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Analysis of Energy Use Intensity (EUI) Factors in Government Office Buildings in Tropical Climate: A Case Study in the Ministerial Office Building and the Directorate General of Water Resources Building of The Ministry of Public Works

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Abstract

Energy Use Intensity (EUI) is a key indicator for evaluating the energy efficiency of buildings. This study aims to analyze the EUI factors in two government office buildings: the Ministerial Office (MO) building and the Directorate General of Water Resources (DGWR) building of The Ministry of Public Works. Both are located in close proximity and share similar physical characteristics under tropical climate. The EUI is analyzed using the walkthrough audit method as a practical approach for assessing energy performance. The results show that the DGWR Building exhibits higher energy consumption, primarily due to the dominance of cooling loads accounting for 54.13% of the total EUI, compared to 46.54% at the MO building. There are three main factors contributing to the EUI variation include: (i) heating, ventilation, and air conditioning (HVAC) system – the water-cooled chiller used in the MO building shows higher efficiency compared to the air-cooled chiller system installed in the DGWR building; (ii) Overall Thermal Transfer Value (OTTV) – although both buildings utilize similar envelope materials, the OTTV value in DGWR building is significantly higher due to its larger window-to-wall ratio (WWR), which increases heat gain through the facade; and (iii) Lighting – while there is no significant difference in total installed lighting power, the higher lighting power density (LPD) in DGWR building contributes to a greater lighting energy load per unit area. Additionally, the implementation of smart lighting systems in MO building contributes to better energy efficiency performance.

Keywords: *energy use intensity; government office buildings; energy efficiency; heating, ventilation, and air conditioning; tropical climate*

1. Introduction

1.1. Background

Indonesia's has demonstrated a sustained commitment to energy conservation to abate the greenhouse gas (GHG) emissions from the demand side. It is in line with the commitment of government of Indonesia in ratification of the Paris Agreement in 2016 through Law No. 16 of 2016. Further, Indonesia submitted their Enhance Nationally Determined Contributions (ENDC) in 2022 aiming to reduce carbon emissions totaling 31.89% (unconditional) and 43.20% (with international support) by 2030 as well as commits to achieve net zero emissions by 2060 or sooner (Puteri, 2024). One of the prominent sectors in reducing GHG emissions is building sector in which the government is aiming to deliver energy conservation through the implementation of energy management in both existing buildings and new constructions (Ahn et al., 2019; Purnami et al., 2022).

In pursuing the energy management in demand side to abate GHG emissions, Ministerial Regulation of Energy and Mineral Resources No. 3 of 2025 imposes the mandatory measure of the EUI for the public buildings under the national and sub-national government. The enforcement of this regulation signifies a pivotal shift towards institutionalizing energy efficiency within the

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public sector. Public buildings are now at the forefront of national efforts to reduce energy consumption and greenhouse gas emissions. All government levels must report the Energy Use Intensity in public buildings regularly to MEMR. This regulation opens opportunities to further explore energy management practices within government office buildings.

Energy Use Intensity (EUI) represents the annual energy consumption per unit of building floor area (kWh/m^2/year) and serves as a key indicator for assessing a building's energy efficiency performance. EUI measurement can be conducted using various methods, categorized into three main approaches: (1) benchmarking based on historical data, (2) flexible spreadsheet models for design iterations, and (3) detailed simulation using specialized software (Chung, 2011). EUI measurement must also consider the building's life cycle (Surahman et al., 2015). At every stage of the building life cycle, obtaining reliable data for EUI calculations, both during the design phase and operational phase, remains a significant challenge.

Several literatures emphasize that building morphology and systems, climatic conditions, and occupant behavior significantly influence the energy consumption patterns of a building (Ali-Tagba et al., 2024; Gassar et al., 2021; He et al., 2022). Accurate measurement and effective management of Energy Use Intensity (EUI) are critical not only for benchmarking and regulatory compliance but also for guiding energy efficiency interventions and informing sustainable building design. In tropical regions such as Indonesia, characterized by consistently high temperatures and humidity, the energy demands for heating, ventilation, and air conditioning (HVAC) are particularly pronounced. These climatic conditions necessitate distinct architectural and technological strategies in the pursuit of Near-Zero Energy Buildings (NZEB).

