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Assessment of Building Envelope Thermal Performance Using Overall Thermal Transfer Value (OTTV) at Labuang Baji Hospital, Makassar

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Abstract: *Hospitals are public service buildings with high energy consumption because they operate continuously and require stable thermal comfort. One aspect that affects building energy efficiency is the performance of the building envelope in resisting heat transfer from the outdoor environment. This study examines the Overall Thermal Transfer Value (OTTV) as an indicator of energy efficiency in Building B of Labuang Baji Hospital, Makassar. The assessment was conducted through field observation and measurement of building-envelope parameters, including façade orientation, wall area, glazing area, material type, thermal transmittance, shading conditions, and solar radiation entering the indoor spaces. OTTV analysis was carried out on the fourth, fifth, and sixth floors with reference to SNI 6389:2020, which specifies a maximum OTTV limit of 35 W/m². The results indicate that the average OTTV values ranged from 81.04 W/m² on the fourth floor to 85.93 W/m² on the fifth floor, all of which substantially exceeded the national standard. The northwest façade consistently recorded the highest average OTTV values (92.80–94.03 W/m²), whereas the south façade exhibited the lowest values (69.00–74.38 W/m²), although these also remained well above the allowable limit. These findings demonstrate that the existing building envelope has not yet achieved the required level of thermal efficiency and contributes to increased cooling loads. The results also identify the northwest façade and upper floors as priority targets for energy retrofit interventions. Recommended improvement measures include the use of high-performance glazing, the installation of external shading devices, optimization of the window-to-wall ratio, and improved wall insulation to reduce heat gain and enhance overall building energy efficiency.*

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INTRODUCTION

As a public facility with a strategic role in health services, a hospital is one of the building types with relatively high energy consumption. This is mainly because hospitals operate for 24 hours and require diverse energy services. Energy is not only used to support medical services, such as diagnostic equipment, surgical equipment, sterilization systems, laboratories, intensive care units, and emergency departments, but also to maintain comfort, safety, and building operation through room-temperature control, air quality, lighting, clean-water supply, security systems, elevators, and hospital information systems.

In the context of Labuang Baji Hospital, Makassar, the complexity of building functions and the variety of service units indicate the need for efficient and sustainable energy management. High energy consumption can increase hospital operating costs, while service quality, patient comfort, and environmental safety must remain properly maintained. Therefore, an energy-efficiency study of Labuang Baji Hospital is important to identify energy-use patterns, detect potential sources of energy waste, and formulate optimal energy-saving strategies without reducing the quality of health services.

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Labuang Baji Hospital occupies a land area of 14,404 m² and has a total building area of 22,738.1 m². The inpatient facilities consist of various room types and quantities. Field observations identified five nurse stations, five rest rooms for medical staff, and 81 inpatient rooms consisting of VVIP, VIP, Class I, Class II, Class III, and special-care rooms. The inpatient services are located in Buildings B, C, D, and E, with varying numbers of beds.

The urgency of energy efficiency in hospital buildings is also reflected in the Indonesian Ministry of Energy and Mineral Resources Regulation No. 8 of 2025 on Energy Management. The regulation emphasizes that energy audits constitute a systematic evaluation of energy utilization, including the assessment of energy consumption patterns and the identification of inefficient energy use, as an integral part of implementing energy management. The results of an energy audit provide a technical basis for developing and prioritizing energy conservation measures that improve building energy performance while maintaining the quality and reliability of healthcare services. This approach is consistent with international energy management principles, which recognize energy audits as a fundamental tool for identifying energy-saving opportunities and supporting continuous improvements in energy performance (International Organization for Standardization, 2018).

Energy-saving strategies can also be implemented through improvements to the building envelope. The envelope includes exterior walls, roofs, glazing, windows, doors, ventilation openings, and other building apertures (Guo et al., 2022). In hospital buildings, the building envelope has an important role because it affects the amount of solar heat entering indoor spaces. If the envelope is not designed properly, outdoor heat can easily enter the building and increase indoor temperature. This condition can reduce thermal comfort and cause the air-conditioning system to work harder.

Thermal comfort refers to the condition in which building users feel comfortable with indoor temperature, humidity, air movement, and heat radiation. In hospitals, thermal comfort is highly important because it directly affects patients, healthcare workers, patient families, and visitors (Cui et al., 2024; S. Ma et al., 2023). Rooms that are too hot, humid, or poorly ventilated may cause discomfort and may interfere with the quality of health services. Conversely, rooms with stable temperature, appropriate lighting, and good air circulation can support patient recovery and create a more comfortable working environment for medical staff.

