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The Impact of Building Design on Energy Savings Case Study: Main Building of the Ministry of Public Works and Housing (PUPR) – Jakarta

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Abstract

The Main Building Design of the Public Works and Public Housing Ministry (PUPR) in Jakarta has a significant impact on energy savings inside, according to the Jatmika Adi Suryabrata (Department of Architecture and Planning, UGM), in 1 month this building achieved Energy Cost Savings of more than IDR 230 million. This paper analyzes building design elements that contribute to increasing energy efficiency, examines four key design elements: building mass form, façade materials, natural lighting, and shading. Each of these elements plays a crucial role in enhancing energy efficiency in the main building of the Ministry of Public Works and Housing.. In addition, the aspect of resilience is a crucial element of the design, ensuring that the building can withstand climate change and potential disasters. Through a case study approach and empirical data analysis, the research results show that efficient building design can reduce electricity consumption by up to 30-50%. These findings confirm that appropriate building design can be a key factor in achieving energy efficiency as well as offering significant economic, environmental, and resilience benefits for government buildings.

Keywords: Resilience, Building design, Energy saving, Four Key Design Elements

Introduction

Rapid globalization and industrialization drive rising energy demand in government buildings. The International Energy Agency (IEA) reports that the building sector contributes 28% of global carbon emissions [1], with urbanization intensifying energy and sustainability challenges, especially in Indonesia.

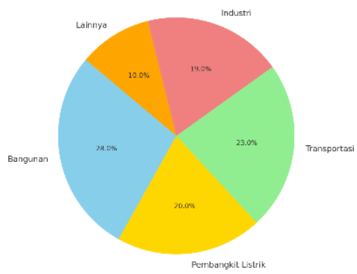

Figure 1.1 Global carbon emissions
Source: International Energy Agency (2023)

Climate change has intensified challenges, with Indonesia's temperature rising by 1.5°C in two decades [2]. Increased extreme heat days [3] and temperatures over 35°C [4] drive higher cooling demand, reducing comfort and productivity.

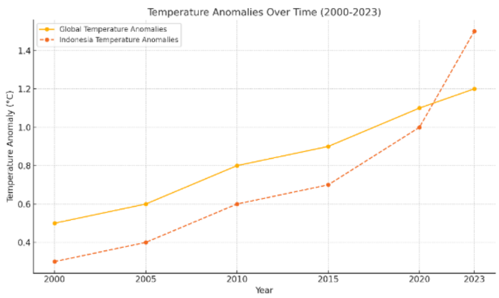

Figure 1.2 Graph of Temperature Anomalies Over Time (2000-2023)
Source: BMKG (2023)

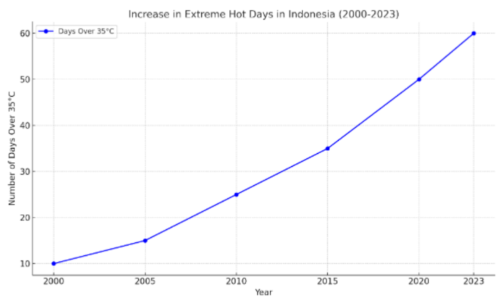

Figure 1.3 Graph of Temperature Increase in Extreme Hot Days in Indonesia (2000-2023)
Source: BMKG (2023)

The PUPR Main Building in Jakarta showcases climate-responsive design, achieving energy efficiency with natural lighting, ventilation, and orientation, saving over IDR 230 million monthly. Jatmiko notes a 40% electricity reduction via Green Architecture. This study examines design elements enhancing efficiency, sustainability, and alignment with SDGs [5].

Figure 1.4 Main Building of Ministry PUPR - Jakarta
Source: PUPR Ministry (2023)

Methodology

This study uses a case study approach on the PUPR Main Building in Jakarta, guided by Baxter and Jack's case study principles [6] and Morgan's mixed-methods approach [7] to analyze design elements and energy performance.

Data Collection

The data collected in this research includes:

Quantitative Data

Quantitative data came from reports and documents on energy use, covering electricity, natural lighting, and facade materials' impact on energy reduction.

Qualitative Data

Qualitative data was collected from literature and technical documents, including design reports, specifications, and energy studies, offering insights into implementing key design elements.

Results and Discussion

Table 2.1 Design Elements and Their Contributions

No	Design Elements	Contribution
1	Building Massing	Influences heat, airflow, and lighting; cuts cooling load by 20% in tropical areas.
2	Facade Materials	Controls heat and lighting; high-insulation or reflective materials cut cooling loads.
3	Natural Lighting	Reduces artificial lighting reliance, saves energy, and enhances workspace quality.
4	Shading	Reduces sunlight exposure, heat ingress by 30%, cooling energy needs, and enhances visual comfort.

Source: Author's Analysis (2024)

Electricity Consumption Reduction

The 2020 GBCI report shows the PUPR Main Building cut electricity use by 30-50% with optimized lighting, special glass, shading, a 28.10 W/m² OTTV, and an H-shaped design [8]. The OTTV of the Ministry PUPR Main Building is well below the national standard of 35 W/m², demonstrating the building's advanced thermal performance [8].