This study investigates the EUI performance of public buildings in the context of a tropical developing country by conducting an in-depth analysis of two proximate government office buildings, Ministerial Office Building and Directorate General of Water Resources (DGWR) Building. The selected buildings share similar morphology and institutional functions, which help ensure consistent occupant behavior and operations, while also differ in spatial orientation, allowing the study to examine how this factor affects EUI in a tropical climate. Additionally, government buildings are prioritized to meet green building standards, as mandated in the Government Regulation No. 16/2021 for 25% energy reduction, and their central role in the national green building roadmap for early implementation of energy conservation initiatives (Ministry of Public Works and Housing, 2023).

1.2. Methods for measuring Energy Use Intensity (EUI)

Several studies highlight significant discrepancies between field measurements (walkthrough audits) and predictive modeling results (Niu & and Leicht, 2016). The substantial gap between estimated energy consumption during the planning phase and actual consumption during building operation (Sunikka-Blank & Galvin, 2012), underscores the need for assessments to identify the factors contributing to these differences. A body of studies on public buildings in tropical and hot/humid climates shows that simple, design-stage models can guide optimal energy use (Shari et al., 2023).

Energy Use Intensity (EUI) is a key indicator for measuring the magnitude of energy consumption in buildings. However, EUI measurement is not yet commonly practiced, as it has not become an independent priority for building owners. Furthermore, existing EUI measurements predominantly rely on simulation-based methods, which, despite offering high accuracy, require substantial technical expertise, detailed input data, and significant computational resources (Garg et al., 2010; Pukhkal, 2021). In contrast, spreadsheet-based and benchmarking methods are more accessible but less adaptive to local contexts and building typologies.

Currently, the adoption and implementation of EUI as a tool to assess building energy performance in Indonesia still face several challenges. Common barriers include the limited availability of data during the early design stages, often caused by planning and design processes that do not comprehensively consider energy data requirements, the lack of operational information such as occupancy patterns and HVAC system configurations, and the suboptimal integration of approaches tailored to tropical climate conditions (Choi, 2017; Serag et al., 2024).

Several studies demonstrate set of driven variables of EUI–chiefly envelope characteristics such as insulations, window-to-wall ratio, solar absorptance value to walls and roof; passive design, and orientation (Maciel et al., 2023; Tan et al., 2023). Tan et al. (2023) investigated the EUI for the government buildings in Malaysia, while Maciel et al. (2023) studies government building for school in Brazil. Tan et al. (2023) depicts significant drivers of EUI comprise WWR, thermal insulation thickness for wall and floors and focuses on solar absorptance values and solar orientation.

To explore the factors influencing EUI, Suswitaningrum et al. (2022) explored the EUI of government's building in Semarang regency and highlighted the potential saving of energy using energy conservation theory while focusing on HVAC and lighting as the prominent consumption in tropical buildings without compromising comfortability of the users. The location of the building–particularly in tropical

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regions nearby the equators–is another essential issue of EUI (Mazzaferro et al., 2020; Vargas & Hamui, 2021).

Ardente et al., (2011) and Röck et al. (2020) applied building life cycle theory to assess energy and environment impact to identify possible retrofitting actions in public building focusing on life cycle approach focused on the following issues: (i) construction materials and components used during retrofits; (ii) main components of conventional and renewable energy systems; (iii) impacts related to the building construction, for the different elements and the whole building. They highlight the role of the life cycle approach for selecting the most effective options during the design and implementation of retrofit actions.

This study investigates the key variables influencing EUI in public buildings situated within tropical climate, with a particular focus on building utilization in developing country contexts. Employing a case study approach, the research examines selected government office buildings in Indonesia that share similar typologies and climatic conditions. In response to gaps identified in the existing body of literature, this study aims to deepen the understanding of EUI determinants by integrating qualitative insights derived from walkthrough audits. By contextualizing EUI analysis within the operational and climatic realities of tropical urban settings, the research contributes to a more nuanced framework for evaluating energy performance in public-sector buildings across developing regions.

1.3. Contribution and Novelty of Research

This study offers a scientific contribution to the field of Energy Use Intensity (EUI) by exploring energy consumption patterns in government office buildings located in tropical climates. Additionally, this research focuses on examining field conditions, similarity of uses and typologies and their alignment with theoretical foundations.