The evaluation of Overall Thermal Transfer Value (OTTV) is therefore important in assessing hospital-building energy efficiency. OTTV is used to estimate the amount of heat transfer through external walls and glazing (Shah et al., 2023). A higher OTTV indicates a greater potential for heat entering the building, while a lower OTTV indicates better envelope performance in resisting heat gain. OTTV analysis can therefore provide a basis for energy-saving strategies, such as selecting suitable wall materials, using energy-efficient glazing, adding shading devices, adjusting opening orientation, and improving façade design. This study focuses on evaluating the thermal performance of the building envelope by referring to SNI 6389:2020 (SNI Nasional, 2020) on energy conservation in building envelopes. The standard sets the maximum allowable OTTV at 35 W/m². OTTV measurements were carried out in a six-storey hospital building with several façade orientations.

Although numerous studies have evaluated the Overall Thermal Transfer Value (OTTV) in office, educational, and commercial buildings, studies focusing on hospital buildings in Indonesia remain very limited. In addition, most previous studies have reported OTTV values only at the whole-building level without providing a detailed comparison across façade orientations and floor levels. Considering that hospitals have unique operational characteristics, continuous occupancy, and high cooling-energy

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demand, a more detailed assessment of the building envelope is required to identify the thermal performance of each façade. Therefore, this study fills this research gap by evaluating the OTTV of Building B at Labuang Baji Hospital based on different façade orientations and floor levels in accordance with SNI 6389:2020. The findings are expected to provide a more comprehensive understanding of the influence of façade orientation on thermal performance and to support evidence-based retrofit strategies for improving energy efficiency in tropical hospital buildings. Unlike previous studies, this research not only assesses compliance with the OTTV standard but also identifies the façade orientations that contribute the greatest thermal loads and establishes priorities for envelope-retrofit strategies. The findings are expected to provide practical guidance for improving the thermal performance and energy efficiency of hospital buildings in tropical climates while contributing additional evidence to the limited body of research on OTTV in Indonesian healthcare facilities.

RESEARCH METHOD

The study was conducted using field observation and direct measurement of several variables, including indoor air temperature, interior wall-surface temperature, outdoor air temperature, wall area, window area, and actual solar radiation entering the room. Field observations were conducted systematically to identify the physical characteristics of the building envelope, including façade orientation, wall construction, glazing configuration, shading conditions, and the dimensions of exterior walls and windows. The collected data were verified through direct site inspections and supported by the architectural drawings of Building B to ensure the accuracy of the measured building-envelope parameters.

The concept of Overall Thermal Transfer Value (OTTV) was first introduced by (ASHRAE, 1975) as an index for evaluating heat transfer through building envelopes. The formulation was later refined by (Chou & Lee, 1988) for application in tropical climates, incorporating three principal heat transfer components: heat conduction through opaque walls, heat conduction through glazing, and solar radiation through glazing. The OTTV calculation covered three main components: wall conduction, glass conduction, and glass radiation. The parameters examined in the OTTV analysis are presented in Table 1.

Table 1. Parameters Measured in the OTTV Analysis

Parameter	Measurement
Wall conduction	Wall orientation (north, south, east, and west); wall area, including opaque wall area and opening area; wall material, such as brick, concrete block, or plaster; U-value based on wall thickness; and exterior surface color, either light or dark.
Glass conduction	Glass size, including length and width; glass type, such as clear or reflective glass; glass thickness, such as 5 mm, 6 mm, or 8 mm; and glass orientation.
Glass radiation	Glass orientation; glass size, including length and width; shading condition, such as canopy, trees, and surrounding buildings; and solar exposure period, such as morning or afternoon.

Source: SNI 6389:2020

The results of the parameter measurements were recorded on a survey form and supported by documentation of field measurements in Building B. Field measurements were carried out using a laser distance meter (measurement accuracy ±2 mm) to determine wall and window dimensions, a digital infrared thermometer (accuracy ±2°C) to measure wall-surface temperatures, and a digital thermo-hygrometer (temperature accuracy ±0.5°C and relative humidity accuracy ±3%) to record indoor and

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outdoor environmental conditions. Façade orientation was determined using a digital compass, while observations of shading conditions and glazing characteristics were conducted through direct visual inspection and photographic documentation. Measurement activities were conducted at Labuang Baji Hospital from 20 May 2024 to 5 August 2024.

