

Effect of glass type variation on overall thermal transfer value (OTTV) and HVAC energy consumption: a case study of the Bank Syariah Indonesia building

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ABSTRACT

The building envelope, particularly façade glazing, is a main pathway for solar heat gain into a building, which can increase the Overall Thermal Transfer Value (OTTV), cooling load, and HVAC energy consumption. This study aims to analyse the effect of glass type variation on OTTV values and cooling system energy consumption in the Bank Syariah Indonesia building. The study employs a quantitative method through simulation-based calculations in accordance with SNI 6389:2020. The analysed glass variations include clear glass (existing condition), tinted glass, and coated glass. The research team obtained data through field observations, interviews with building management, and documentation reviews. The results show that the OTTV value under the existing condition is 27.47 W/m². Tinted glass reduces the OTTV value to 25.40 W/m², while coated glass yields the lowest OTTV value of 25.10 W/m². This reduction in OTTV leads to lower cooling loads and reduced cooling system energy consumption compared to the existing condition. Based on the results, coated glass is the most effective alternative because it produces the lowest OTTV value and offers greater energy-saving potential for office buildings.

Keywords: Overall thermal transfer value (OTTV), glass type, energy consumption, cooling system, office building.

INTRODUCTION

The building sector contributes significantly to energy consumption, particularly in air-conditioned buildings. In office buildings in tropical regions such as Indonesia, a large portion of electrical energy is used to operate air-conditioning systems because of the high solar radiation the building envelope receives. As a tropical country, Indonesia has substantial solar radiation potential, with an average solar insolation of approximately 4.5 kWh/m²/day (Rozak et al., 2023). This condition also contributes to the high solar heat load on building envelopes, including façade

glazing. One component of the building envelope that significantly affects heat transfer is the glazing on the façade. Glass characteristics, such as the shading coefficient (SC) and heat transmittance, influence the amount of solar heat entering the building, thereby affecting the Overall Thermal Transfer Value (OTTV), cooling load, and cooling system energy consumption (Utama & Setyowati, 2022).

SNI 6389:2020 stipulates that the maximum OTTV for air-conditioned buildings in Indonesia is 35 W/m², as part of efforts to improve building energy

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efficiency (Nasional, 2020). One way to meet this requirement is to select a glass type that reduces heat transfer without compromising daylighting (Widyakusuma, 2025). Therefore, evaluating glass-type variations is important for identifying more energy-efficient building envelope materials.

Several previous studies have shown that the use of glass with better thermal characteristics can reduce OTTV values and lower cooling energy demand (Kurniawan et al., 2023; Mukhtar et al., 2023; Wibowo et al., 2020). However, these studies were generally conducted on buildings and façade conditions different from one another, so the effectiveness of each glass type still needs to be examined in buildings with different characteristics.

Previous studies have examined the effect of glass type on OTTV values across different building types. Aseani et al. (2019) found that the use of tinted Panasap glass in the Central Java PMI Training Building produced varying OTTV values across wall orientations, with the highest value occurring on the façade side receiving the greatest direct solar radiation (Aseani et al., 2019). Another study by Utama and Setyowati (2022) on a multi-story building showed that selecting appropriate façade glass can be an effective energy-conservation strategy for reducing OTTV values while lowering the building's energy consumption. Meanwhile, a study by Akmal (2024) on the Sopo Del Tower high-rise building produced more complex findings: the use of Stopray-type glass alone did not have a significant effect on energy efficiency, whereas the combination of Stopray glass and horizontal shading elements was shown to significantly affect the reduction of OTTV values (Akmal, 2025). These differing results across studies indicate that the effectiveness of a given glass type in reducing OTTV depends strongly on building characteristics, façade

orientation, and other accompanying envelope elements, meaning findings from one building cannot be generalised to another without caution. This underscores the need for further research on glass type variation in buildings with different characteristics, including office buildings such as the Bank Syariah Indonesia building.

This study aims to analyse the effect of clear glass, tinted glass, and coated glass on OTTV values and cooling system energy consumption in the Bank Syariah Indonesia building, using the calculation method specified in SNI 6389:2020. The findings are expected to serve as a reference for selecting more efficient glass materials to improve the building's thermal performance and support energy conservation efforts in office buildings.