2. Research Methodology

This study constitutes an initial exploration focusing on the examination of factors influencing Energy Use Intensity (EUI), with the aim of contributing to the formulation of a theoretical framework for the future development of an advanced EUI model. A case study approach was employed, involving two government office buildings located within the Ministry of Public Works complex in a tropical region south of the equator, in accordance with recommended case study research principles (Yin, 2017).

The proposed evaluation model was tested by calculating EUI values using data collected through comprehensive walkthrough audits and subsequently validated against actual energy consumption records. The analysis aimed to determine the relative impact of specific architectural, operational, and contextual variables on building energy performance. The overall research flow is illustrated in Figure 1.

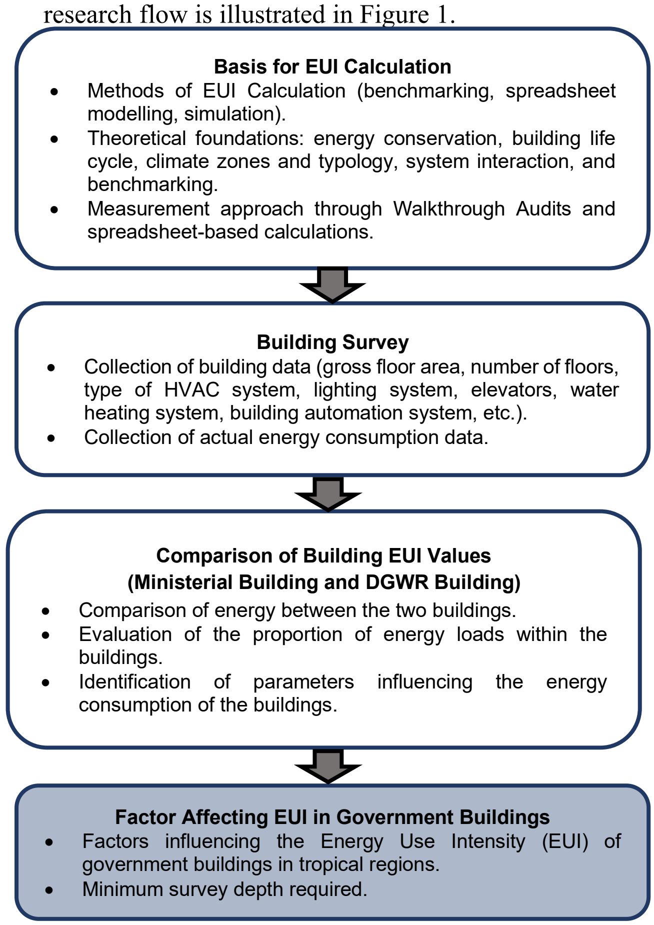

Figure 1 Research Flow.
Source: Author's Analysis, 2025

3. Result and Discussion

This section presents the findings of the EUI assessment. The data collections conducted gathering secondary data such as as-built-drawing, specifications of the mechanical and electrical (M&E) – such as elevators, electric pumps, chiller of the air conditions, as well as the specification of glasses and lighting. Additional operational data, including building operating hours, historical energy consumption records (derived from monthly utility bills), and maintenance logs, were also gathered. Following the secondary data collection, walkthrough audits were undertaken to directly observe and verify patterns of energy use and equipment performance. The comprehensive dataset was subsequently processed using a spreadsheet-based analytical model to calculate the EUI for both buildings.

The analysis in this study focuses on identifying and comparing the main factors that influence the Energy Use Intensity (EUI) of the buildings. It also includes an initial evaluation of how the findings from the field align with the existing body of literature related to building

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energy performance. This approach supports to explore better understanding on drivers of EUI in government office buildings located in tropical climates, and to contribute to more practical and context-specific methods for assessing energy intensity in public facilities.

3.1. Description of the case studies

The two buildings selected as case study objects in this research are the Ministerial Office (MO) building and the Directorate General of Water Resources (DGWR) building, both located within the Ministry of Public Works (MPW) complex, as illustrated in Figure 2. These buildings were chosen because they represent the typical characteristics of office buildings in Indonesia and are equipped with energy management systems relevant for analysis.

Figure 2. The two objects of case study: The Ministerial Office (MO) building and The Directorate General of Water Resources (DGWR) building.

