Overall Thermal Transfer Value (OTTV) Analysis of the Banten Provincial Language Office Building

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ABSTRACT

This study evaluates the thermal performance of the building envelope at the Banten Provincial Language Office through an analysis of the Overall Thermal Transfer Value (OTTV). The objective of this study is to calculate the OTTV value and identify the facade elements that contribute the greatest heat load to ensure compliance with the SNI 03-6389-2020 standard (maximum 35 W/m²). The primary method used was a mixed-methods approach employing a case study methodology, which involved field observations, analysis of construction drawings, and an OTTV spreadsheet calculator provided by the Ministry of Public Works and People's Housing (PUPR). The main results show that the current OTTV value is 69.43 W/m², which does not meet the national standard. The east facade contributes the highest heat gain (85.10 W/m²) due to a window-to-wall ratio (WWR) of 54.72% and 8 mm-thick clear glass. Building orientation, materials, glass type, opening area (WWR), and the use of shading systems are critical factors in calculating the OTTV value. Modifying the glass material by using Stopray Double Glass on the east and north facades successfully reduced the total OTTV value by 50.02% to 34.70 W/m². This material intervention proved effective in meeting national energy conservation standards.

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1. INTRODUCTION

As awareness of climate change and sustainability issues grows, the phenomenon of global warming caused by high energy consumption requires serious attention across various sectors. The Directorate General of New, Renewable, and Energy Conservation at the Ministry of Energy and Mineral Resources reports that the building sub-sector, which includes commercial and residential categories, accounts for 18% of total national energy consumption, making it the third-largest consumer after the industrial and transportation sectors. Therefore, the application of energy-efficient green building principles is a key component of energy efficiency strategies as well as the fulfillment of emission reduction targets in the building sector [1]. This makes energy efficiency a top priority that must be widely implemented, including in the field of construction [2].

The implementation of energy efficiency is crucial in our efforts to reduce the impact of environmental damage. It also plays a major role in maintaining the availability of energy sources, particularly those derived from non-renewable resources [3]. To mitigate the effects of excessive energy use, efforts must be made through development that incorporates the concept of energy-efficient or green buildings; this concept has a highly positive impact on energy conservation [4].

Essentially, green building is a concept that emphasizes the importance of conserving natural resources such as energy and water. The application of this concept is not limited to the construction of new buildings but can also be applied to optimize existing buildings [5]. According to the standards of the Green Building Council Indonesia (GBCI), one of the key criteria in the green building category is the effort to improve energy efficiency and promote sustainable energy conservation [6].

In tropical countries like Indonesia, energy conservation poses a unique challenge for architects when designing buildings. Buildings in this region often struggle to meet thermal comfort standards. This is due to environmental variables such as high air temperatures, relative humidity, solar radiation, and air velocity, which often do not support ideal indoor conditions [7]. There are two sources of heat load handled by HVAC systems: heat load from outside the building and heat load from inside the building. Heat load originating from the building envelope is quantified by a parameter known as the Overall Thermal Transfer Value (OTTV) [8].

OTTV is closely related to the building envelope. The building envelope is the outermost layer that is directly exposed to sunlight. This element serves as the primary pathway for heat radiation to enter the building, given that most thermal energy is transferred through this component [9]. The building envelope plays a crucial role in regulating energy consumption within the building. Generally, heat transfer in the building envelope involves three basic elements: solar radiation penetrating through glass, heat transfer (conduction) through solid walls, and heat conduction occurring in window or opening areas [10].

The challenge in achieving energy efficiency standards for institutional and public service buildings in Banten Province relates to the aesthetic design of building facades and envelopes, which are often not optimally integrated with the building's thermal performance parameters. At the ITB Ahmad Dahlan Karawaci educational building in Tangerang, Banten, it was found that the newly renovated institutional building still has an OTTV value of 52,66 W/m² on its facade/building envelope. [11].

The Banten Provincial Language Office building is a new structure that was officially inaugurated on December 30, 2024. It is located on Jalan Ciemas Raya Banjaragung, Blok Kibali, Sumur Putat, Cipocok Jaya District, Serang City, Banten. This building serves as a public service center for language and literature [12]. The selection of the Banten Provincial Language Office as the subject of study was based on the characteristics of its building envelope, which is dominated by transparent elements, as well as the orientation of the building's longest side facing east and the use of an external shading system applied to the building.

