The Effectiveness of Building Envelope through OTTV Analysis
Case Study: Building B, Universitas Pembangunan Jaya

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ABSTRACT
Directorate General of New Renewable Energy and Energy Conservation states that the most significant contributor to gas emissions in the Refrigeration and Air Conditioning (RAC) sector in Indonesia is Unitary Air Conditioning (UAC). The percentage of UAC continues to increase because Indonesia has had around 2000 skyscraper constructions since 2015. Regarding future building performance, there are many strategies to design the green building concept, such as how we feel about the building envelope. The building envelope should be prepared to gain energy efficiency and can be determined by calculating the Overall Thermal Transfer Value (OTTV). Based on SNI 6389:2011, OTTV has a maximum value of 35 W/sqm. The OTTV itself is equal to the heat load that enters the building for instance, if the OTTV is low then less heat will enter the building. Thus, the use of UAC is also lower. This research will analyze the effectiveness of the building envelope in Building B, Universitas Pembangunan Jaya, which currently uses external shading for the building envelope. However, even with external shading, the use of air conditioning and curtains when the room inside is operating still occurs. It is assumed that the existing building envelope in Building B may not work effectively. Therefore, this research wants to find out whether the building envelope in Building B, Universitas Pembangunan Jaya is effective through OTTV analysis and make retrofit suggestions to improve building performance.

Keywords: Energy Efficiency, Building Envelope, Overall Thermal Transfer Value

INTRODUCTION
Universitas Pembangunan Jaya is an eight-story building that has been active since 2015. It is located on Jalan Cendrawasih Raya Blok B7/P, Bintaro Jaya, South Tangerang, Banten. There are two buildings at UPJ, namely Building A and Building B. Based on the observation of researchers who is also building B's users, this building relies on air conditioning and an internal shade (curtains). The use of an air conditioner occurs during activities.

Based on the Directorate General of New, Renewable Energy and Energy Conservation in 2017, one of Indonesia's most significant contributors to gas emissions in the Refrigeration and Air Conditioning (RAC) zone is Unitary Air Conditioning (UAC). The total gas emissions produced by UAC are 51% of the total gas emissions produced by the RAC sector. In 2015, as many as 2000 skyscrapers were built in Indonesia (Council on Tall Building and Urban Habitat, 2016). It affects the number of UAC usage in Indonesia. The number of gas emissions causes the condition of the earth's atmosphere to increase, which is called global warming. Global warming is the increase of the average temperature of the earth's atmosphere, sea, and land (Dinas Lingkungan Hidup, 2019).

Therefore, several buildings began to apply the concept of Green Building as an effort to minimize global warming. In GREENSHIP, there are six categories for implementing the Green Building concept, one of which is Energy Efficiency and Conservation (EEC). One of the efforts is to pay attention to the cover design of a building. The building envelope is the building element that envelops the building, which is translucent or opaque walls and roofs where most of the thermal energy moves through these elements (Badan Standarisasi Nasional, 2000). Paying attention to the building envelope can help create a sense of comfort for users in the room and reduce the energy used by the building (Aksamija, 2013). Energy efficiency regarding the building envelope can be determined by calculating the Overall Thermal Transfer Value (OTTV). Based on SNI 6389-2011, OTTV in a building must have a maximum value of 35 W/sqm. If OTTV values are known, efficiency and energy conservation can be carried out better, especially in air conditioners, because the lower the OTTV value, the lower the heat load that enters the building (Pemerintah Provinsi DKI Jakarta, 2012). Thus, the energy load of the room becomes more bass as well.

Building B Universitas Pembangunan Jaya is currently using external shade. However, the use of air conditioners and curtains when the room is operating still occurs. So, the researcher assumes that the building envelope in Building B may not work effectively. Therefore, the researcher wants to know the effectiveness of the building envelope in Building B, Universitas Pembangunan Jaya, through the analysis of the OTTV value (to reach the maximum value of SNI 6389:2011). Researchers will also conduct a green retrofit on Building B, Universitas Pembangunan Jaya, if the analysis results of the OTTV value exceed the maximum limit (35 W/sqm). Green retrofits are improvements made to improve energy and environmental performance, conserve water resources, and improve the quality and comfort of space (Rahmawati, Wisnumurti, & Nugroho, 2018). Researchers will be giving green retrofit efforts for optimizing the OTTV value in achieving the maximum value in the design of the building envelope of Gedung B Universitas Pembangunan Jaya.

