically Autodesk Revit software, as a novelty in research that increases the accuracy and effectiveness of building optimization (Perdana, 2023). This also aims to make optimizing it easier so that the strategy can be tried and simulated using this software. For this reason, this research aims to determine and assess buildings' green-level performance analyze and evaluate factors that reduce a building's green rating. After assessing the existing building design, we also provide simulation-based optimization strategy solutions. It is hoped that with this research, hospital management can use this optimization strategy to increase its green rating and apply for green building certification.

RESEARCH METHOD

Based on the research objective to assess and optimize green building performance in the case study object, this research uses several methodologies or what is better known as a combined strategy (Groat & Wang, 2013). This methodology combines several interrelated methodologies. In the context of this research, it combines the case study method with simulation. Case studies are the core methodology, so each analysis departs from existing case studies (Groat & Wang, 2013). Case studies are a research context that can reveal the unique value of an object so that it will give rise to new findings in research. The existing case study will be modeled using the BIM method to obtain accuracy. Using BIM Modeling, comprehensive building information and optimization can be done in real-time. To model the case study object in this research, triangulation was carried out using field surveys and measurements, as well as checking the as-built building of the building. The modeling results will be valid when the conditions in the model are similar to existing conditions. After the model is valid, the next stage is carried out.

Further analysis will be conducted using the EDGE Building simulation method (Cavalliere, Habert, Dell'Osso, & Hollberg, 2019). Building data from the model is input into the EDGE Building assessment application to calculate the energy consumption and resources required by the building. This method has also been used in several studies to assess the green rating of hospital buildings Pamungkas, 2017; Pamungkas, Sucipto, Murtiono, & Farkhan, 2017; Putra, Wibowo, & Syafrudin, (2020). This shows that the EDGE Building can be used as a valid instrument for conducting assessments of green building ratings DESANES & CHRISTANDO, (2023). From the results of the green building assessment using EDGE Building, the performance conditions of the existing green buildings of the study object will be obtained. So, several variables that increased and decreased the green rating level were found. After the assessment, optimization steps are taken on the variable factors that reduce the green rating. The analysis using the EDGE Building application instrument is carried out hierarchically to determine the influence coherently to identify what factors need to be improved to achieve green building criteria.

Furthermore, in carrying out optimization, simulation analysis using BIM is needed to determine whether these steps can be applied to building objects (Angga, 2023). The research hypothesis is based on the results of research conducted by previous researchers. The factors that reduce the level of green rating in buildings are the variables of the level of use of renewable energy and conservation of water resources.

RESULT AND DISCUSSION

The research location is on Ahmad Yani Street Number.11-13, Ngaglik, Kec. Batu, Kota Batu, Jawa Timur 65311. This type of hospital is a primary teaching hospital. In the master plan of the Karsa Husada Batu, Graha Amarilis Regional Hospital is to become an integrated inpatient building on the western land. The Graha Amarilis building is the main inpatient building of the Karsa Husada Batu Academic Hospital. This building was built in 2021. The Graha Amarilis building has 4 main floors consisting of the basement, the 1st floor, which contains class II inpatient rooms and also a hemodialysis room area; the 2nd floor is a class II, Class I inpatient and some master room, and the 3rd floor is a Master and VIP inpatient room. The Graha Amarilis inpatient installation building has a capacity of 138 beds divided into 18 Class II, 4 Class I, 17 Mater Room, and 7 VIP classes. This building has a main orientation facing south as the primary access to the building. This building was built with a rigid frame structure with reinforced concrete construction. In the central area of the building, there is a void that divides the building into two masses, which are directly connected by a corridor area and a waiting room. This building has 79 bathrooms with clean hot and cold-water facilities. This building is supplied by the primary electrical power source from the PLN grid power, supported by several solar panels to supply electrical power to the area outside the building. Apart from that, the building is also supported by a generator as a backup source of electrical Energy in the case of a PLN power grid. The building has a 4607 m² total area, a shield roof design over two wing masses connected to the core, and a concrete roof on several sides. The building's vertical circulation system uses double elevators and is equipped with emergency stairs. This building is connected to the ICU installation building, which is to the south of the building and is directly connected by a corridor to facilitate the mobilization of inpatients when they need intensive care or are unconscious.

Figure 1. BIM Modelling Building Isometry – Existing of The Graha Amarilis Building

The case study building was modeled using BIM, specifically using Autodesk Revit. Modeling is carried out in the stages of field survey, measurement, and using working drawings (DED). Currently, no as-built drawings exist, so a survey is still needed to increase modeling accuracy. After the building has been modeled according to the existing conditions of the building, climatic conditions and building performance are also tested manually using measurement techniques using building comfort measuring instruments such as thermometer stations, Luxmeters, and decibel meters. This is used to collect data on the existing conditions of the building, which will later be used as a triangulation of the validity of the building model. The beginning of the study also includes an analysis of the building's comfort performance, such as the building's daylight and noise level. Upon conducting an initial daylight factor measurement test, several areas were identified as problematic, appearing in black (Figure 2). We can learn from the figure that the Graha Amarilis inpatient building needs more daylight to reduce artificial lighting, which can decrease the building's energy consumption (Acosta et al., 2015).