METHODOLOGY

This study was conducted at the Bank Syariah Indonesia building located in Bandung City. The building has an area of approximately 900 m² and uses 14 split cassette-type air-conditioning units. Based on field observations, the building uses clear glass as its existing glazing, so the OTTV value was first analysed under this condition before simulating tinted and coated glass. This building was selected as the research object because it is an office building with glass façades, making it potentially exposed to solar radiation that can affect its Overall Thermal Transfer Value (OTTV). The analysis focuses on the building envelope, covering the walls and glazing, based on the existing condition. The data collected include building orientation, wall area, glass area, glass type, wall material, and air-conditioning system specifications.

Table 1. Comparison of shading coefficient values across different glass types (Ahmed & Fikry, 2019)

Glass type	Shading coefficient
Single Clear	0.69–0.73
Tinted Gray	0.48–0.60
Coated HP Green	0.33



Figure 1. Research Object: Bank Syariah Indonesia Building, Bandung

This study uses a quantitative, simulation-based approach to analyse the effect of glass-type variation on the Overall Thermal Transfer Value (OTTV) and cooling system energy consumption in the Bank Syariah Indonesia building. The analysis followed SNI 6389:2020 on Building Envelope Energy Conservation for Building Structures.

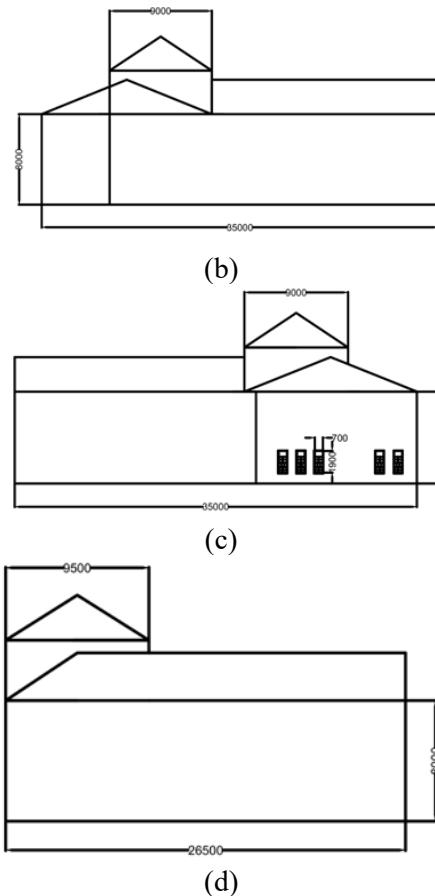
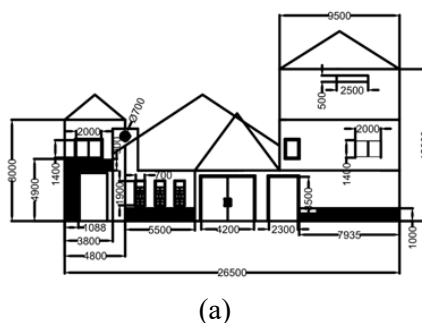


Figure 2. As-Built Drawings of the Building Façades: (a) East, (b) North, (c) South, (d) West

The north and west facades are designed without window openings ($WWR = 0$). Consequently, solar heat gain and glazing conduction components for these orientations are zero, leaving the OTTV calculation dependent solely on the thermal properties of the opaque wall.

Research data were obtained through field observation, interviews with building management, documentation studies, and the collection of technical building data, including building dimensions, wall and glass area, façade orientation, building envelope material specifications, and cooling system data. These data were used to calculate the OTTV value for each façade orientation (Usman & Abdullah, 2023).