A. Ministerial Office (MO) Building of the Ministry of Public Works

The Ministerial Office (MO) building is located in Kebayoran Baru, South Jakarta, in The Ministry of Public Works complex area and was constructed in 2011 as a high-rise office building featuring an integrated energy management system. The building operates during standard working hours and is equipped with a water-cooled chiller-based HVAC system, energy-efficient lighting, and a Building Automation System (BAS). The domestic hot water system utilizes individual electric heaters, and water-saving technologies have also been implemented. With these characteristics, the building represents a modern tropical office building and serves as a suitable case for the development of an EUI calculation model.

B. Directorate General of Water Resources (DGWR) Building

The Directorate General of Water Resources (DGWR) building is part of the Ministry of Public Works complex located in Kebayoran Baru, South Jakarta, and functions as a medium-rise office building constructed between 2008 and 2009. The building is equipped with an air-cooled chiller system for cooling, energy-efficient lighting, and a Building Automation System (BAS) for indoor temperature regulation. The domestic hot water system employs individual electric water heaters, and water-saving technologies have also been implemented. These characteristics make the DGWR Building relevant case study for investigating the potential development of a hybrid EUI calculation model.

The profiles of both buildings provide empirical data that support the integration of five theoretical approaches, particularly within the context of tropical climates and the design characteristics of office buildings in Indonesia. A comparison of the two building profiles is presented in Table 1.

Table 1. Comparison of the Building Profiles: MO Building and DGWR Building

Component	MO Building	DGWR Building
Year of Construction	2011	2008-2009
Number of Floors	17 floors, 1 basement, 1 roof office	8 floors, 1 basement, 1 roof office
Gross Floor Area (GFA)	26.648,07 m²	18.943 m²
Window-to-Wall Ratio (WWR)	29,36%	66%
Overall Thermal Transfer Value (OTTV)	28.59 Watt/m^2	95,32 Watt/ m^2
Façade Area*	2866 m^2	9337,29 m^2
Wall Material	Lightweight concrete	Lightweight concrete
Glass Material	8 mm reflective stopsol glass, 6 mm and 8 mm clear glass	8 mm reflective stopsol glass, 6 mm and 8 mm clear glass
HVAC System	Water-cooled chiller, 600 TR	Air-cooled chiller, 881 TR
Air-Conditioned Area	22.704 m²	11.867,7 m²
Building Automation System (BAS)	Available	Available
Number of CFL Lamps	2.077 units (27.001 Watt)	943 units (12.259 Watt)
Number of LED Lamps	1.050 units (11.721 Watt)	1.188 units (15.586 Watt)
Number of Fluorescent (TL) Lamps	3.011 units (42.154 Watt)	2.597 units (52.732 Watt)
Water Heater	29 units (350 Watt/unit)	15 units (3.000 Watt/ unit)
Low-Flow Fixtures	100%	100%
Grey Water Optimization	No	No
Number of Elevators	8 unit (17 persons, 1.275 kg)	5 unit (20 persons, 1.350 kg)

*Façade Area: Approximate total area of building envelope excluding roof. Source: Survey Data, 2025

3.2. EUI Analysis on Case Study

The survey results for the Ministerial Building and the Directorate General of Water Resources (DGWR) Building reveal a significant difference in their Energy

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Use Intensity (EUI). The DGWR Building exhibits an EUI that is 40% higher than that of the Ministerial Building, at 322 kWh/m²/year and 193 kWh/m²/year, respectively. In general, this discrepancy is primarily attributed to differences in the energy consumption of HVAC systems, lighting, and elevator operations. However, anomalies were observed in the energy consumption of water heaters and pumps, where the Ministerial Building recorded higher consumption despite having larger system capacities.

The detailed calculations of the energy loads for both the Ministerial Office building and the DGWR building are presented in Table 2 and Table 3.