The fourth, fifth, and sixth floors were selected because these floors contain the largest concentration of inpatient rooms with different façade orientations and represent the upper levels of Building B that are directly exposed to solar radiation. Compared with the lower floors, these levels experience greater external heat exposure due to reduced obstruction from surrounding buildings and vegetation. Consequently, they provide an appropriate basis for evaluating the influence of façade orientation and floor elevation on the thermal performance of the building envelope.

OTTV analysis was performed on the fourth, fifth, and sixth floors based on the available floor plans and façade orientations. The fourth floor contains 22 inpatient rooms, the fifth floor contains 18 inpatient rooms, and the sixth floor contains 22 inpatient rooms. The calculated OTTV values were then compared with the maximum value specified in SNI 6389:2020, namely 35 W/m². The calculation was conducted using the OTTV spreadsheet issued by the Directorate of Construction Development, Ministry of Public Works and Housing, based on the existing condition of each inpatient room in the General Care Building (Building B).

To ensure data reliability, all field measurements were conducted using the same instruments and standardized measurement procedures throughout the study period. Building-envelope dimensions and façade characteristics were cross-checked with the original architectural drawings, while all OTTV calculations were performed using the standardized spreadsheet provided by the Directorate of Construction Development to ensure consistency with the calculation procedures specified in SNI 6389:2020.

The calculated OTTV values were subsequently analyzed according to façade orientation and floor level to identify variations in thermal performance across the building envelope and to determine façade orientations with the highest potential for solar heat gain. Descriptive statistical analysis was applied to compare OTTV values among façade orientations and floor levels, enabling the identification of the most critical façade zones requiring energy-efficiency improvements.

RESULTS AND DISCUSSION

Energy use in a building is generally associated with lighting and air-conditioning needs. Heat transfer occurs when heat from outside enters indoor spaces through walls, roofs, glazing, doors, ventilation openings, and building gaps. The greater the heat entering the building, the greater the cooling load imposed on the air-conditioning system. As a result, electrical-energy consumption increases. In buildings with a high proportion of glazing, particularly on east- and west-facing façades, solar heat gain tends to increase (Halawa et al., 2018). Consequently, room temperature rises and cooling demand becomes higher. Therefore, the design of openings should consider window size, building orientation, glass type, shading, canopies, louvers, and secondary skins.

Lighting also contributes directly to energy consumption because lamps use electricity. The more lamps are used and the longer they operate, the greater the energy consumption (Elnour et al., 2022). Daylighting can reduce lighting demand during daytime; however, excessive glazing without adequate protection may increase solar heat entering the room. Daylighting therefore needs to be designed in

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a balanced manner: bright enough, free from glare, and not causing excessive heat gain. Good daylighting can reduce the use of artificial lighting but should be controlled through opening orientation, shading, glass type, interior surface color, and room depth (Kapoor et al., 2021).

At the study location, particularly in the inpatient buildings of Labuang Baji Hospital, the façade is dominated by glass materials. The dominant use of glass on the building façade strongly influences the thermal condition of the interior spaces because solar radiation can increase indoor heat gain. As a consequence, the air-conditioning system must work harder to maintain indoor thermal comfort.

Figure 1. North and northwest façade orientations of Building B, Labuang Baji Hospital

OTTV Analysis on the Fourth Floor of Building B

Figure 2 shows the fourth-floor plan of Building B and the location of the inpatient rooms. On this floor, the inpatient rooms are distributed across four façade orientations: north, northwest, southeast, and south.