Through an analysis of the Overall Thermal Transfer Value (OTTV) in accordance with SNI 6389:2020, this study aims to examine the performance of building envelopes in supporting energy conservation efforts. This is achieved by controlling the heat flow entering the building in tropical climates such as those found in the city of Serang. According to [13] minimizing heat transfer is one of the key strategies in energy-efficient building design. The building envelope plays a crucial role in controlling indoor temperatures, thereby directly influencing the workload of the cooling system. Therefore, the overall thermal performance of a building heavily depends on the design and materials that constitute its envelope elements. This study uses Overall Thermal Transfer Value (OTTV) analysis to measure the amount of heat entering through exterior walls and window openings.

Through this approach, elements such as building orientation, façade material composition, opening area (window-to-wall ratio), and the presence of shading systems will be identified and analyzed. The evaluation results are expected to provide an objective picture of the energy performance of the Banten Provincial Language Office building to improve energy efficiency and the implementation of energy-efficient architecture or green building.

This study aims to determine the Overall Thermal Transfer Value (OTTV) of the building envelope of the Banten Provincial Language Office, as well as to identify the factors influencing this OTTV value. The building under study is a new structure; therefore, it is not yet known whether it meets the criteria for an energy-efficient building in accordance with applicable national standards. In this context, the OTTV value is used as an initial evaluation parameter to assess energy efficiency and conservation through the building envelope. This approach was implemented as part of efforts to apply the concept of green architecture, specifically in terms of energy efficiency and conservation in new buildings in tropical climates, particularly in the city of Serang, Banten Province.

2. METHOD

The method used in this study is a mixed-methods approach, which combines qualitative and quantitative methods through the collection of primary and secondary data. The subject of this study is the Banten Provincial Language Office building, located at Jalan Ciemas Raya Banjaragung Blok Kibali, Sumur Putat, Cipocok Jaya Subdistrict, Serang City, Banten. The observations were conducted from October 2025 to January 2026.

1. The quantitative data analysis involves calculating the Overall Thermal Transfer Value (OTTV) of the exterior envelope of a conditioned (air-conditioned) building. This calculation process uses the official Microsoft Excel Spreadsheet Formula Calculator from the Indonesian Ministry of Public Works and Public Housing (PUPR), based on the national standard SNI 6389:2020. The quantitative variables calculated include the total facade area, the window-to-wall ratio (WWR), and the building envelope materials, which consist of opaque wall conduction, glass conduction, and opening radiation.

Table 1. SHGC and U-Value of Glass Materials (source: PT. Asahimas Flat Glass Tbk)

Glass material code	SHGC	U-Value
Clear Glass 8 mm	0,81	5,70

2. The qualitative data analysis was conducted to identify the characteristics of the existing conditions of the Banten Provincial Language Office building. The process began by identifying and mapping spaces equipped with air conditioning systems/AC, specifically on the second and third floors, which were the primary focus of the OTTV calculations. The document study was conducted on the complete architectural working drawings (floor plans, elevations, sections, and facade details) obtained directly from the design consultant, Studio Kertas Bening Arsitek, with the purpose of analyzing the characteristics of the building envelope/facade, the construction details of the exterior shading devices, and the site's orientation relative to the sun's path in Serang City.

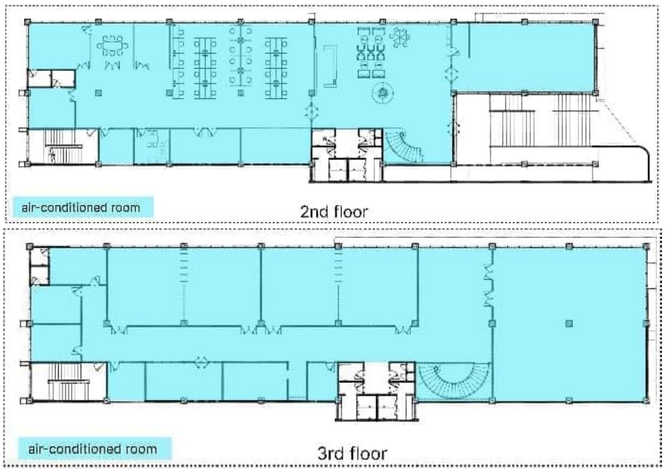

Figure 1. floor plan of the air-conditioned room (source: author, 2026)

Table 2. Solar radiation factor (SF, W/m²) for the city of Serang, Banten (source: National Standards Agency, SNI 6389:2020)

City	N	NE	E	SE	S	SW	W	NW
Serang	162	168	173	142	123	172	224	205

2.1. Overall Thermal Transfer Value (OTTV)

The OTTV calculation is a method used to measure the amount of heat transfer entering through a building envelope. This measurement covers all components of the building envelope, including walls and glass/windows (openings) [14]. According to the National Standardization Agency's SNI 6389:2020, the OTTV value calculation applies only to air-conditioned building envelopes with a maximum calculated value of 35 W/m² [15].