LITERATURE REVIEW

Green Retrofit

The rise of the construction of high-rise buildings makes the earth's gas emissions increase so that global warming occurs. Therefore, it is the building's responsibility that has been built to do a Green Retrofit. Green retrofit buildings are improvements or modifications to existing buildings (Hong, Deng, & Ezeh, 2019). Researchers will do a green retrofit on Building B of Universitas Pembangunan Jaya through the design of the building envelope so that it affects the optimization of the OTTV value of the building.

Building Envelope: Type, Material, Design Principles

The building envelope is an opaque component and a translucent component that separates the inside of the building from the outside of the building (Badan Standarisasi Nasional, 2011). Its function is to protect the building from the external environment, such as heat, wind, and rain, and also reduce energy consumption for cooling and light. According to the IFC Guide, in office buildings in Indonesia, about 63% of 100% of external heat is obtained through windows and walls. Therefore, Indonesia issued SNI on building envelopes and set the OTTV standard not to exceed 35 watts/sqm. There are two types of building envelope construction in Indonesia based on thermal characteristics (Pemerintah Provinsi DKI Jakarta, 2012). There is curtain wall construction and brick-window wall construction. The use of curtain walls in high-rise buildings enhances the commercial appeal and maximizes the views. However, this has another impact, which is increasing energy consumption in HVAC and lighting because heat radiation enters the building very quickly, and building users mostly use curtains so that the incoming light is minimal. As explained by Jimmy Priatman, 1999, in his journal, high-rise buildings have basic materials for building envelopes, namely: Cementitious Materials, Masonry Materials, Stone Materials, Metal Materials, and Glass Materials. A building envelope material is essential because each material has a different absorptance value of solar radiation (α). The absorbance value of solar radiation has been determined by SNI 6389:2011. Henceforth, The IFC guidelines explain that building envelope design principles are applied to reduce heat gain from the envelope, including building shape and orientation, window area, glass material, external shade, internal shade, and wall.

Building Heat Conditions

The thermal performance of the building and the exterior affects the thermal conditions inside the building (Alfian, 2018). Heat transfer is transferring energy from one area to another due to the temperature difference between these areas (Mursadin & Subagyo, 2016). There are three principles of heat, as follows: conduction (occurs in two objects that have physical contact), radiation (occurs between a vacuum and the objects around it) and, convection (through an intermediate (fluid or gas).

OTTV Calculation

Overall Thermal Transfer Value (OTTV) is the value specified as the design criteria for the exterior walls and glass of the building (Badan Standarisasi Nasional, 2011). OTTV is regulated in SNI 6389-2011 with the specified standard, which is no more than 35 W/sqm. Each outer wall of the building with its respective orientation must be calculated using the formula:

Table 1 Each Orientation OTTV Formula. (Source: SNI 6389, 2011)

$OTTV_i$ = Wall's Conduction + Glass's Conduction + Glass's Radiation
$OTTV_i = \alpha[(U_w \times (1-WWR) \times TD_{EK}] + (U_f \times WWR \times \Delta T) + (SC \times WWR \times SF)$
Description: α = The absorbance of solar radiation U_w = Thermal transmittance of opaque walls (W/sqm.K) WWR = *Window to Wall Ratio* TD_{EK} = Equivalent temperature difference (K) SF = solar radiation factor (W/sqm) SC = Shade coefficient of the fenestration system Uf = Fenestration thermal transmittance (W/sqm .K) ΔT = The design temperature difference between the outside and the inside

OTTV calculation for the entire outer wall using the formula:

Table 2 OTTV formula for the Entire Outer Wall. (Source: SNI 6389, 2011)

$\text{OTTV total} = \dfrac{(OTTV_1 \times A_1) + (OTTV_2 \times A_2) + \dots + (OTTV_i \times A_i)}{A_1 + A_2 + \dots + A_i}$
Description: A_{oi} = area of the wall on the outer wall i (sqm) $OTTV_i$ = overall thermal transfer value in the wall section i (Watt/sqm)

The formula for calculating external shade is:

Table 3 UPJ External Shade Formula. (Source: SNI 6389, 2011)

$SC = SC_k \times SC_{eff}$
Description: SC = window shading coefficient (fenestration system) SC_k = glass material shading coefficient SC_{eff} = effective shading coefficient of external shading devices.

METHODOLOGY

The research method used by the researcher is quantitative and experimental research methods. Quantitative research methods are ways to answer research problems related to data through numbers and statistical programs (Wahidmurni, 2017).