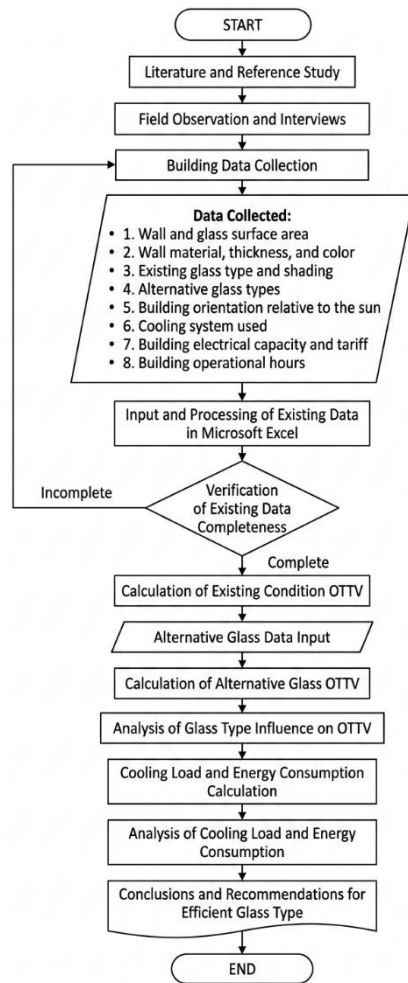


Figure 3. Flowchart of the study methodology for building OTTV and energy performance analysis

The study began with a literature review on building energy conservation and the OTTV calculation method based on SNI 6389:2020. The study then conducted field observations to obtain data on the existing condition of the Bank Syariah Indonesia building. The data were subsequently processed using Microsoft Excel to calculate the OTTV value under the existing condition. Simulations were then carried out by replacing the glass type with tinted glass and coated glass, while keeping all other building parameters unchanged. The OTTV value obtained for each glass type was used to calculate the cooling load

and energy consumption, which were then compared to determine the most efficient glass type.

The OTTV value was calculated using the equation specified in SNI 6389:2020, which accounts for heat transfer through the wall (conduction), heat transfer through the glass (conduction), and solar radiation transmitted through the glass.

The OTTV equation according to SNI 6389:2020 is presented in Equation (1):

$$OTTV = \alpha[(U_w \times (1 - WWR) \times TD_{Ek}) + (U_f \times WWR \times \Delta T) + (SC \times WWR \times SF)] \quad (1)$$

The OTTV value obtained is then used to calculate the cooling load contributed by the building envelope, as shown in Equation (2):

$$Q_{env} = OTTV \times A_{env} \quad (2)$$

where Q_{env} is the cooling load from the building envelope (W), and A_{env} is the total area of the building envelope (m^2). The electrical energy consumption is subsequently calculated based on the cooling load and the Coefficient of Performance (COP) of the air-conditioning system, as shown in Equation (3):

$$P_{AC,env} = Q_{env}/COP_{AC} \quad (2)$$

where $P_{AC,env}$ is the electrical power consumed by the air-conditioning system to offset the envelope cooling load (W), and COP_{AC} is the Coefficient of Performance of the air-conditioning system.

Finally, the annual energy consumption is calculated using Equation (4):

$$E_{AC,env} = P_{AC,env} \times t_{day} \times t_{year} \quad (2)$$

where $E_{AC,env}$ is the annual energy consumption (Wh/year), $P_{AC,env}$ is the electrical power (W), t_{day} is the daily operating hours (hours/day), and t_{year} is

the total number of operating days per year (days/year).

The calculation results were then compared to determine the effect of using clear glass, tinted glass, and coated glass on OTTV values, cooling load, and energy consumption.

RESULT AND DISCUSSION

OTTV Calculation

Table 1 presents the OTTV calculation results for each building façade orientation under the existing condition (clear glass), compared with the two glass substitution scenarios: tinted glass and coated glass.

Table 2. Comparison of OTTV across building facades for baseline clear glass and alternative glazing types

Building Façade	Existing Partial OTTV (Clear Glass) (W/m ²)	Option 1 Partial OTTV (Tinted Glass) (W/m ²)	Option 2 Partial OTTV (Coated Glass) (W/m ²)
East	37.02	27.37	25.98
North*	24.39	24.39	24.39
South	26.9	25.94	25.81
West*	24.39	24.39	24.39
Total Building OTTV	27.47	25.4	25.1

*Has no glazing

The results show that the East façade contributes the highest OTTV value under the existing condition, reaching 37.02 W/m², which is considerably higher than the North, South, and West facades. Variations in glazing specifications do not alter the OTTV values for the north and west elevations. Because these façades have no fenestration (WWR = 0), thermal transfer remains constant and is dictated entirely by opaque wall conduction.