The formula for calculating the OTTV value embedded in the calculator spreadsheet is based on the following equation:

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

OTTV = Wall Conduction + Glass Conduction + Glass Radiation

OTTV = Overall thermal transmittance of an exterior wall with a specific orientation (W/m²);
α = Solar radiation absorptance;
Uw = Thermal transmittance of an opaque wall (W/m²·K);
WWR = Ratio of window area to total exterior wall area for the specified orientation;
TDEK = Equivalent temperature difference (K);

SF = Solar radiation factor (W/m²);
SC = Shading coefficient of the window system
Uf = Thermal transmittance of the window system (W/m²·K);
ΔT = Design temperature difference between the exterior and interior.

3. RESULTS AND DISCUSSION

Based on observations of the materials used in the building envelope of the Banten Provincial Language Office, namely: 150 mm-thick lightweight bricks and 8 mm-thick clear glass openings. The glass in the windows and doors is equipped with horizontal and vertical external shading devices and the building envelope incorporates a combination of aluminum composite panels.

Based on the data obtained, the facade of the Banten Provincial Language Office is dominated by the use of glass combined with external shading systems. The glass material plays a crucial role in influencing the amount of heat transfer into the building's interior.

Figure 2. Building envelope of the Banten Provincial Language Office (source: author, 2026)

Figure 3. (a) Type of openings and shading on the north elevation (source: author, 2026)

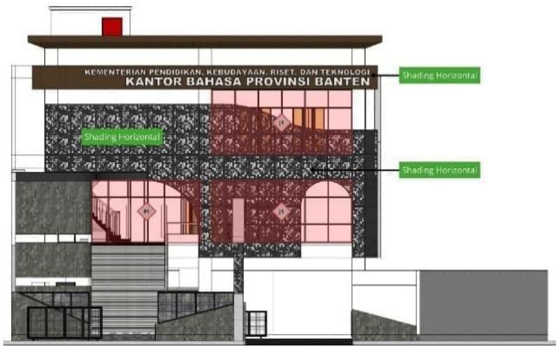

Figure 4. (b) Type of openings and shading on the south elevation (source: author, 2026)

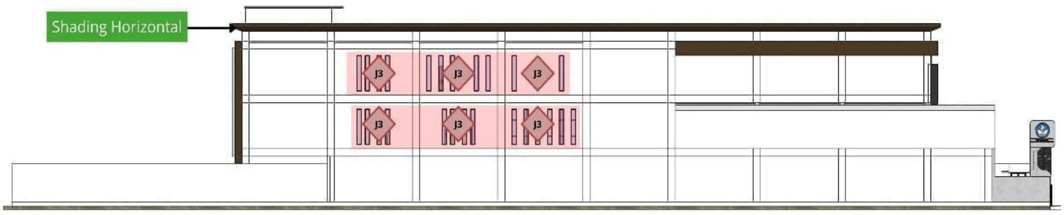

Figure 5. (c) Type of openings and shading on the west elevation (source: author, 2026)

Figure 6. (d) Type of openings and shading on the east elevation (source: author, 2026)

The building's orientation has an important role in determining the heat transfer or solar radiation entering the building, with the building's longest sides facing east and west and the shortest sides facing north and south.

Table 3. Fenestration System Code (source: author, 2026)

Code	Size Opening	Opening Location	Opening Orientation	Number of Opening Units
Type J1	660 x 300 cm	2nd and 3rd floors	East, West, and South	19 Unit
Type J2	443 x 300 cm	2nd floor	North	1 Unit
Type J3	40 x 280 cm	2nd and 3rd floors	West	25 Unit
Type J4	322 x 300 cm	2nd and 3rd floors	North and East	3 Unit
Type P1	660 x 300 cm	2nd floor	South (Entrance)	1 Unit

3.1. Identification of Wall and Fenestration System Specifications

The following is Table 4, which identifies the specifications for exterior walls, exterior window systems, and exterior shading systems based on the existing conditions of the Banten Provincial Language Office building.

Table 4. Identify the specifications of the exterior walls
(source: PUPR OTTV Calculator, reprocessed by the author, 2026)

Jumlah Tipe Konstruksi Dinding	1

Type	Konstruksi
EW 1	Bata Ringan
-	
-	
-	
-	
-	
-	
-	
-	

The exterior walls of the Banten Provincial Language Office building use a single type of primary wall construction lightweight brick for the entirety of the building envelope, with a wall thickness of 150 mm, coded as EW 1.