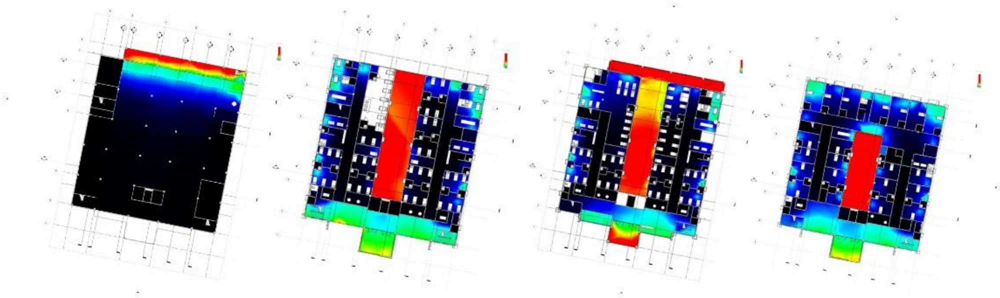

Figure 2. Daylighting Factor Condition of The Graha Amarilis Existing building

The noise distribution in the building is analyzed on each floor, revealing distinct patterns. The basement floor exhibits a concentration of noise in the central region. On the first and second floors, noise spread more widely throughout the corridors and rooms. Notably, the top floor displays a unique noise profile, with green dominating the central area and red only present on the front side of the building, distinguishing it from the floors below. Notably, the third floor shows a favorable noise level in the patient room area (Figure 3).

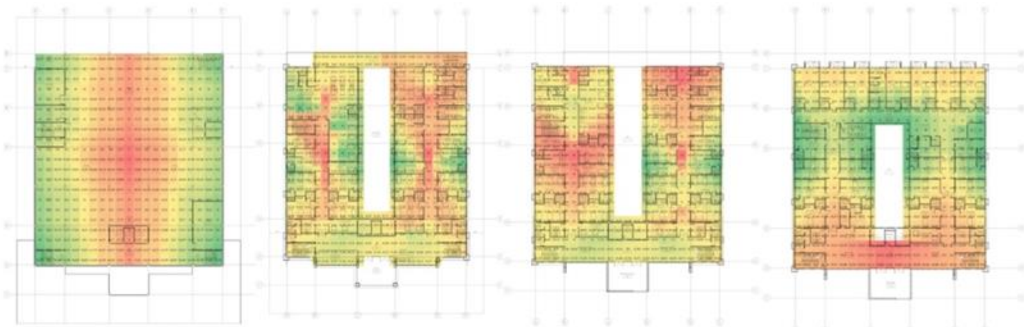

Figure 3. Noice Level Condition of The Graha Amarilis Existing building

The Use of EDGE Building Apps as An Assessment Tool for The Calculation of Building Efficiency Levels

To comply with modern standards for energy efficiency and sustainable building development, measuring the level of green percentage in buildings is essential. The Karsa Husada Hospital has been constructed with a green hospital concept. Therefore, it underscores the importance of meeting the required green building standards. Based on the thermal and noise conditions that have been analyzed previously, it can be seen that there is no need for noise-related analysis for optimization with the EDGE building.

Figure 4. The existing BIM model of The Graha Amarilis Building

To commence the process of Edge Building Apps, the first step is to input all relevant building profile data, including location, building dimensions, orientation, space requirements, position based on ASHRAE Climate Zones, and climate conditions such as temperature, humidity, rainfall, wind speed based on Climate Consultant. Once all the building data has been entered, the system generates 0% Energy, 0% Water, and 0% Materials. This indicates the seamless integration of the building profile with its surrounding environment, resulting in optimal harmony.

Next, enter Energy, Water, and material calculations. Edge Building Apps offers 34 Energy calculation points, 17 Water points, and 11 material points. There are several factors that can influence the percentage of each point. The following graph shows the initial percentages before the inclusion of energy, water, and materials items.