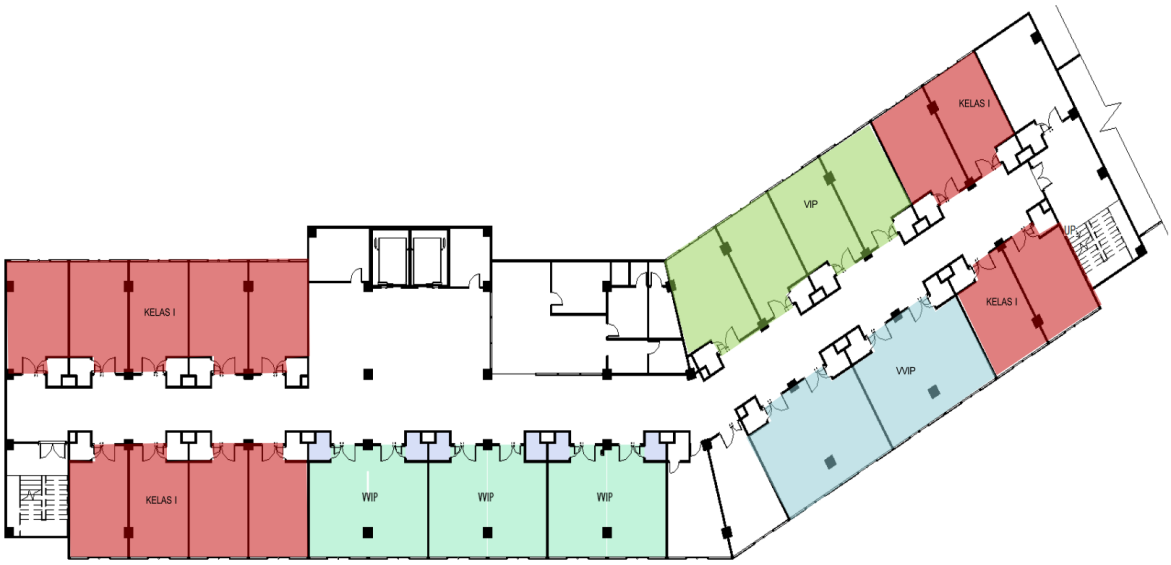

Figure 2. Fourth-Floor Plan of Building B

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Table 2. OTTV Values for Inpatient Rooms On The Fourth Floor

Location	Maximum	Minimum	Number of rooms	Average
North	84.67	79.05	7	81.79
Northwest	96.23	92.00	4	94.03
Southeast	80.45	76.87	6	79.35
South	70.24	67.24	5	69.00
Average OTTV on the fourth floor				**81.04**

The OTTV values for the north-facing façade on the fourth floor range from 79.05 to 84.67 W/m², with an average value of 81.79 W/m². The relatively small fluctuation indicates that the thermal characteristics of the north-facing envelope are relatively uniform. The northwest-oriented rooms show the highest OTTV values on this floor, ranging from 92.00 to 96.23 W/m², with an average value of 94.03 W/m². This indicates that the northwest façade receives greater heat gain than the other orientations.

For the southeast-facing façade, the OTTV values range from 76.87 to 80.45 W/m², with an average value of 79.35 W/m². The south-facing façade produces the lowest values, ranging from 67.24 to 70.24 W/m², with an average of 69.00 W/m². Overall, the average OTTV of the fourth floor is 81.04 W/m². Although this is lower than the averages on the fifth and sixth floors, all values remain above the maximum limit of 35 W/m² specified in SNI 6389:2020.

The relatively consistent OTTV values observed within each façade orientation indicate that the thermal performance of the fourth-floor envelope is primarily governed by façade orientation rather than by local variations among individual rooms. However, the noticeable differences between orientations demonstrate that solar exposure remains the dominant factor influencing heat transfer through the building envelope. These results provide a clear basis for identifying façade orientations that should be prioritized in future energy retrofitting strategies, particularly those with the highest thermal loads (Ascione et al., 2013; Z. Ma et al., 2012).

OTTV Analysis on the Fifth Floor of Building B

The fifth floor of Building B contains 18 inpatient rooms distributed across three façade orientations: north, northwest, and southeast. The floor plan is shown in Figure 3.

Figure 3. Fifth-Floor Plan of Building B

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Table 3. OTTV Values for Inpatient Rooms On The Fifth Floor

Location	Maximum	Minimum	Number of rooms	Average
North	83.74	81.86	6	82.79
Northwest	94.12	92.05	4	92.80
Southeast	90.15	78.15	6	82.20
Average OTTV on the Fifth floor				**85.93**

The north-facing façade on the fifth floor has OTTV values ranging from 81.86 to 83.74 W/m², with an average of 82.79 W/m². The values for the northwest-facing rooms range from 92.05 to 94.12 W/m², with an average of 92.80 W/m². The small variation of approximately 2 W/m² indicates that the thermal characteristics of the northwest façade on this floor are relatively uniform. The southeast façade shows a wider range of OTTV values, from 78.15 to 90.15 W/m², with an average of 82.20 W/m². The highest value was observed at one measurement point, indicating possible differences in façade characteristics, such as a larger glazing area, different material properties, or limited shading. Overall, the average OTTV value on the fifth floor is 85.93 W/m², which is the highest average among the three observed floors. All façade orientations on this floor exceed the OTTV standard limit.