Table 5. Identification of exterior window system specifications
(source: PUPR OTTV Calculator, reprocessed by the author, 2026)

No	Kode Tipe Konstruksi Sistem Fenestrasi	Nama	SHGC	U Value (W/m²K)	Peneduh Luar	Kode Spesifikasi Peneduh Luar (lihat tabel 3,4,5)	Keterangan
1	F1	Clear Glass 8 mm	0,81	5,70	yes	SV1	Peneduh luar vertikal / sirip - sirip ACP
2	F2	Clear Glass 8 mm	0,81	5,70	yes	SH1	Peneduh luar horizontal overhang ACP
3	F3	Clear Glass 8 mm	0,81	5,70	yes	SH2	Peneduh luar horizontal overstek atap ACP
4	F4	Clear Glass 8 mm	0,81	5,70	no		
5	F5	Clear Glass 8 mm	0,81	5,70	yes	SE1	Peneduh kombinasi ceiling (perpustakaan)
6	F6	Clear Glass 8 mm	0,81	5,70	yes	SH3	Peneduh Horizontal perforated parsial S1
7	F7	Clear Glass 8 mm	0,81	5,70	yes	SH4	Peneduh Horizontal perforated parsial S2
8	F8	Clear Glass 8 mm	0,81	5,70	yes	SH5	Peneduh Horizontal perforated parsial S3
9	F9	Clear Glass 8 mm	0,81	5,70	yes	SH6	Peneduh Horizontal perforated parsial S4
10	F10	Clear Glass 8 mm	0,81	5,70	yes	SH7	Peneduh Horizontal perforated parsial S5
11	F11	Clear Glass 8 mm	0,81	5,70	yes	SE2	Peneduh kombinasi ceiling entrance
12	F12	Clear Glass 8 mm	0,81	5,70	yes	SH8	Peneduh Horizontal perforated parsial T1
13	F13	Clear Glass 8 mm	0,81	5,70	yes	SH9	Peneduh Horizontal perforated parsial T2
14	F14	Clear Glass 8 mm	0,81	5,70	yes	SH10	Peneduh Horizontal perforated parsial T3
15	F15	Clear Glass 8 mm	0,81	5,70	yes	SH11	Peneduh Horizontal perforatedparsial T4
16	F16	Clear Glass 8 mm	0,81	5,70	yes	SH12	Peneduh Horizontal perforated parsial T5
17	F17						
18	F18						

All components of the glazing system at the Banten Provincial Language Office use 8-mm-thick clear glass. This material has a solar heat gain coefficient (SHGC) of 0.81 and a U-value of 5.70. The glazing system is classified into two categories: openings equipped with a shading system and openings without a shading system.

Table 6. Details of the horizontal external shading element
(source: PUPR OTTV Calculator, reprocessed by the author, 2026)

No	Kode Peneduh Luar Horisontal	panjang (P1)	tinggi (H)	kemiringan	Scef Utara / Selatan	Scef Barat / Timur	Scef TimurLaut / BaratLaut	Scef Tenggara / BaratDaya
		[m]	[m]	[derajat]				
1	SH1	0,83	3	0	0,877	0,875	0,863	0,857
2	SH2	1,4	1,9	0	0,692	0,657	0,655	0,629
3	SH3	3,24	4,2	50	0,667	0,458	0,532	0,500
4	SH4	3,24	1,9	50	0,658	0,396	0,476	0,443
5	SH5	1,38	1,1	50	0,658	0,397	0,476	0,443
6	SH6	1,62	1,5	50	0,658	0,406	0,483	0,449
7	SH7	4,16	2,1	50	0,658	0,396	0,476	0,443
8	SH8	3,24	4,2	50	0,667	0,458	0,532	0,500
9	SH9	2,82	3,5	50	0,663	0,447	0,509	0,477
10	SH10	1,86	1,9	50	0,660	0,424	0,492	0,459
11	SH11	2,82	3,5	50	0,663	0,447	0,509	0,477
12	SH12	1,404	1,14	50	0,658	0,397	0,476	0,443
13	SH13				-	-	-	-
14	SH14				-	-	-	-

Table 7. Details of vertical external shading elements
(source: PUPR OTTV Calculator, reprocessed by the author, 2026)

No	Kode Peneduh Luar Vertikal	panjang (P1)	lebar (W)	kemiringan	Scef Utara / Selatan	Scef Barat / Timur	Scef TimurLaut / BaratLaut	Scef Tenggara / BaratDaya
		[m]	[m]	[derajat]				
1	SV1	0,3	0,6	0	0,775	0,905	0,791	0,791
2	SV2				-	-	-	-
3	SV3				-	-	-	-
4	SV4				-	-	-	-
5	SV5				-	-	-	-