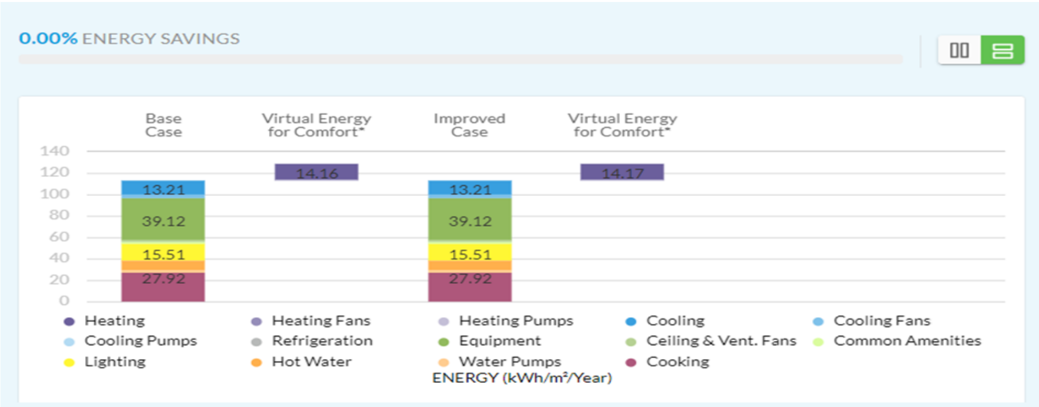

Figure 5 Base Case Graphic of Energy Building

Energy Efficiency Analysis in Building

In the context of Edge Buildings, the process of determining energy usage is referred to as Energy Efficiency Measures (EEM). A thorough evaluation of the building's existing conditions is instrumental in selecting the appropriate energy items for analysis (Figure 5). The energy items that are utilized in this research have been carefully curated to ensure their relevance and applicability (Tabel 1).

Table 1. Focus of analysis on energy items

		ENERGY	WATER	MATERIAL
EEM01	Window-To-Wall Ratio	-0.03%	0	
EEM02	Reflective Roof: Solar Reflectance Index 38	-0.36%	0	
EEM03	Reflective Exterior Walls: Solar Reflectance Index 45	-0.36%	0	
EEM04	External Shading Devices: annual Average Shading Factor (AASF) 0	0.36%	0	
EEM09	Efficiency of Glass: U-Value 3.83	-0.33%	0	-1.00%
EEM11	Natural Ventilation	2.37%	0	-1.00%
EEM13	Cooling System Efficiency: COP (W/W) 3.81	4.40%	0	-1.00%
EEM18	Domestic Hot Water System: Solar, Heat Pump, Boiler	-0.29%	0	-1.00%
EEM22	Efficient Lighting for Internal Areas except OT	0.84%	0	-1.00%
EEM30	Submeters for Heating and/or Cooling Systems	1.69%	0	-1.00%
EEM32	Power Factor Corrections	3.39%	0	-1.00%
EEM33	On-site Renewable Energy: 7.2% of Annual Energy Use	10.35%	0	-1.00%

The table provided indicates the energy items that can contribute to the increase in the percentage of green buildings. Specifically, EEM33, which pertains to on-site renewable Energy used in buildings, has a significant impact at 7.2%, potentially increasing the percentage up to 10.35%. However, it should be noted that this energy item also harms the efficiency level of the Material, as evidenced by item EEM09. This pertains to the Efficiency of Glass, which can be reduced by -1.00% when using a type of glass with a U-Value of 3.83.

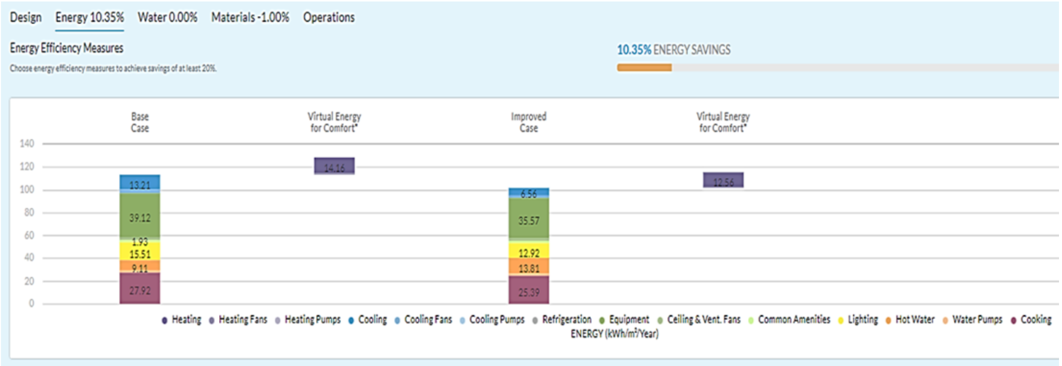

Figure 6 Improved Case Graphic of Energy Building

Through a step-by-step process of inputting energy items, it is possible to identify opportunities for enhancing the energy-saving potential of a building. This process can also reveal energy items that are consuming more building energy. After inputting 12 energy requirements for a particular building, it was discovered that the total percentage of Energy was 10.35%, Water was 0.00%, and Material was -1.00% (Figure 6). Based on these results, it can be concluded that the energy items in this building are yet to achieve energy efficiency as the percentage is still below 20%. Therefore, optimization is necessary to improve the efficiency of this building.

Water Use Efficiency Analysis in Building

Water Efficiency Measurement (WEM) measures the percentage of water efficiency in the EDGE Building application. The selection of water points is based on the DED drawing and existing conditions in the building. The following results are based on the items used for water analysis (Table 2).