Table 2. Energy Load Calculation Results for the Ministerial Office Building

		Value	Unit
GFA		26648.07	m2
Average EUI (2017-2019)		193	kWh/m2/yr
Load Type	**Component**	**Value**	**Unit**
Internal Heat Gain	Occupant Heat Gain	351.75	kW
	Lighting Heat Gain	68.67	kW
	Annual Equipment Heat Gain	138569.96	kWh/year
	Total Internal Heat Gain	473.73	KW
	Annual Internal Heat Gain	**1231698.9**	**kWh/ year**
External Heat Gain	Façade Heat Gain	416.01	kW
	Roof Heat Gain	30.76	kW
	Total External Heat Gain	446.78	KW
	Annual External Heat Gain	**11161634**	**kWh/year**
HVAC Load	Installed HVAC Capacity	600.00	TR
		2110.20	kW
	HVAC Cooling Capacity	5.33	COP
		11247.37	kW
	Load Factor	0.44	Load Factor
	HVAC Electrical load	920.51	kW
	Total HVAC Energy Load	10.00	Operating hours/day
		260.00	Operating days/ year
		2393332.9	**kWh/ year**
HVAC EUI		**89.81**	**kWh/m2/yr**
HVAC EUI (%) of Total Actual EUI		**46.54**	**%**
Lighting Load	Total Lighting Load	80876	Watt
		10.00	Operating hours/day
		260.00	Operating days/ year
		210277.6	**kWh/ year**
Lighting EUI		**7.89**	**kWh/m2/yr**
Lighting EUI (%) of Total Actual EUI		**4.09%**	**%**
Water Heater Load	Total Water Heater Load	10.15	kW
		2.00	Operating hours/day
		260.00	Operating days/ year
		0.5	Load Factor
		2639	kWh/ tahun
Water Heater EUI		**0.10**	**kWh/m2/yr**
Water Heater EUI (%) of Total Actual EUI		**0.05%**	**%**
Elevator Load	Total Elevator Load	96	kW
		10.00	Operating hours/day
		10%	Motor operating time per day
		260.00	Operating days/year
		0.7	Load Factor
		19219.2	kWh/ tahun
Elevator EUI		**0.72**	**kWh/m2/yr**
Elevator EUI (%) of Total Actual EUI		**0.37%**	**%**
Equipment Load	Total Equipment Load	10	W/m2
		266.48	kW
		10.00	Operating hours/day
		260.00	Operating days/year
		692849.82	kWh/year
Equipment EUI		**26.00**	**kWh/m2/yr**
Equipment EUI (%) of Total Actual EUI		**13%**	**%**

Source: Author's Calculation, 2025

Table 3. Energy Load Calculation Results for the DGWR Building

		Value	Unit
GFA		18943	m2
Average EUI (2017-2019)		322	kWh/m2/yr
Load Type	**Component**	**Value**	**Unit**
Internal Heat Gain	Occupant Heat Gain	250.04	kW
	Lighting Heat Gain	69.25	kW
	Annual Equipment Heat Gain	98503.6	kWh/year
	Total Internal Heat Gain	357.1878	KW
	Annual Internal Heat Gain	**928688.28**	**kWh/ year**
External Heat Gain	Façade Heat Gain	890.03	kW
	Roof Heat Gain	22.79	kW
	Total External Heat Gain	912.82	KW
	Annual External Heat Gain	**2372332**	**kWh/year**
HVAC Load	Installed HVAC Capacity	881.00	TR
		3098.49	kW
	HVAC Cooling Capacity	3.50	COP
		10844.67	kW
	Load Factor	0.41	Load Factor
	HVAC Electrical load	1270.01	kW
	Total HVAC Energy Load	10.00	Operating hours/day
		260.00	Operating days/ year
		3302029	**kWh/ year**
HVAC EUI		**174.31**	**kWh/m2/yr**
HVAC EUI (%) of Total Actual EUI		**54.13%**	**%**
Lighting Load	Total Lighting Load	80577	Watt
		10.00	Operating hours/day
		260.00	Operating days/ year
		209500.2	**kWh/ year**

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Lighting EUI		**11.06**	**kWh/m2/yr**
Lighting EUI (%) of Total Actual EUI		**3.43%**	**%**
Water Heater Load	Total Water Heater Load	45	kW
		2.00	Operating hours/day
		260.00	Operating days/ year
		0.5	Load Factor
		11700	kWh/ tahun
Water Heater EUI		**0.62**	**kWh/m2/yr**
Water Heater EUI (%) of Total Actual EUI		**0.19%**	**%**
Elevator Load	Total Elevator Load	92.5	kW
		10.00	Operating hours/day
		10%	Motor operating time per day
		260.00	Operating days/year
		0.7	Load Factor
		18518.5	kWh/ tahun
Elevator EUI		**0.98**	**kWh/m2/yr**
Elevator EUI (%) of Total Actual EUI		**0.30%**	**%**
Equipment Load	Total Equipment Load	10	W/m2
		189.43	kW
		10.00	Operating hours/day
		260.00	Operating days/year
		492518	kWh/year
Equipment EUI		**26.00**	**kWh/m2/yr**
Equipment EUI (%) of Total Actual EUI		**8%**	**%**