Table 8. Details of the combined external shading element
(source: PUPR OTTV Calculator, reprocessed by the author, 2026)

No	Kode Peneduh Luar Vertikal	panjang (P1)	tinggi (H)	panjang (P2)	lebar (W)	kemiringan	Scef Utara / Selatan	Scef Barat / Timur	Scef Timu	Scef Tenggara / BaratDaya
		P1 (m)	H (m)	P2 (m)	W (m)	[derajat]				
1	SE1	7,13	3,1	7,13	13,8	0	0,658	0,477	##	0,475
2	SE2	14,25	3,1	14,25	6,6	0	0,658	0,454	##	0,452
3	SE3						-	-	#	-
4	SE4						-	-	#	-
5	SE5						-	-	#	-

In calculating the OTTV value, three categories of shading devices are used. All exterior shading elements at the Banten Provincial Language Office encompass these three types, namely horizontal (SH), vertical (SV), and combination/egg-shaped (SE) shading devices. The technical parameters required as input data include the length (L), height (H), and width (W) of the shading device, as well as its angle of inclination.

3.2. Calculation of OTTV for North Orientation

Details about the north elevation are shown in Figure 7. and Table 9. The building construction on this side uses lightweight brick in accordance with the wall specifications in Table 4.

Figure 7. Detail of the north facade (source: author, 2026)

For the openings, the fenestration system uses 8 mm clear glass of types F1 and F4 (see Table 5.). The main difference between these two types of openings lies in their shading: the F1 opening uses vertical shading provided by white ACP louvers (SV1), whereas the F4 opening does not use any external shading at all.

Table 9. Identification of the North Facade
(source: PUPR OTTV Calculator, reprocessed by the author, 2026)

FASAD	Tinggi (jarak antar lantai)	Panjang	Area Fasad	Tipe Konstruksi Dinding	Kode Tipe Konstruksi Sistem Fenestrasi	Area Bukaan	Total Jumlah Lantai	Total Area Fasad	LOKASI
			[1]			[2]	[3]	= [1] x [3]	
	(m)	(m)	(m²)			(m²)		(m²)	
U 1	4,2	6,6	27,72	EW 1	F1	13,29	1	27,72	lantai 2
U 2	4,2	10,8	45,36	EW 1	F1	9,66	1	45,36	lantai 3
U 3	4,2	4,2	17,64	EW 1	F4	9,66	1	17,64	lantai 2
U 4			-					-	
U 5			-					-	

Table 10. The amount of heat transfer in the north (source: Author, 2026)

Orientation	Heat Transfer (W)		
	Wall Conduction	Opening Conduction	Radiaton Opening
North	1,030,38	929,39	4.197,63

Table 10. above shows that solar radiation through glass (radiation opening) is the largest contributor to the heat load inside the building (4,197.63), while glazing conduction contributes the least amount of heat. Glazing radiation indicates that the use of clear glass is currently the main cause of solar heat gain on the north side.

3.3. Calculation of OTTV for South Orientation

Details about the north elevation are shown in Figure 8. and Table 11. The building construction on this side uses lightweight brick in accordance with the wall specifications in Table 4.

Figure 8. Detail of the south facade (source: author, 2026)

The construction type for this side of the building uses lightweight brick material in accordance with the specifications in Table 4. For the openings, the fenestration system uses 8 mm clear glass with shading systems of types F2, F11, and F6 – F10 (see Table 5).

Table 11. Identification of the South Facade
(source: PUPR OTTV Calculator, reprocessed by the author, 2026)

No	FASAD	Tinggi (jarak antar lantai)	Panjang	Area Fasad	Tipe Konstruksi Dinding	Kode Tipe Konstruksi Sistem Fenestrasi	Area Bukaan	Total Jumlah Lantai	Total Area Fasad	LOKASI
				[1]			[2]	[3]	= [1] x [3]	
		(m)	(m)	(m²)			(m²)		(m²)	
1	S 1	4,2	4,25	17,85	EW 1	F6	12,75	1	17,85	Lantai 2
2	S 2	4,2	2,35	9,87	EW 1	F7	7,05	1	9,87	Lantai 2
3	S 3	1,2	2,35	2,82	EW 1	F8	2,585	1	2,82	Lantai 3
4	S 4	1,1	2,35	2,59	EW 1	F2	2,35	1	2,59	Lantai 3
5	S 5	2	14,4	28,80	EW 1	F2	12,54	1	28,80	Lantai 3
6	S 6	1,5	1,2	1,80	EW 1	F9	1,632	1	1,80	Lantai 3
7	S 7	2,1	3,3	6,93	EW 1	F10	6,21	1	6,93	Lantai 3
8	S 8	4,2	6,6	27,72	EW 1	F11	19,8	1	27,72	Lantai 2
9	S 9			-					-	
10	S 10			-					-	