The fifth-floor exhibits the highest average OTTV among all observed floors, indicating that this level experiences the greatest thermal load through the building envelope. This finding suggests that the upper floor is more vulnerable to solar heat gain, which may be influenced by greater exposure to solar radiation, reduced shading from surrounding structures, and the combined effects of roof and façade heat transfer. Consequently, the fifth floor should be prioritized in future building envelope improvement strategies, as reducing heat gain at this level could significantly enhance the overall thermal performance and energy efficiency of the hospital building. Similar findings have been reported by (Zune et al., 2021), who emphasized that upper floors in tropical buildings generally experience higher cooling loads due to increased solar exposure. Likewise, the (International Energy Agency, 2021) highlighted those targeted improvements to building envelopes, particularly on highly exposed façades and upper floors, are among the most effective strategies for reducing cooling energy demand and improving building energy performance.

OTTV Analysis on the Sixth Floor of Building B

The sixth floor of Building B contains inpatient rooms facing north, northwest, southeast, and south. The floor plan is shown in Figure 4.

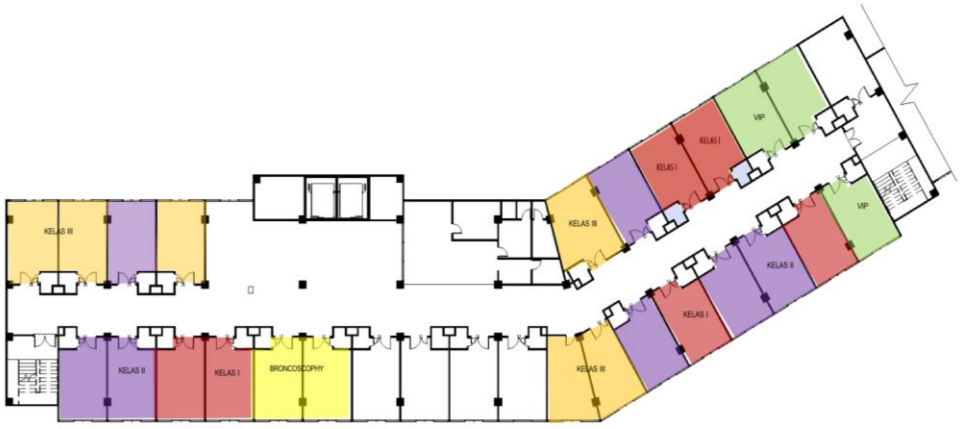

Figure 4. Sixth-Floor Plan of Building B

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Table 4. OTTV Values for Inpatient Rooms On The Sixth Floor

Location	Maximum	Minimum	Number of rooms	Average
North	82.84	81.86	3	82.38
Northwest	94.35	92.14	6	93.66
Southeast	89.14	80.35	8	82.25
South	78.87	69.45	4	74.38
Average OTTV on the Sixth floor				**83.17**

The OTTV values on the north-facing façade of the sixth floor range from 81.86 to 82.84 W/m², with an average of 82.38 W/m². The relatively small variation indicates a uniform thermal condition on this façade. The northwest-facing façade also shows relatively consistent values, ranging from 92.14 to 94.35 W/m², with an average of 93.66 W/m². A different pattern is observed on the southeast and south façades. The southeast façade ranges from 80.35 to 89.14 W/m², while the south façade ranges from 69.45 to 78.87 W/m². The wider range indicates more diverse façade conditions, which may relate to variations in glazing area, shading, or local exposure to solar radiation. On the sixth floor, the northwest façade produces the highest average OTTV, followed by the north, southeast, and south façades. The south façade has the lowest average, but its value still exceeds the standard limit.

Although the south façade demonstrates better thermal performance than the other orientations, its OTTV value remains substantially higher than the maximum limit of specified. This finding indicates that the existing building envelope has not yet achieved the required level of thermal efficiency. Therefore, strategies to improve the thermal performance of the building envelope should be considered, including optimizing the window-to-wall ratio (WWR), utilizing high-performance glazing, enhancing wall insulation, and incorporating external shading devices (Bellia et al., 2013). These measures can effectively reduce heat transfer through the building envelope, lower cooling loads, and ultimately improve the overall energy efficiency of the building (Zahari et al., 2023).

Discussion

The recapitulation of the results of the OTTV analysis at Building B of Labuang Baji Hospital is presented in Table 5.