Table 2. Focus of analysis on water items

		ENERGY	WATER	MATERIAL
WEM01	Water-efficient Showerheads:10L/min	10.20%	-0.77%	-1.00%
WEM02	Water-efficient Faucets for all Bathrooms: 20L/min	-4.89%	-96.18%	-1.00%
WEM04	Efficient Water Closets for All Bathrooms: 5L/High volume flush and 2 L/Low volume flush	-4.87%	-80.80%	-1.00%
WEM07	Water-efficient Urinals: 1L/flush	-4.87%	-78.06%	-1.00%
WEM08	Water-efficient Faucets for Kitchen Sinks: 10L/min	-48.7%	-78.06%	-1.00%
WEM15	Waste Water Treatment and Recycling System: 100% Treated	-5.03%	-78.06%	-1.00%
WEM17	Smart Meters for Water	-5.03%	-78.06%	-1.00%

Upon careful examination of the water usage data, it is apparent that the building's water consumption is suboptimal and results in a notable energy drain. The building employs seven water items, registering a 0% or less water percentage. The most effective measure to reduce water consumption is the implementation of Water-efficient Faucets for all bathrooms under WEM02, which achieves a flow rate of 20L/min. This measure also yields a corresponding reduction in energy use, with a percentage of -4.89%.

According to this study, achieving a water percentage of 20% will require significant, specialized optimization. The water analysis chart shows that building data shows that building water consumption exceeds the limits (Figure 7). The improved case has a higher level than the base case. Notably, the wash basin's water usage necessitates the most significant improvements.

Figure 7. Improved Case Graphic of Water Percentage Building Measurement

Green Criteria on Material Efficiency

The following calculation is on material items in Edge Building, abbreviated as MEM (Material Efficiency Measures). The selection of material items in this research is in accordance with those used in buildings. The materials used are grouped based on items on the Edge as follows:

Table 3. Focus of analysis on material items

		ENERGY	WATER	MATERIAL
MEM01	Bottom Floor Construction Type 1: Concrete Slab | In-situ Reinforced Conventional Slab	-4.25%	-73.48%	2.00%
MEM02	Intermediate Floor Construction Type 1: Concrete Slab | In-situ Reinforced Conventional Slab	-4.25%	-73.18%	30.00%
MEM03	Floor Finish Type 1: Vinyl Sheet Type 2: Ceramic Tiles	-4.25%	-73.18%	25.00%
MEM04	Roof Construction Type 1: Tiled Roof | Clay Tiles on Steel Rafters Type 2: Concrete Slab|In-situ Reinforced Conventional Slab	-7.16%	-73.18%	28.00%
WEM05	Exterior Walls Concrete Blokcks | AAC Blocks	-7.15%	-73.18%	28.00%
MEM07	Window Frames	-7.15%	-73.18%	29.00%
MEM08	Window Glazing - Single Glazing	-7.38%	-73.18%	29.00%

Based on the table presented, it is evident that the materials utilized in this structure are highly efficient. This is demonstrated by a percentage exceeding 20%. MEM02 - Intermediate Floor Construction - is the material item that significantly enhances the green efficiency level.

The building incorporates a concrete slab utilizing the In-situ Reinforced Conventional Slab type. Notably, the percentage of material usage is consistent throughout the structure.

In order to ensure optimal performance, it is of utmost importance to maintain a balanced percentage distribution among the various building items. While it may be permissible for the material percentage to exceed 20%, it is crucial to ensure that the levels of both material and water items remain within the acceptable range. Therefore, it is imperative to prioritize the optimization of items that have a significant impact on other percentage levels. By doing so, one can ensure that the overall performance of the building is optimized to its fullest potential.

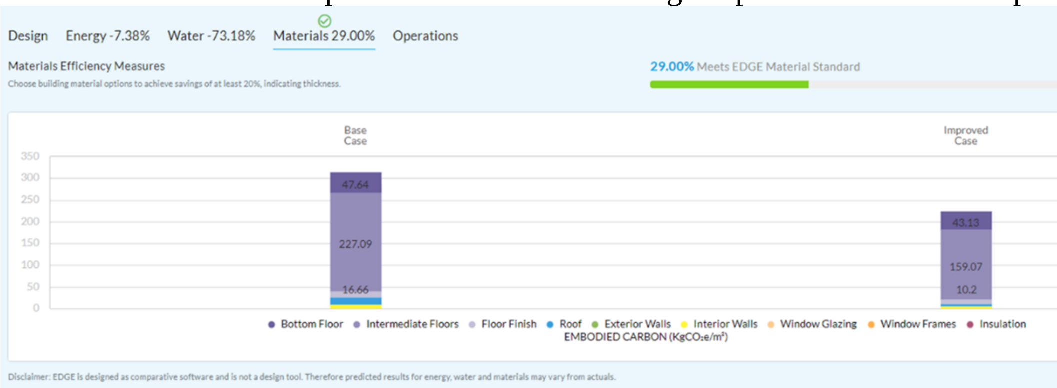

Figure 8. Graphs a Substantial Increase in Emphasis on The Materials Used

The graph above provides clear evidence of a substantial increase in emphasis in the improved case compared to the base case (Figure 8). This finding strongly indicates that the building materials used in construction can significantly reduce the structure's energy consumption and emission levels.