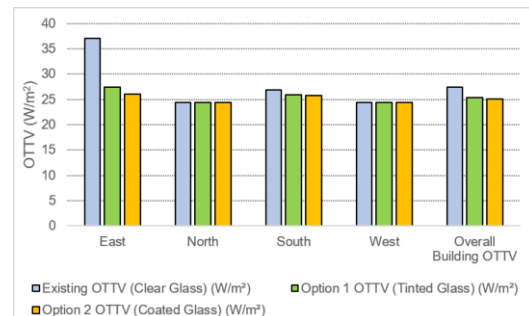


Figure 4. OTTV Values by Building Façade Orientation for Existing (Clear Glass), Option 1 (Tinted Glass), and Option 2 (Coated Glass)

This is likely because the East orientation receives more direct morning solar radiation, resulting in greater solar heat gain through the clear glass. Substituting clear glass with tinted glass substantially reduces the East façade's OTTV value from 37.02 W/m² to 27.37 W/m², while coated glass achieves an even lower value of 25.98 W/m², indicating its superior ability to reduce solar heat transmission on the most heat-exposed façade. In contrast, the North and West façades show no change in OTTV (24.39 W/m²) across all three glass types, suggesting these orientations already receive minimal solar radiation under the existing condition, making the choice of glass type less influential in those directions. The South façade shows a modest reduction, from 26.9 W/m² to 25.94 W/m² with tinted glass and 25.81 W/m² with coated glass. At the building level, the overall OTTV decreases from 27.47 W/m² in the existing condition to 25.4 W/m² with tinted glass and further to 25.1 W/m² with coated glass — both values already well below the SNI 6389:2020 maximum threshold of 35 W/m². These results indicate that although the existing building already complies with the national OTTV standard, coated glass provides the most effective improvement in thermal performance, particularly on façades with high solar exposure, such as the East orientation.

Effect of OTTV on Cooling Load

Table 3 presents the overall building envelope heat gain resulting from each glazing scenario, calculated based on the total envelope area and the corresponding OTTV value.

Table 3. Calculated building envelope heat gain and thermal transfer performance under existing and alternative glazing types

Glazing Scenario	OTTV (W/m ²)	Total Envelope Area (m ²)	Envelope Heat Gain (kW)
Existing / Baseline (Clear Glass)	27.47	1,083.20	29.75
Option 1 (Tinted Glass)	25.4	1,083.20	27.51
Option 2 (Coated Glass)	25.1	1,083.20	27.19

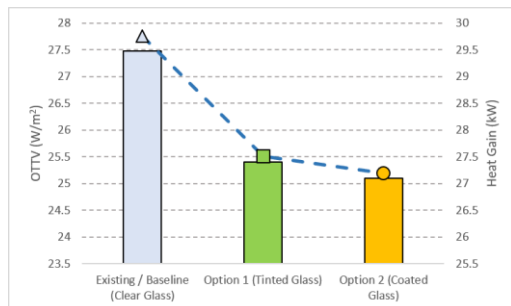


Figure 5. Relationship Between OTTV and Heat Gain for the Existing Condition, Option 1 (Tinted Glass), and Option 2 (Coated Glass)

As shown in Table 3 and Fig. 5, because the total envelope area remains constant at 1,083.20 m² across all three scenarios, envelope heat gain follows the same declining trend as OTTV. The

baseline condition with clear glass produces the highest envelope heat gain (29.75 kW), corresponding to an OTTV of 27.47 W/m². Substituting clear glass with tinted glass (Option 1) reduces envelope heat gain to 27.51 kW, a decrease of about 2.24 kW (7.5%) relative to the baseline. Coated glass (Option 2) further reduces heat gain to 27.19 kW, an 8.6% decrease from the baseline and the lowest heat gain among the three scenarios, despite only a marginal difference from Option 1 (0.32 kW, or roughly 1.2%).

Rather than a uniform reduction across the building, these energy savings are strongly driven by façade orientation, Window-to-Wall Ratio, and the glass's thermo-optical properties. Because the North and West elevations have no windows, thermal transfer on these facades remains static and depends entirely on opaque wall conduction. Consequently, the observed overall thermal performance gains are localised entirely to the fenestrated East and South elevations. Decreasing the Shading Coefficient and U-value in Options 1 and 2 directly mitigates solar radiation heat gain and fenestration conduction on these sun-exposed orientations. These results indicate that low-SC coated glass is the most effective intervention for controlling envelope heat gain, though tinted glass captures the majority of the potential thermal load reduction.