Table 4 Methodology of The Research. (Source: Author, 2022)

Background	Data Collection	Data Analysis	Conclusion
Is the design of the building envelope of Universitas Pembangunan Jaya Building effective judging by the OTTV analysis? How can the building envelope of Building B UPJ make adjustments to optimize the OTTV Value?	**Study of Literature** The main data collection used is to explore the literature that is related to the calculation of OTTV, energy efficiency, and building envelopes. **Observation Field** Observing the object with the aim, researchers will find out more detailed phenomena that occur in the object to verify existing data, and input for simulation purposes. **Documentation** Visiting the location of the existing object and do documentation in the form of photos or 3D form to support visualization.	1. Type (W) and its variable (Uw, TDek, and α). 2. Determining the area of each wall type (Aw) and fenestration area (Af). 3. Determining SC Glass, U-Value Glass, and Effective SC. 4. Calculating the values of Wall Conduction, Glass Conduction, and Glass Radiation. 5. Calculating Overall OTTV Value	Knowing the value of the OTTV to determine the effectiveness of the building envelope. Provide suggestions for improvement (green retrofit) to fulfill OTTV standards based on SNI 6389:2011.

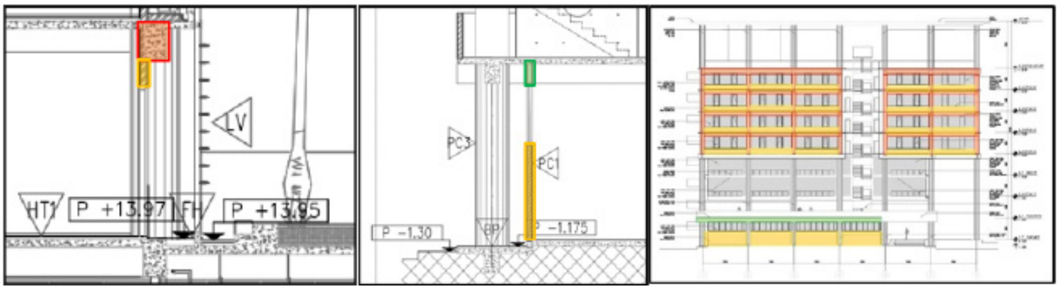
RESULT & DISCUSSION

Building Shape and Orientation

The orientation of Building B Universitas Pembangunan Jaya is North and South. Which makes the side of Building B Universitas Pembangunan Jaya face West and East. The importance of determining the orientation of the building is because it affects the amount of light that enters the building the wider openings in the West and East, the more heat radiation occurs. The existing Universitas Pembangunan Jaya building has the most windows on the East side. This orientation factor makes researchers assume that mostly sunlight and solar radiation enter the building through the east side.

Picture 1 Building B Universitas Pembangunan Jaya.
(Source: upj.ac.id, 2022)

Determine the Wall Type (W) and its Variables (Uw, TDek, and α)



Picture 2 Type of wall material for UPJ Building B. (Source: Author, 2022)

With the three types of wall materials used, the materials are categorized as follows:

Table 5 Wall materials and Calculation of Wall Type (W), Uw, TDEK Building B UPJ. (Source: Author, 2022)

Code	Materials	Colors	Uw	TDek	α
W1	White paint + Concrete + White Paint		2,2725	10	0,3
W2	White Paint + Aci Plaster + Light Brick + Aci Plaster + White Paint		1,6228	12	0,3
W3	White paint + Gypsum + rockwool + Gypsum + White paint		0,1584	15	0,3

Determine the Area of Each Wall Type (Aw) and Fenestration Area (Af)

Table 6 Calculation of Wall Area (Aw) Building B UPJ. (Source: Author, 2022)

Code	East	North	West	South
Aw_1	166,66 sqm	163,31 sqm	109,72 sqm	107,05 sqm
Aw_2	332,47 sqm	235,91 sqm	281,24 sqm	312,38 sqm
Aw_3	-	-	-	13,61 sqm
Total	**499,13 sqm**	**399,22 sqm**	**390,96 sqm**	**433,04 sqm**
All Total	**1722,35 sqm**			

Table 7 Calculation of Window Area (Af) Building B UPJ. (Source: Author, 2022)

Code	East	North	West	South
Af_1	166,66 sqm	163,31 sqm	109,72 sqm	107,05 sqm
Total	**499,13 sqm**	**399,22 sqm**	**390,96 sqm**	**433,04 sqm**
All Total	**1722,35 sqm**			

Determine SC Glass, U-value Glass, and Effective SC

The glass material on all sides of building B of Universitas Pembangunan Jaya is 8 mm clear glass. The glass materials are categorized as follows:

Table 8 Glass Material and Calculation of Uf and SC Values for Each Fenestration Type (Source: Author, 2022)

Code	Materials	Uf	SC
F1	Clear glass 8 mm	6,17	0,95

In determining the SCef, the researcher uses the help of excel, which can be accessed at https://iai-jakarta.org.