First Optimization: Focus on The Urgency Point

The core goal of optimization is to improve effectiveness by identifying and rectifying any factors that may be causing a significant reduction. As part of this study, optimization was staged to ensure that every element reached its desired sustainability level. This method identifies the underlying causes of inefficiency and enhances the efficiency of all resources, including energy, water, and materials.

Table 4. Optimize based on the sequential item

		ENERGY	WATER	MATERIAL
WEM14	Rainwater Harvesting System	-7.38%	-72.55%	29.00%
WEM15	Waste Water Treatment and Recycling System: 100% Treated	-7.38%	-58.60%	29.00%
WEM02	Water-efficient Faucets for all Bathrooms: 10L/min	4.73%	18.51%	29.00%
EEM18	Domestic Hot Water System: Solar, Heat Pump, Boiler	8.84%	18.51%	29.00%
EEM07	Green roof	10.49%	18.51%	29.00%
WEM01	Water-efficient Showerheads:8L/min	10.60%	19.26%	29.00%
WEM02	Water-efficient Faucets for all Bathrooms: 8L/min	12.41%	34.69%	29.00%
EEM33	On-site Renewable Energy	24.49%	34.69%	29.00%

After analyzing the data presented in the table, it was determined that the initial round of optimization focused on water and energy items. Notably, the analysis of the water item revealed that implementing Water Saving Faucets in all Bathrooms (WEM02) led to significant performance improvements. Water usage was reduced from 20L/min to 10L/min, and ultimately to 8L/min, resulting in a remarkable increase in water efficiency of 34.69% (as indicated in Table 4). These encouraging outcomes were primarily due to the reduced water volume consumption per minute (Figure 9).

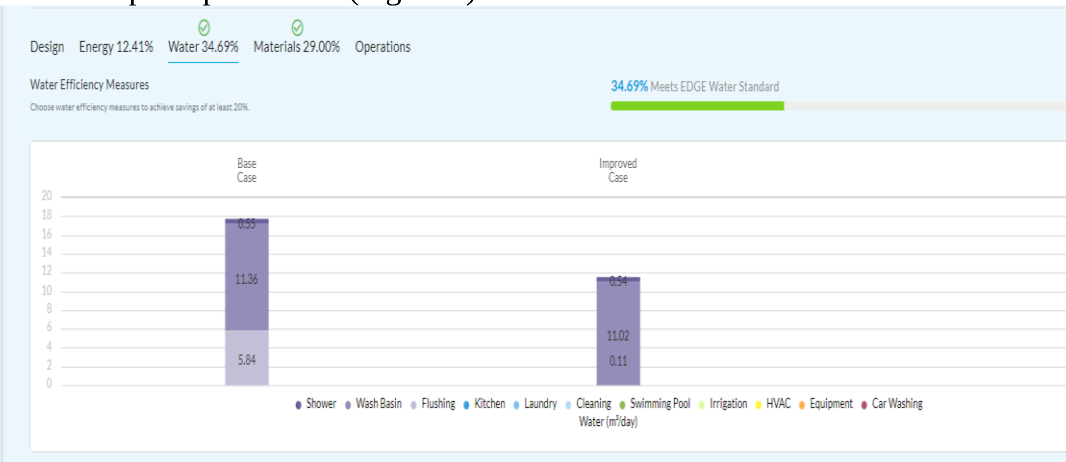

Figure 9. Graph of Optimization results for increasing water efficiency measurement items

Optimization has also been applied to energy items, resulting in a significant percentage increase after including renewable materials on site, especially item EEM33. This Material underwent adjustments by increasing the volume percentage of Solar Photovoltaic use in buildings by 20%, increasing the total energy percentage by 24.49% (Figure 10).

The research continued with proof in the drawings of the building design. A percentage above 20% means the building shows good green building value. However, further optimization is necessary to adapt to the actual conditions if it fails to match the design conditions.

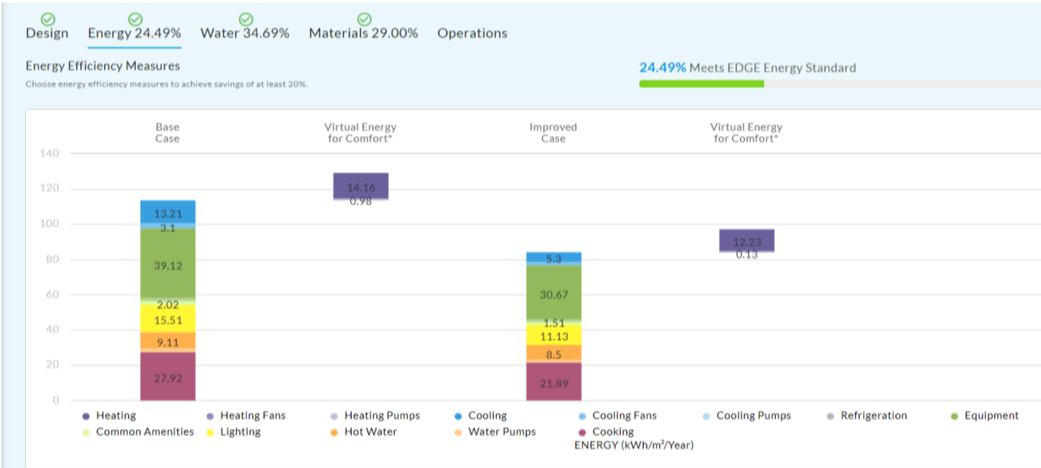

Figure 10. Optimization graph emphasizing the energy efficiency of the Graha Amaryllis building