Table 5. Summary of OTTV Values for Building B

Floor	Average OTTV (W/m²)	Highest orientation	Lowest orientation
Fourth floor	81.04	Northwest (94.03 W/m²)	South (69.00 W/m²)
Fifth floor	85.93	Northwest (92.80 W/m²)	Southeast (82.20 W/m²)
Sixth floor	83.17	Northwest (93.66 W/m²)	South (74.38 W/m²)

The OTTV results for the three observed floors show that all values exceed the maximum limit of 35 W/m². The fifth floor records the highest average OTTV, followed by the sixth and fourth floors. The lower average value on the fourth floor may be influenced by local shading effects, façade geometry, different glazing proportions, or the relative position of adjacent building elements. Although some vegetation may contribute to shading, at a floor elevation of approximately 10–12 m the shading effect from trees is likely to be limited unless the trees have tall and dense canopies close to the façade. Therefore, shading from surrounding building masses, roof overhangs, balconies, canopies, or projecting façade elements is a more plausible explanation for reduced direct solar radiation on certain parts of the fourth-floor façade. These passive architectural elements can effectively intercept incident solar radiation before it reaches the building envelope, thereby reducing solar heat gain, lowering cooling loads, and enhancing the thermal performance of the façade. Such

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passive design strategies are widely recognized as effective approaches for improving building energy performance in tropical climates, where solar radiation is the primary source of external heat gain (Al-Masrani & Al-Obaidi, 2019; Chaitanya et al., 2018).

The comparison among orientations indicates that façade orientation strongly affects the magnitude of heat transfer through the building envelope. The northwest façade consistently produces the highest OTTV values across all observed floors. This condition can be attributed to greater afternoon solar exposure, during which both incident solar radiation and outdoor air temperature are typically at their highest levels. Consequently, west- and northwest-facing façades experience higher solar heat gains, leading to increased thermal loads on the building envelope (Lionar et al., 2024; Szokolay, 2012). Consequently, the heat gain transmitted through walls and glazing becomes greater. In contrast, the south façade produces the lowest OTTV values because it receives relatively lower direct solar exposure compared with the northwest façade. However, the south-facing values are still far above the standard, indicating that the façade cannot yet be categorized as thermally efficient.

The difference between north- and south-facing façades also confirms the role of solar-radiation intensity in OTTV. Where the wall material, glazing type, window-to-wall ratio, and shading coefficient are similar, the orientation with a higher solar factor will tend to produce a higher OTTV (A. L. S. Chan, 2023; L. S. Chan, 2021). In this study, the north-facing façade generally produced higher OTTV values than the south-facing façade on floors where both orientations were present. This suggests that solar radiation through glazing is an important contributor to the OTTV of Building B.

The high OTTV values across all orientations indicate that heat transfer is not affected by orientation alone. Other envelope characteristics, including the window-to-wall ratio, wall and glass thermal transmittance, shading coefficient, exterior surface absorptance, and the absence or inadequacy of external shading devices, also contribute to the high OTTV values. Studies on tropical buildings have shown that window-to-wall ratio, glazing properties, shading, orientation, and façade configuration are key factors influencing cooling energy demand and building thermal performance . (Gupta & Deb, 2023; Irvandi et al., 2021).

As a healthcare building that operates continuously, the high OTTV values may increase the cooling load and electrical-energy consumption of the air-conditioning system. Therefore, improving the thermal performance of the building envelope is necessary. Recommended strategies include using high-performance or low-emissivity glazing, adding external shading devices according to façade orientation, applying secondary skins on façades exposed to high solar radiation, reducing the window-to-wall ratio in selected areas, and improving wall insulation. These measures are expected to reduce heat gain, lower the cooling demand, and improve the energy efficiency of Building B without compromising the thermal comfort of patients, healthcare workers, and visitors.

Compared with previous OTTV studies conducted on office, commercial, and educational buildings in tropical climates, the OTTV values obtained in this study are considerably higher. (A. L. S. Chan, 2023) reported that buildings with optimized façade design and appropriate shading generally achieved lower OTTV values, while (Shah et al., 2023) demonstrated that improvements in glazing performance and window-to-wall ratio significantly reduced heat transfer through building envelopes. In contrast, the average OTTV values of Building B at Labuang Baji Hospital ranged from 81.04 to 85.93 W/m², more than twice the maximum allowable value specified in SNI 6389:2020. These

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findings indicate that the existing building envelope is still highly susceptible to solar heat gain and requires substantial improvements to enhance its thermal performance. Furthermore, unlike most previous studies that evaluated OTTV at the whole-building level, this study provides a more detailed assessment by comparing thermal performance across different façade orientations and floor levels. This approach enables the identification of façade zones with the greatest thermal loads, thereby providing more practical information for prioritizing building-envelope retrofit strategies in tropical hospital buildings.