Table 3.1 Comparison of OTTV in Indonesian Government Buildings

No	Building Name	OTTV W/m2
1	Gedung Utama Kementrian PUPR	28.10
2	Gedung Kementerian Kesehatan	41.60
3	Gedung Kemen. Perdagangan	41.90
4	Gedung DPRD DKI Jakarta	34.47
5	Gedung Kementerian Pertahanan	33.40

Source: Author's Analysis (2024)

The OTTV (Overall Thermal Transfer Value) of the Ministry PUPR Main Building, at 28.10 W/m², is well below the national standard of 35 W/m², showcasing advanced thermal performance. This efficiency reduces cooling energy consumption, enhances indoor comfort, and sets a benchmark for sustainable government infrastructure [8].

Design Elements Affecting Electricity Consumption Efficiency

I. Building Massing, designed in the shape of the letter "H."

Figure I.1 Building Form and Orientation of the Main Building of the Ministry of PUPR
Source: Author's Document (2024)

Gibberd (1967) states that the H-shaped design significantly improves spatial efficiency and reduces east-west sunlight exposure, making it particularly suitable for tropical climates [9]. This design minimizes heat gain while optimizing natural ventilation and lighting. Suryabrata (2021) further highlights that redesigning the PUPR Main Building to adopt an H-shaped configuration not only reduced heat exposure but also enhanced the building's ability to utilize natural light effectively. These improvements contributed to a significant boost in energy efficiency, reducing the reliance on artificial cooling and lighting systems while creating a more comfortable and sustainable environment for occupants [5].

Table I.1 Advantages and Disadvantages between Rectangular Shape and H-Shape

Aspek	Advantages	Disadvantages
Rectangular Shape	-Reduces construction costs with a simple structure. -Maximizes land use on smaller plot	-East-west sunlight heats interiors. -Poor ventilation affects central areas.
H-Shape	- Reducing sunlight exposure. -Enhances ventilation and natural light. -Resilience and adapts to rising temperatures	-Higher costs due to complex structure. -Requires larger land than simpler designs.

Source : Author's Analysis (2024)

II. Facade Materials

Figure II.1 Glass Facade with Special Coating
Source : Kementerian PUPR , Laporan Evaluasi Kinerja Bangunan, 2023

This PUPR Building uses 8mm-12mm Stopsol Dark Blue glass, reducing solar heat gain by 45%, maintaining natural lighting, improving energy efficiency, and reducing AC reliance[10].

III. Natural Lightning

North-south windows reduce cooling loads and improve efficiency. Guantio and Pribadi (2020) report that lowering the window-to-wall ratio can save up to 53.51% energy [11].

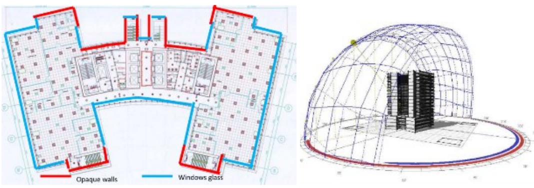

Figure III.1 Placement of glass windows in the Main Building of the Ministry o (PUPR)
Source : Jatmika Adi Suryabrata (2021)

IV. Shading

A. Shading from the "H"-shaped Building Mass Form

Figure IV.1 Shading from the Building Mass and Canopy
Source : Jatmika Adi Suryabrata (2021)

The "H"-shaped building mass serves as a shading element, reducing solar exposure, heat gain, and improving thermal comfort while enhancing aesthetics and maximizing natural lighting [12].

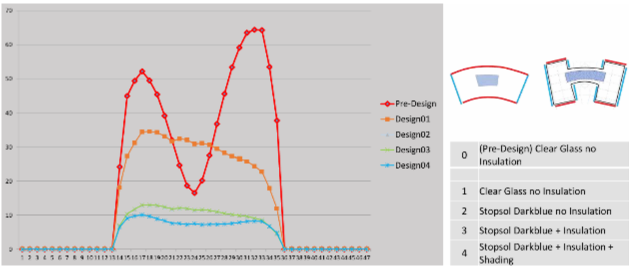

Figure IV.2 Graph Solar Gain Exterior Window (kW) gedung utama kementrian PUPR
Source : d+e Lab (2021)

The PUPR Main Building's canopy reduces solar heat and optimizes natural lighting. The graph shows shading reduces exterior window solar gain by 40%, from 14 kW to 8 kW in Design 3, highlighting its role in minimizing solar heat exposure [12] [13].

Conclusion

This building exemplifies energy-efficient, climate-resilient design for government buildings. The PUPR Main Building's "H"-shaped Massing Building provides shading, maximizes natural lighting, and reduces artificial lighting needs. Coated glass cuts solar heat gain by 45%, stabilizing temperatures and lowering AC use. Shading canopies and natural lighting reduce electricity consumption by 30-50%, while thermal management addresses rising temperatures and supports global carbon reduction goals [14] [15].

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