Final Strategy Optimization on Buidling Design

Once each item has surpassed a 20% threshold, a comprehensive analysis of the design is performed to synchronize shifts in energy focus with the design. An inconsistency within the building design was uncovered upon executing the initial optimization strategy. Consequently, adjustments to the optimization plan were required to ensure its effectiveness for building implementation. The procedure follows a sequential process as outlined below:

1. The initial optimization approach under review is the installation of solar panels on the roof. However, it has been discovered that the extensive roof space cannot accommodate the full

quantity of solar panels suggested in Optimize 1. Consequently, adjustments must be made to item EEM33, specifically On-site Renewable Energy.

2. Adjustments to the solar panel area depicted in EEM33 are necessary to comply with the minimum roof capacity regulations. Consequently, the solar photovoltaic items previously set at 20% must now be reduced to 7.2%, resulting in an energy yield of 12.33%.
3. Incorporate the EEM20 device, specifically the Air Economizer, to raise the percentage by 14.88%.
4. 4. Providing skylights to the building of 120m2 of floor area and increasing the percentage up to 15.31%
5. A modification has been implemented to enhance the energy output in EEM18, specifically in the domestic hot water system. This involves a shift in the percentage of energy usage, wherein diesel consumption decreases by 20%, heat pump utilization decreases by 10%, and boiler usage increases by 70%. This adjustment has resulted in an energy percentage of 17.59%.
6. Make changes by increasing the Solar Photovoltaic coverage area on the roof of the building by 2.7% so that the total use of On-site Renewable energy is 10%. This can reduce energy use in the building so that the efficiency percentage obtained is 20.07%.

Table 5. Final optimization of all items by adjusting building conditions

		ENERGY	WATER	MATERIAL
MEM04	Roof Construction - Customized Material: PV - Concrete Slab | In-Situ Reinforced Conventional Slab	24.42%	34.69%	23.00%
EEM33	On-site Renewable Energy 7.2% of Annual Energy Use	12.33%	34.69%	23.00%
EEM20	Economizer: - Air Economizer	14.88%	34.69%	23.00%
EEM25	Skylight: - Floor Area 120 m2	15.31%	34.69%	23.00%
EEM18	Domestic Hot Water (DHW) System: - Solar 20% - Heat Pump 10% - Boiler 70%	17.59%	34.69%	23.00%
EEM33	On-site Renewable Energy: 10% of Annual Energy Use 10%	20.07%	34.69%	23.00%

According to the information presented in the table, it is evident that achieving a high green level is not simply a matter of reaching a specific number (Table 5). It also requires the building to be in a suitable condition. If the design does not allow for incorporating elements that can boost the green percentage, alternative optimization strategies must be explored and tailored to the building's specific conditions. The final analysis of the Graha Amarilis building at Karsa Husada Hospital indicates that the optimization of the green percentage is 20.07% for Energy, 34.69% for Water, and 23.00% for Materials (Figure 11).

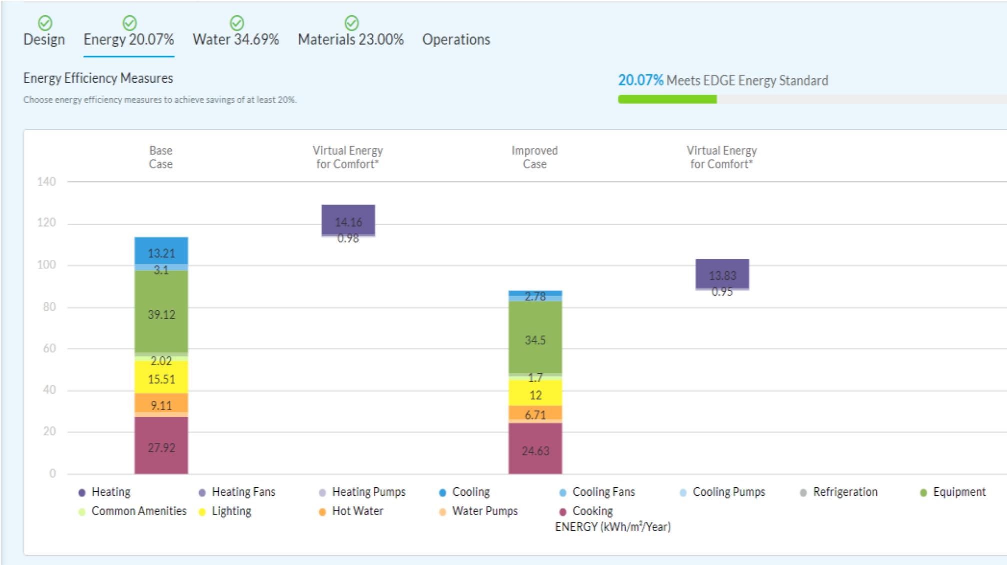

Figure 11. The Final Graph Result of the Energy efficiency measurement based on compliance with the design