Source: Author's Calculation, 2025

3.3. Results of Energy Load Identification in the Case Study Buildings

The calculation results indicate that the level of identified energy loads in both buildings remains relatively low. In the Ministerial Office Building of the Ministry of Public Works, the total identified energy load accounts for only 64.52% of the total EUI, while in the Directorate General of Water Resources Building, it reaches 66.14%. Consequently, 35.48% and 33.86% of the energy consumption in each building, respectively, remain untraced to specific load types.

The result shows the significant gap between the walkthrough audits compared to the real energy consumption. It is in line with the findings of Hörner & Lichtmeß (2019) observing EUI in older existing buildings. Substantial deviations potentially occur between the identified energy load and actual measured consumption using simplified models with standard input assumptions are used. Further, they observed that older existing buildings energy consumption often underestimated actual consumption with the margin up to 50%.

Several factors contribute to the incompleteness of the identification process, including: (1) occupant-owned equipment such as computers, printers, and other electronic devices were not comprehensively recorded and were only estimated based on standard assumptions; (2) the HVAC systems have been operating for over a decade, likely resulting in significant efficiency degradation compared to their original technical specifications used as the calculation baseline; and (3) the actual operational hours of the buildings often exceed the official schedule, such as usage during after-hours or weekends, which is not formally recorded but still contributes to additional energy consumption.

These factors highlight the need for more in-depth energy audit methods and the integration of monitoring systems to obtain a more comprehensive and precise depiction of building energy consumption. The observed incompleteness further emphasizes the importance of developing EUI calculation models that can accommodate real-world conditions, including non-technical factors and actual operational variables that are not systematically documented.

In the Ministerial Office Building, the annual EUI is composed of the following: HVAC systems at 89.81 kWh/m² (46.54%), lighting at 7.89 kWh/m² (4.09%), elevators at 0.72 kWh/m² (0.37%), and water heaters at 0.10 kWh/m² (0.05%). Meanwhile, in the Directorate General of Water Resources Building, the contribution of each energy load to the total EUI is as follows: HVAC at 174.31 kWh/m² (54.13%), lighting at 11.06 kWh/m² (3.43%), elevators at 0.98 kWh/m² (0.3%), and water heaters at 0.62 kWh/m² (0.19%).

When compared with the benchmarking data from BPPT (2020) on 48 office buildings, the ideal energy consumption composition for office buildings includes: HVAC systems (64.7%), lighting and power outlets (15.0%), elevators/escalators (7.0%), and other electrical equipment (13.3%). This gap further strengthens the argument that undetected energy consumption exists under limited audit conditions, underscoring the need for more comprehensive calculation approaches or alternative, more adaptive methods.

3.4. Comparison of Individual Energy Loads

An energy load analysis was conducted to evaluate the contribution of five key components—HVAC, lighting, elevators, water heaters, and pumps—to the total EUI of the Ministerial Office Building of the Ministry of Public Works and the Directorate General of Water Resources Building. Although the two buildings share similar functions, operational patterns, and technical capacities, interestingly, the findings reveal significant differences in energy consumption. This comparison reflects not only the efficiency of the systems employed but also the influence of design, operational management, and occupant behavior.

1. *Air Conditioning System (HVAC)*

The Ministerial Office Building uses a water-cooled chiller system with a capacity of 600 TR, while the Directorate General of Water Resources Building

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employs an air-cooled chiller system with a capacity of 881 TR. Although the installed capacities are relatively comparable, the difference in cooling system type has resulted in a substantial energy consumption gap: 89.81 kWh/m² in the Ministerial Office Building versus 174.31 kWh/m² in the Directorate General of Water Resources Building. This finding is consistent with the literature, which highlights that water-cooled chiller systems typically exhibit higher efficiency, especially when supported by a robust Building Automation System (BAS) (Manimaran et al., 2014; Yang & Wang, 2015). The discrepancy is even more notable considering that the HVAC system in the Ministerial Office Building serves an area almost twice as large as that of the Directorate General of Water Resources Building. This underscores the critical importance of selecting an appropriate HVAC system during the building design stage. Additionally, the study found that the HVAC EUI of the Ministerial Office Building is below the standard average for office buildings, which positively influences its overall EUI assessment.