Table 12. The amount of heat transfer in the south (source: author, 2026)

Orientation	Heat Transfer (W)		
	Wall Conduction	Opening Conduction	Radiaton Opening
South	341,50	1.850,13	5.319,92

Table 12. above shows that solar radiation through transparent openings (5,319.92) is the largest contributor to the heat load, while wall conduction contributes the least heat. These figures prove that lightweight brick wall materials are highly effective at blocking outdoor heat; however, the use of clear glass is currently the main cause of high solar heat gain into air-conditioned rooms on the south side.

3.4. Calculation of OTTV for West Orientation

Details about the north elevation are shown in Figure 9 and Table 13. The building construction on this side uses lightweight brick in accordance with the wall specifications in Table 4. For the openings, the glazing system uses 8 mm clear glass with F3 and F5 shading systems and an F4 system without shading (see Table 5).

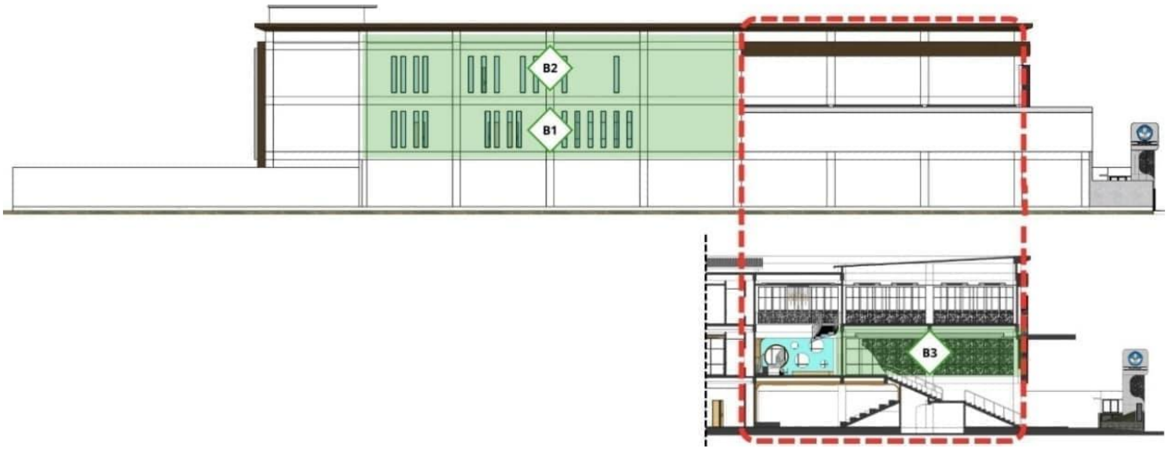

Figure 9. Detail of the west facade (source: author, 2026)

Table 13. Identification of the West Facade
(source: PUPR OTTV Calculator, reprocessed by the author, 2026)

No	FASAD	Tinggi (jarak antar lantai)	Panjang	Area Fasad	Tipe Konstruksi Dinding	Kode Tipe Konstruksi Sistem Fenestrasi	Area Bukaan	Total Jumlah Lantai	Total Area Fasad	LOKASI
				[1]			[2]	[3]	= [1] x [3]	
		(m)	(m)	(m²)			(m²)		(m²)	
1	B 1	4,2	21	88,20	EW 1	F4	15,68	1	88,20	Lantai 2
2	B 2	4,2	21	88,20	EW 1	F3	12,32	1	88,20	Lantai 3
3	B 3	4,2	13,8	57,96	EW 1	F5	39,6	1	57,96	Lantai 2
4	B 4			-					-	
5	B 5			-					-	
6	B 6			-					-	

The specifications for the external shading on this facade include F3 type openings that utilize the roof overhang as external shading (SH2). Meanwhile, F4 type openings do not use any external shading system at all. For F5 type openings, radiation protection is provided using a combination-type shading system (SE1) derived from the ceiling in the library/entrance area on the second floor.

Table 14. The amount of heat transfer in the west (source: Author, 2026)

Orientation	Heat Transfer (W)		
	Wall Conduction	Opening Conduction	Radiaton Opening
West	1.702,09	1.926,60	9.003,29

Table 14. above shows solar radiation through glass openings is once again the largest contributor to the heat load inside the building (9,003.29) while wall conduction contributes the least amount of heat. Although the lightweight brick walls are working hard to retain heat, the use of clear glass in the openings on the west side (which receives direct afternoon sunlight) is the main cause of the high heat levels inside the air-conditioned room.