After carrying out a simulation of the green rating optimization strategy using edge building and knowing what points need to be optimized, the building is re-modeled using Autodesk Revit (Balo et al., 2020). Elements that can increase the green rating are applied to buildings (figure 12). Adding shading device fins, increasing the wall window ratio, increasing more efficient utility plumbing equipment, such as heat pumps, rainwater conservation systems, solar-powered boilers, using faucets with lower water flow and aeration, installing solar panels (Shaabany et al., 2018), and also adding skylights be a concrete solution in optimizing the green rating of the Graha Amarilis inpatient building (Chel et al., 2009).

Re-Modeling of Improved Design: Building Design Revision Based Optimization Edge Building Parameter

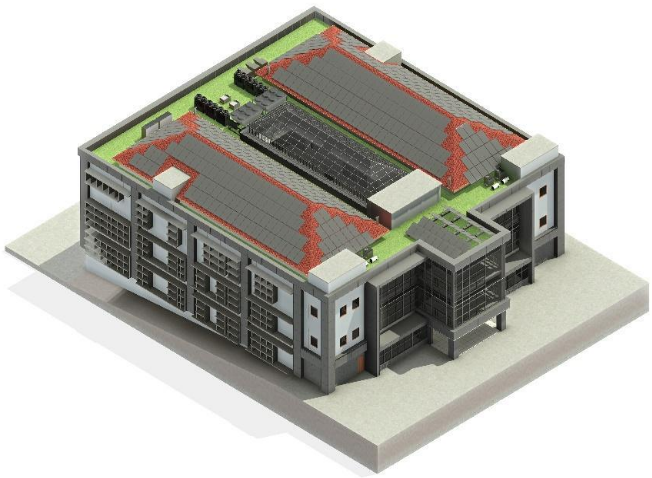

Figure 12. The ultimate design has been revised in accordance with the optimization of the design, which is based on EDGE Building

Natural lighting simulations were also done using Autodesk Revit with lighting analysis tools. It is essential to know whether there is an increase in the penetration of indirect sunlight into buildings. After applying a larger ratio of wall windows to the curtain wall and multi-fin shading device, a significant daylight factor is obtained, as evidenced by the areas marked in green having a daylight factor of 5% and only a few remaining areas that are still below 5% appearing in black. (Figure 13).

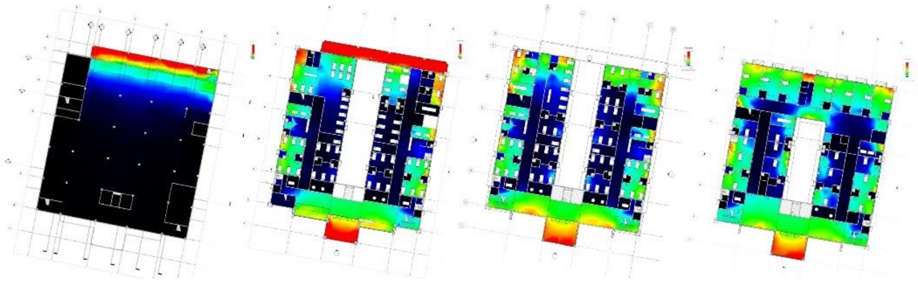

Figure 13. Daylighting Factor Condition After optimization of The Graha Amarilis Existing Building Facade

CONCLUSION

After carrying out the assessment analysis process of the level of green building performance in the Graha Amarilis Karsa Husada Batu Academic Hospital case study in existing conditions, results were obtained on energy and water criteria that had not reached the minimum green building rating determined by EDGE Building, namely 20%. This is due to the use and processing of non-renewable energy and resources, so this building cannot be categorized as green building. The main factor that reduced of water efficiency criteria caused by high water consumption is managing water flow by installing conventional taps and using conventional water heaters. Meanwhile, the building's energy content, which still relies on PLN electricity sources and generators, also supports the drastic reduction in the green rating level. Therefore, an optimization strategy focusing on these two substances is needed to increase green ranking. The items that were optimized were energy items EEM18 (Domestic Hot and Water (DHW) System), EEM33 (On-site Renewable Energy), EEM20 (Economizer), and EEM25 (Skylight). On the water item, optimization was carried out at points WEM 01 (Water-efficient showerheads), and WEM 02 (Water-efficient Faucets for all Bathrooms). Finally, after several simulations on this item, energy consumption savings were obtained by 20.07%, water by 34.69%, and materials by 23.00%. With these adjustments, the Graha Amarilis Inpatient Building can reach green building standards and become more sustainable and environmentally friendly.

REFERENCES

Adhim, A. (2015). Perencanaan Dan Perancangan Rumah Sakit Ibu Dan Anak Kabupaten Bangkalan (Tema: Rumah Sakit Hijau: Green Hospital).