The present findings also demonstrate that façade orientation alone cannot fully explain the thermal performance of hospital buildings. Although the northwest façade consistently recorded the highest OTTV values, differences within the same orientation indicate that glazing proportion, façade configuration, and shading conditions also contribute substantially to heat transfer. Therefore, building-envelope retrofit strategies should adopt an integrated approach that simultaneously considers orientation, glazing performance, window-to-wall ratio, and external shading rather than relying solely on orientation-based interventions.

From a practical perspective, the results of this study provide building managers and hospital authorities with a clear priority for implementing energy-efficiency improvements. Rather than applying retrofit measures uniformly across the building, interventions can first be focused on the northwest façade and upper floors, where the thermal loads are highest. Such a priority-based retrofit strategy is expected to produce greater energy savings while minimizing renovation costs.

CONCLUSION

Based on the OTTV assessment of Building B at Labuang Baji Hospital, Makassar, the thermal performance of the building envelope has not yet met the energy-conservation requirement. Heat transfer through walls and glazing remains high, which may increase cooling loads and building electrical-energy consumption. Façade orientation has a clear influence on OTTV. The northwest façade is the orientation with the highest OTTV values on all observed floors, making it the most vulnerable part of the building to solar heat gain. In contrast, the south façade produces the lowest OTTV values, although it still exceeds the maximum allowable limit. In addition to orientation, the high OTTV values are influenced by the proportion of glazing, the thermal properties of wall and glass materials, thermal transmittance, shading coefficient, exterior surface characteristics, and the limited use of effective shading devices. Therefore, energy-efficiency improvements should prioritize envelope-retrofit strategies, especially on the northwest façade, through the use of energy-efficient glazing, external shading, secondary skins, reduced window-to-wall ratio, and improved wall insulation.

This study is limited to the evaluation of the thermal performance of the building envelope in Building B of Labuang Baji Hospital using the OTTV method based on SNI 6389:2020. The analysis did not include other factors affecting overall building energy performance, such as HVAC system efficiency, lighting systems, occupant behavior, operational schedules, or whole-building energy consumption. Future studies are recommended to integrate OTTV analysis with dynamic building-energy simulation, cooling-load assessment, and comprehensive energy audits to provide a more holistic evaluation of hospital energy performance. Furthermore, future research should investigate the effectiveness of various façade-retrofit strategies, including high-performance glazing, external

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shading devices, secondary-skin systems, and improved wall insulation, in reducing OTTV and cooling-energy demand in tropical hospital.

REFERENCES

Al-Masrani, S. M., & Al-Obaidi, K. M. (2019). Dynamic shading systems: A review of design parameters, platforms and evaluation strategies. *Automation in Construction*, *102*, 195–216. https://doi.org/10.1016/j.autcon.2019.01.014

Ascione, F., Bianco, N., De Masi, R. F., & Vanoli, G. P. (2013). Rehabilitation of the building envelope of hospitals: Achievable energy savings and microclimatic control on varying the HVAC systems in Mediterranean climates. *Energy and Buildings*, *60*, 125–138. https://doi.org/10.1016/j.enbuild.2013.01.021

ASHRAE. (1975). *ASHRAE Standard 90-75: Energy conservation in new building design.*

Badan Standardisasi Nasional**.** (2020). *SNI 6389:2020. Konservasi energi selubung bangunan pada bangunan gedung.*

Bellia, L., De Falco, F., & Minichiello, F. (2013). Effects of solar shading devices on energy requirements of standalone office buildings for Italian climates. *Applied Thermal Engineering*, *54*(1), 190–201. https://doi.org/10.1016/j.applthermaleng.2013.01.039

Chaitanya, B., Bahadur, V., Thakur, A. D., & Raj, R. (2018). Biomass-gasification-based atmospheric water harvesting in India. *Energy*, *165*, 610–621. https://doi.org/10.1016/j.energy.2018.09.183

Chan, A. L. S. (2023). Evaluating the appropriateness of adopting a single Overall Thermal Transfer Value and its implication to building energy regulation. *Journal of Building Engineering*, *76*, 107225. https://doi.org/10.1016/j.jobe.2023.107225

Chan, L. S. (2021). Investigating the thermal performance and Overall Thermal Transfer Value (OTTV) of air-conditioned buildings under the effect of adjacent shading against solar radiation. *Journal of Building Engineering*, *44*, 103211. https://doi.org/10.1016/j.jobe.2021.103211