Beyond system efficiency, the thermal performance of the building envelope, as indicated by the Overall Thermal Transfer Value (OTTV), also significantly impacts the cooling load. The Ministerial Office Building has an OTTV of 28.59 W/m², substantially lower than the 95.32 W/m² recorded for the Directorate General of Water Resources Building. This difference is largely influenced by the Window-to-Wall Ratio (WWR), which is lower at 29.36% for the Ministerial Office Building compared to 66% for the Directorate General of Water Resources Building. The OTTV value of the Ministerial Office Building complies with the maximum threshold of 35 W/m² as stipulated in SNI 6389:2020, whereas the OTTV of the Directorate General of Water Resources Building significantly exceeds this limit, resulting in a higher cooling load.

2. *Lighting System*

The total installed lighting power in both buildings is nearly identical (around 80,000 Watts); however, the annual lighting energy consumption at the Directorate General of Water Resources Building reaches 11.06 kWh/m² compared to 7.89 kWh/m² at the Ministerial Office Building—a difference of 40%. This discrepancy is not solely due to the type or efficiency of the lighting fixtures but is also influenced by differences in building floor area. With similar total installed lighting power, the lighting power density (LPD) at the Directorate General of Water Resources Building is consequently higher, approximately 4.25 W/m² compared to 3.04 W/m² at the Ministerial Office Building. A higher LPD directly implies a greater lighting load per unit area. In addition to LPD, differences in lighting energy use could also be attributed to variations in usage intensity, lighting control systems, ballast types, and the extent to which natural daylight is utilized. Given that lighting systems account for up to 15% of total energy consumption according to BPPT studies, improving lighting efficiency presents a major energy-saving opportunity, particularly through the integration of automatic control technologies such as smart lighting systems.

3. *Elevators*

Elevator energy consumption at the Directorate General of Water Resources Building is recorded at 0.98 kWh/m², higher than that at the Ministerial Office Building at 0.72 kWh/m² (a 36% difference). Although the Directorate General of Water Resources Building has fewer elevator units (5 units) compared to the Ministerial Office Building (8 units), the rated power per unit and usage frequency appears to be more intensive. Moreover, having fewer floors does not necessarily lead to lower energy consumption if vertical traffic distribution is not efficiently managed through proper elevator usage management systems.

4. *Water Heater*

This component exhibits an interesting anomaly. Although the total installed capacity of water heaters at the Ministerial Office Building is significantly larger (10,150 Watts) compared to the Directorate General of Water Resources Building (3,000 Watts), the recorded energy consumption is paradoxically higher at the Directorate General of Water Resources Building (0.62 kWh/m² versus 0.10 kWh/m²). This suggests a usage pattern that is not linearly correlated with the installed capacity. While the water heater's contribution to the total EUI is relatively small, it is nevertheless a critical indicator that system efficiency relies heavily on user behavior, and not solely on technical specifications.

4. Conclusion

The comparison of EUI between the Ministerial Office Building and DGWR Building reveals that the DGWR Building exhibits higher energy consumption, primarily due to the dominance of cooling loads accounting for 54.13% of the total EUI, compared to 46.54% at the Ministerial Office Building. The two cases study buildings show a significant difference in EUI, influenced by three factors. First, HVAC – The water-cooled chiller system at the Ministerial Office Building is more efficient compared to the air-cooled chiller technology used at the DGWR Building. Second, OTTV Influenced in part by the window-to-wall ratio (WWR), where, despite both buildings using similar envelope materials, the higher WWR at the DGWR Building results in a much higher OTTV compared to the Ministerial Office Building. Third, Lighting – While there is no significant difference in total lighting power, the higher lighting power density (LPD) in the DGWR Building leads to a greater lighting load per unit area. The implementation of smart lighting systems at the Ministerial Office Building also contributes to better

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energy efficiency. Both buildings still show a gap between actual EUI with result of audit approximately 34–35%, indicating the need for further energy audits to obtain more detailed data on the factors influencing the EUI differences and to later provide targeted recommendations for improving building performance. For instance, additional studies are needed to assess the impact of natural ventilation on heat transfer from the external environment into the building, considering the potential influence of natural airflow and building height.

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