3.5 Calculation of OTTV for East Orientation

Details about the north elevation are shown in Figure 10. and Table 15. The building construction on this side uses lightweight brick in accordance with the wall specifications in Table 4.

Figure 10. Detail of the east facade (source: author, 2026)

For the openings, the fenestration system uses 8 mm clear glass with F1-type and F12 – 16 type shading systems (see Table 5). The F1 openings use vertical shading from white ACP fins (SV1), and the F12–16 openings employ the same shading system, namely the perforated horizontal shading type (SH8 – SH12).

Table 15. Identification of the east Facade
(source: PUPR OTTV Calculator, reprocessed by the author, 2026)

No	FASAD	Tinggi (jarak antar lantai)	Panjang	Area Fasad	Tipe Konstruksi Dinding	Kode Tipe Konstruksi Sistem Fenestrasi	Area Bukaan	Total Jumlah Lantai	Total Area Fasad	LOKASI
				[1]			[2]	[3]	= [1] x [3]	
		(m)	(m)	(m^2)			(m^2)		(m^2)	
1	T 1	4,2	8,3	34,86	EW 1	F12	24,9	1	34,86	Lantai 2
2	T 2	3,5	1,2	4,20	EW 1	F13	2,556	1	4,20	Lantai 2
3	T 3	1	1,2	1,20	EW 1	F14	1,2	1	1,20	Lantai 2
4	T 4	4,2	16,28	68,38	EW 1	F15	16,8	1	68,38	Lantai 2
5	T 5	4,2	29,11	122,26	EW 1	F1	26,4	1	122,26	Lantai 2
6	T 6	1,14	30	34,20	EW 1	F16	34,2	1	34,20	Lantai 3
7	T 7	1,9	30	57,00	EW 1	F1	57	1	57,00	Lantai 3
8	T 8	2,3	28,5	65,55	EW 1	F1	49,06	1	65,55	
9	T 9			-					-	
10	T 10			-					-	

Table 16. The amount of heat transfer in the east (source: Author, 2026)

Orientation	Heat Transfer (W)		
	Wall Conduction	**Opening Conduction**	**Opening Radiaton**
East	1.791,63	6.045,31	25.151,44

Table 16. above shows solar radiation through glass openings is the largest contributor to the heat load inside the building (25,151.44). This figure indicates that the east-facing facade, which is dominated by clear glass openings (receiving direct morning sunlight), is the primary pathway for heat into the air-conditioned space.

3.6. Results of the Analysis of the Total OTTV Value Calculation

The thermal performance of the Banten Provincial Language Office building was assessed by analyzing the OTTV values for each orientation to determine the specific impact of each facade on overall heat transmission.

Quantitative calculations of the OTTV value under existing conditions were analyzed separately for each facade orientation to measure the specific thermal contribution of each building aspect. The detailed calculation results are presented in full in Table 17.

Table 17. Summary Calculation of the OTTV Value for the Banten Provincial Language Office
(source: author, 2026)

Facade Orientation	Heat Transfer (W) in Building Envelopes			Total (Watt)	Total façade area (m^2)	Total opening area (m^2)	WWR (%)	OTTV (W/m^2)
	Wall Conduction	**Opening Conduction**	**Opening Radiation**					
North	1,030,38	929,39	4.197,63	**6.157,40**	133,56	32,61	**24,42**	**46,10**
South	341,50	1.850,13	5.319,92	**7.511,55**	98,38	64,92	**65,99**	**76,36**
West	1.702,09	1.926,60	9.003,29	**12.631,98**	234,36	67,60	**28,84**	**53,90**
East	1.791,63	6.045,31	25.151,44	**32.988,37**	387,65	212,12	**54,72**	**85,10**
North	**4.865,60**	**10.751,43**	**43.672,28**	**59.289,30**	**853,94**	**377,24**	**44,18**	**69,43**

Based on the calculation of the overall OTTV value for all orientations in Table 17 above, the total OTTV value for the building envelope of the Banten Provincial Language Office is 69.43 W/m². This value is still above the maximum limit of 35 W/m², which means that this building does not yet meet the energy efficiency standards set forth in SNI 6389:2020. This high OTTV value indicates that the building envelope of the Banten Provincial Language Office is not yet capable of effectively preventing heat transfer from outside into the building.