Chou, S. K., & Lee, Y. K. (1988). A simplified Overall Thermal Transfer Value equation for building envelopes. *Energy*, *13*(8), 657–670. https://doi.org/10.1016/0360-5442(88)90096-5

Cui, H., Zhang, L., Yang, H., & Shi, Y. (2024). Optimizing thermal comfort and energy efficiency in hospitals with PCM-enhanced wall systems. *Energy and Buildings*, *323*, 114740. https://doi.org/10.1016/j.enbuild.2024.114740

Elnour, M., Fadli, F., Himeur, Y., Petri, I., Rezgui, Y., Meskin, N., & Ahmad, A. M. (2022). Performance and energy optimization of building automation and management systems: Towards smart sustainable carbon-neutral sports facilities. *Renewable and Sustainable Energy Reviews*, *162*, 112401. https://doi.org/10.1016/j.rser.2022.112401

Guo, S., Wang, W., & Zhou, Y. (2022). Research on energy saving and economy of old buildings based on parametric design: A case study of a hospital in Linyi City, Shandong Province. *Sustainability*, *14*(24), 16681. https://doi.org/10.3390/su142416681

Gupta, V., & Deb, C. (2023). Envelope design for low-energy buildings in the tropics: A review. *Renewable and Sustainable Energy Reviews*, *186*, 113650. https://doi.org/10.1016/j.rser.2023.113650

Halawa, E., Ghaffarianhoseini, A., Ghaffarianhoseini, A., Trombley, J., Hassan, N., Baig, M., Yusoff, S. Y., & Ismail, M. A. (2018). A review on energy conscious designs of building façades in hot and humid climates: Lessons for (and from) Kuala Lumpur and Darwin. *Renewable and Sustainable Energy Reviews*, *82*, 2147–2161. https://doi.org/10.1016/j.rser.2017.08.061

International Energy Agency. (2021). *Energy efficiency 2021*. https://www.iea.org/reports/energy-efficiency-2021

International Organization for Standardization. (2018). *ISO 50001:2018. Energy management systems—Requirements with guidance for use.*

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Irvandi, M., Soebiyan, V., & Tomasowa, R. (2021). OTTV based shading devices optimization for multi-storey building in tropical Jakarta. *IOP Conference Series: Earth and Environmental Science*, *794*(1), Article 012239. https://doi.org/10.1088/1755-1315/794/1/012239

Kapoor, N. R., Kumar, A., Meena, C. S., Kumar, A., Alam, T., Balam, N. B., & Ghosh, A. (2021). A systematic review on indoor environmental quality in naturally ventilated school classrooms: A way forward. *Advances in Civil Engineering*, *2021*, Article 8851685. https://doi.org/10.1155/2021/8851685

Lionar, R., Kroll, D., Soebarto, V., Sharifi, E., & Aburas, M. (2024). A review of research on self-shading façades in warm climates. *Energy and Buildings*, *314*, 114203. https://doi.org/10.1016/j.enbuild.2024.114203

Ma, S., Deng, W., Lu, J., Zhou, T., & Liu, B. (2023). Investigation of thermal comfort and preferred temperatures for healthcare staff in hospitals in Ningbo, China. *Journal of Building Engineering*, *80*, 108029. https://doi.org/10.1016/j.jobe.2023.108029

Ma, Z., Cooper, P., Daly, D., & Ledo, L. (2012). Existing building retrofits: Methodology and state-of-the-art. *Energy and Buildings*, *55*, 889–902. https://doi.org/10.1016/j.enbuild.2012.08.018

Shah, I., Soh, B., Lim, C., Lau, S.-K., & Ghahramani, A. (2023). Thermal transfer and temperature reductions from shading systems on opaque facades: Quantifying the impacts of influential factors. *Energy and Buildings*, *278*, 112604. https://doi.org/10.1016/j.enbuild.2022.112604

Szokolay, S. (2012). *Introduction to architectural science: The basis of sustainable design* (3rd ed.). Routledge.

Zahari, A. F., Mulyadi, R., & Jamala, N. (2023). The effect of shading devices on OTTV (Overall Thermal Transfer Value) value of office buildings: Case study of PT Industri Kapal Indonesia (IKI) Building. *ASTONJADRO*, *12*(3), 868–885. https://doi.org/10.32832/astonjadro.v12i3.14255

Zune, M., Tubelo, R., Rodrigues, L., & Gillott, M. (2021). Improving building thermal performance through an integration of Passivhaus envelope and shading in a tropical climate. *Energy and Buildings*, *253*, 111521. https://doi.org/10.1016/j.enbuild.2021.111521

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