Impact of OTTV on Energy Consumption

Table 4 presents the electrical energy consumption of the air-conditioning system attributable to the building envelope heat gain for each glazing scenario.

Table 4. Electrical Energy Consumption Savings of the Air-Conditioning System for Each Glazing Scenario

Condition	Envelope Heat Gain (kW)	Average COP*	$P_{AC,env}$ (kW)	$E_{AC,env}$ (kWh/year) **
Existing OTTV (Clear Glass)	29.75	3.27	9.1	24,564.70
Option 1 OTTV (Tinted Glass)	27.51	3.27	8.41	22,714.90
Option 2 OTTV (Coated Glass)	27.19	3.27	8.31	22,448.00

* The average COP of split-type air conditioners based on nameplate specifications

** Annual operating hours are assumed to be 2700 hours, based on 10 working hours per day over 270 days per year.

As shown in Table 4, the reduction in envelope heat gain achieved by tinted and coated glass translates directly into lower electrical power demand and annual energy consumption for the air-conditioning system. Under the existing condition (clear glass), the system requires 9.1 kW to offset the envelope heat gain, resulting in an annual consumption of 24,564.70 kWh. Substituting clear glass with tinted glass (Option 1) reduces the power demand to 8.41 kW and the annual consumption to 22,714.90 kWh (approximately 7.5%) compared to the baseline. Coated glass (Option 2) provides further improvement, lowering power demand to 8.31 kW and annual consumption to 22,448.00 kWh (approximately 8.6%). When compared with a related study by Efiariza et al. (2025) on the Student Activity Centre (PUSGIWA) building at Universitas Indonesia, which reduced its OTTV value from 37.80 W/m² to 28.96 W/m² (about 23.4%) by replacing clear glass with a low-reflective, low-emissivity coated glass, the energy saving achieved in the present study (8.6%) is comparatively modest (Efiariza et al., 2025). This difference is reasonable because the Bank Syariah Indonesia

building's existing OTTV (27.47 W/m²) already complied with the SNI 6389:2020 threshold of 35 W/m² before any glass substitution, leaving considerably less room for improvement than a building such as PUSGIWA UI, whose existing envelope exceeded the standard. Nevertheless, both studies consistently show that replacing clear glass with coated or low-emissivity glass is an effective passive strategy for reducing OTTV, cooling load, and associated electrical energy, regardless of a building's initial compliance status.

CONCLUSION

The analysis showed that glass type variations in the Bank Syariah Indonesia building affect OTTV, cooling load, and cooling system energy consumption. The existing OTTV value using clear glass was 27.47 W/m², which already complied with the SNI 6389:2020 threshold of 35 W/m². Nevertheless, substituting clear glass with tinted glass reduced the OTTV value to 25.4 W/m², while coated glass produced the lowest OTTV value of 25.1 W/m². This reduction in OTTV directly decreased the envelope heat gain from 29.75 kW under the existing condition to

27.51 kW with tinted glass and 27.19 kW with coated glass, which in turn lowered the cooling system's electrical energy consumption from 24,564.70 kWh/year to 22,448.00 kWh/year under the coated glass scenario.

Based on these findings, coated glass is the most effective glazing alternative among the evaluated scenarios for OTTV and cooling load reductions, although its thermal performance advantage over tinted glass remains relatively minor. While coated glass yields the lowest envelope heat gain, tinted glass captures most of the overall thermal improvement, leaving only an incremental gain of 1.2% for coated glass. Comparison with related literature further indicates that the magnitude of potential energy savings from glass substitution is strongly governed by the building's initial envelope performance. For buildings whose baseline OTTV already complies with relevant energy standards, such as the Bank Syariah Indonesia building, achievable energy savings tend to be moderate compared with buildings that initially fail to meet standard thresholds. Therefore, high-performance glazing can be recommended as a passive energy conservation strategy to optimise building thermal performance, particularly for facades with high solar exposure, providing practical insights for building managers and designers seeking to minimise cooling loads without compromising visual comfort and daylighting.

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