The high value on the east-facing facade is dominated by solar radiation heat, which reaches 25,151.44 W accounting for approximately 76% of the total heat load on that side while the east facade is also the building's longest side, featuring numerous transparent openings and glass windows. An interesting phenomenon is observed when comparing the east side with the south side: although the south side has a much higher window-to-wall ratio (WWR), at 65.99%, its OTTV value (76.36 W/m²) remains lower than that of the east side, which has the highest OTTV value of 85.10 W/m². This indicates that the solar factor (SF) of 123 (see Table 2) is significantly lower on the east side.

Meanwhile, for the west and north orientations, the OTTV values were recorded at 53.90 W/m² and 46.10 W/m², respectively. For the west-facing facade, despite having a relatively low WWR (28.84%), the value still exceeds the SNI standard due to intense afternoon solar radiation exposure with a solar factor (SF) of 224 (see Table 2). Meanwhile, the north-facing facade recorded the best performance, supported by the lowest opening ratio of 24.42%. However, its value still exceeds the 35 W/m² standard.

WWR value of 44.18% indicates that the building envelope is dominated by radiative elements, particularly glass with high SHGC and U-values. This is also consistent with the principle that the higher the window-to-wall ratio, the greater the amount of heat entering the building, and vice versa. Technically, this means that nearly half of the building envelope's surface area consists of transparent elements (glass).

3.7. Modification of Glass Materials in the Façade of the Banten Provincial Language Office Building

The east-facing orientation contributed the highest OTTV value of 85.10 W/m² because it is dominated by glazed openings with high Solar Heat Gain Coefficient (SHGC) and U-values. Modifications to the glazing materials were applied to two orientation alternatives: the east and north orientations. The selection of the north orientation is based on the geographical location of Serang City, which lies south of the equator.

Table 18. Modification of the glass cladding on the Banten Provincial Language Office building (source: Author, 2026)

Orientation	Glass Type	SHGC	U – Value	OTTV Value (W/m²)
East	6mm Stopray (#2) + 12mm AS + 6mm Clear Glass	0,21	0,15	**25,55**
North	6mm Stopray (#2) + 12mm AS + 6mm Clear Glass	0,21	0,15	**17,69**

Based on Table 17. above, modifying the glass material for the east-facing orientation reduces the OTTV by 70%, resulting in an OTTV value of 25.55 W/m², while for the north orientation, it reduces the OTTV by 61%, resulting in an OTTV value of 17.69 W/m².

Table 19. OTTV Values for the Banten Provincial Language Office: Baseline (Existing) Conditions and conditions after modification (source: Author, 2026)

Orientation	Facade Area	OTTV Value (W/m²)	
		Baseline (OTTV Value)	*Double Glass* – Stopray (East + North)
Utara	133,56	**46,10**	**17,69**
Selatan	98,38	**76,36**	**76,36**
Timur	387,65	**85,10**	**25,55**
Barat	234,36	**53,90**	**53,90**
Total	**853,94**	**69,43**	**34,70**

OTTV value modified glass material	OTTV value does not meet standards	OTTV value meets standards

The modification replacing the existing glass with Stopary double-pane glass on the east and north openings resulted in a relatively good total OTTV value of 34.70 W/m², representing a 50.02% reduction from the previous OTTV value (69.43 W/m²).

4. CONCLUSION

Based on the results of the thermal performance analysis of the building envelope of the Banten Provincial Language Office, the Overall Thermal Transfer Value (OTTV) of the existing building envelope was recorded as very high, at 69.43 W/m². This value exceeds the maximum limit set by the national standard SNI 6389:2020 (35 W/m²), so the building is classified as not yet meeting the criteria for an energy-efficient building. The main component contributing the largest external heat load to the building is solar radiation through transparent openings (window glass), This high contribution from solar radiation is due to the high window-to-wall ratio (WWR) (44.18%) as well as the characteristics of the clear glass used (8 mm clear glass), which has low thermal resistance and a high solar heat gain coefficient (SHGC) of 0.81.

This analysis shows that building orientation, materials, the type and properties of the glass, and the effectiveness of shading devices are factors that influence the amount of heat transfer into the building.

Optimization through glass replacement modifications aims to examine differences in the thermal conductivity of building envelope materials (glass). Switching to a glass material with a U-value of 1.50 and an SHGC of 0.22 demonstrates the building envelope's ability to inhibit heat transfer by radiation and conduction through openings. The change in OTTV value from 69.43 W/m² to 34.70 W/m² indicates that selecting a type of glass with low thermal conductivity can reduce the OTTV value while meeting the energy efficiency standards of SNI 6389:2020 for a building.

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