Amran, M. E., & Muhtazaruddin, M. N. (2018). Assessment Of Renewable Distributed Generation In Green Building Rating System For Public Hospital. International Journal Of Engineering And Technology (Uae), 7(3), 40–45.

Angga, P. (2023). Bim Based Evaluation Of Daylight Factor Aspect In The Sharia Housing Project That Implemented Islamic Housing Concept. International Journal Of Multidisciplinary Research And Publications, 5(9), 161–167.

Aripin, S., Othman, R., & Nawawi, N. M. (2015). The Relevance Of Green Building In Creating A Healing Environment In Hospital Designs In Malaysia. Perspektif Jurnal Sains Sosial Dan Kemanusiaan, 7(3), 39–46.

Arzemani, M., Sedghi, S., & Nasiripour, A. A. (2017). Standard Evaluation Of Green Hospital In Medical Centers Of North Khorasan University Of Medical Sciences In 2016. Management Strategies In Health System, 2(2), 118–129.

Astuti, E. (2016). Hubungan Motivasi Belajar Dengan Prestasi Belajar Pada Mahasiswa S1 Keperawatan Di Stikes William Booth Surabaya. Jurnal Keperawatan, 5(1), 36–42.

Azar, F. E., Farzianpour, F., Foroushani, A. R., Badpa, M., & Azmal, M. (2015). Evaluation Of Green Hospital Dimensions In Teaching And Private Hospitals Covered By Tehran University Of Medical Sciences. Journal Of Service Science And Management, 8(02), 259.

Cavalliere, C., Habert, G., Dell'osso, G. R., & Hollberg, A. (2019). Continuous Bim-Based Assessment Of Embodied Environmental Impacts Throughout The Design Process. Journal Of Cleaner Production, 211, 941–952.

Desanes, T. R. O., & Christando, S. S. (2023). Evaluasi Perbandingan Implementasi Rating Tools Material Konstruksi Green Building Menggunakan Greenship Versi 1.2 Dan Edge Versi 3.0. Universitas Katholik Soegijapranata Semarang.

Dhillon, V. S., & Kaur, D. (2015). Green Hospital And Climate Change: Their Interrelationship And The Way Forward. Journal Of Clinical And Diagnostic Research: Jcdr, 9(12), Le01.

Groat, L. N., & Wang, D. (2013). Architectural Research Methods. John Wiley & Sons.

Khoirina, M. M. (2016). Analysis Of Green Accounting To Support Corporate Social Responsibility (Case Study: Semen Gresik Hospital). Akrual: Jurnal Akuntansi, 8(1), 1–10.

Marshal, O., Sunaryo, N. C., Kurniawan, S. J., Herwendanasari, D., Hariyanto, E., & Andarini, S. (2021). Green Hospital Implementation In Indonesia: A Literature Review. Journal Of Community Health And Preventive Medicine, 1(2), 32–42.

Mayangkusuma, A. (2017). Evaluasi Penerapan Prinsip Green Hospital Pada Design Gedung Lima Lantai Di Rs Jiwa Daerah Surakarta. Universitas Gadjah Mada.

Muir, K., Stucki, M., & Keller, R. (2018). Green Hospital: Bringing Life Cycle Innovation Into The Healthcare Sector. 1st Life Cycle Innovation Conference (Lcic), Berlin, 29-31 August 2018.

Pamungkas, A. R. (2017). Kajian Implementasi Green Building Rumah Sakit Universitas Sebelas Maret Surakarta Berdasarkan Sistem Sertifikasi Edge (Excellence In Design For Greater Efficiencies).

Pamungkas, A. R., Sucipto, T. L. A., Murtiono, E. S., & Farkhan, A. (2017). Implementasi Green Building Konservasi Air Rumah Sakit Uns Berdasarkan Sistem Sertifikasi Edge (Excellence In Design For Greater Efficiencies). Prosiding Seminar Nasional Uns Vocational Day, 1.

Perdana, A. (2023). A Comparative Study Of Natural Lighting Quality In Sharia Housing Based On Daylight Factor Evaluation Using Autodesk Revit. Journal Of Artificial Intelligence In Architecture, 2(2), 13–27.

Pham, D. H., Shin, H. K., & Ahn, Y. H. (2019). Green Building Rating Systems In Vietnam Market-A Comparative Analysis Between Leed, Lotus, Edge, And The Vietnamese National Regulation. 대한건축학회 학술발표대회 논문집, 39(2), 705–706.

Putra, R. M., Wibowo, M. A., & Syafrudin, S. (2020). Aplikasi Green Building Berdasarkan Metode Edge. Wahana Teknik Sipil: Jurnal Pengembangan Teknik Sipil, 25(2), 98–111.

Sunarto, S. (2018). Environmental Strategic Planning Rumah Sakit Persahabatan Menuju Green Hospital. Ijeem-Indonesian Journal Of Environmental Education And Management, 3(2), 101–114.

Tanner, R. (1997). A Low Energy Green Hospital. Health Estate Journal: Journal Of The Institute Of Hospital Engineering, 51(6), 2–4.