Table 9 Calculation of SCef (Source: Author, 2022)

No.	Codes of Horizontal External Shade	Length	Height	Tilt Degree	SCef
1	SH1	0,25	0,25	0	0,68

Calculating The Values of Wall Conduction, Glass Conduction, and Glass Radiation

Table 10 UPJ Building B Wall Conduction Calculation (Source: Author, 2022)

Orientation	Code	TDek	Aw	Uw	α	Total
East	W1	10	166,66 sqm	2,2725	0,3	1136,20
North	W1	10	163,31 sqm	2,2725	0,3	1113,37
West	W1	10	109,72 sqm	2,2725	0,3	748,02
South	W1	10	107,05 sqm	2,2725	0,3	729,81
East	W2	12	332,47 sqm	1,6228	0,3	1942,32
North	W2	12	235,91 sqm	1,6228	0,3	1378,21
West	W2	12	281,24 sqm	1,6228	0,3	1643,03
South	W2	12	312,38 sqm	1,6228	0,3	1824,95
East	W3	15	-	0,1584	0,3	0
North	W3	15	-	0,1584	0,3	0
West	W3	15	-	0,1584	0,3	0
South	W3	15	13,61 sqm	0,1584	0,3	131,42
All Total			**1722,35 sqm**			**10644,47 W**

Table 11 UPJ Building B Glass Conduction Calculation (Source: Author, 2022)

Orientation	Code	Area	ΔT	Uf	Total
East	F1	756,51 sqm	5	4,27	15676,24
North	F1	527,3 sqm	5	4,27	11257,86
West	F1	258,24 sqm	5	4,27	4793,50
South	F1	432,48 sqm	5	4,27	8994,33
All Total		**1974,53 sqm**			**42794,43 W**

Table 12 UPJ Building B Glass Radiation Calculation (Source: Author, 2022)

Orientation	Code	Area	SC	SF	Total
East	F1	756,51 sqm	0,75	112	63546,84
North	F1	527,3 sqm	0,75	130	51411,75
West	F1	258,24 sqm	0,75	243	47064,24
South	F1	432,48 sqm	0,75	97	31462,92
All Total		**1974,53 sqm**			**193485,75 W**

Calculating Overall OTTV Value

Table 13 Calculation of overall OTTV Value (Source: Author, 2022)

Orientation	Total
Wall Conduction	10522,38 W
Glass Conduction	42794,43 W
Glass Radiation	193485,75 W
All Total	**265000,66 W**
ΔAw	1722,35 sqm
ΔAf	1974,53 sqm
All Total	**3696,88 sqm**
OTTV Value	**71,68 W/sqm**

The OTTV value in Building B Universitas Pembangunan Jaya is **71.68 W/sqm**. The value does not meet the requirements specified in SNI 6389:2011, which is 35 W/sqm. So, it can be said that the cover design of the Universitas Pembangunan Jaya building has not been effective in meeting the OTTV value requirements.

Green Retrofit Suggestions

1. It is replacing the glass with a lower U-value and SHGC. Clear glass can be replaced by double-glazed high solar gain low-glass because it has a much lower U-value and SHGC than before, with a U-value of 0.25 and an SHGC of 0.42. It could change the OTTV value from 71.68 W/sqm to 26,27 W/sqm.
2. The slope of the external shade can also affect the OTTV value. If we change the glass material and the slope of the exterior from 0^o to 50^o, it can make the OTTV value become 25,87 W/sqm.
3. Window to Wall Ratio (WWR) in a building also influences the OTTV value. Building B Universitas Pembangunan Jaya has a WWR value of 114.64%. With the WWR percentage, it can reduce the OTTV weight. The percentage of WWR that can meet the OTTV value determined by SNI 6389:2011 is 35%. With a WWR value of 35%, the OTTV value of Gedung B Universitas Pembangunan Jaya can decrease to 34.76 W/sqm.

CONCLUSION

Building B of Universitas Pembangunan Jaya was not initially designed with the OTTV simulation. At this time, new buildings should try to implement the green building concept. There are so many categories that can be applied to this concept, one of them is by paying attention to the design of the building envelope because it affects the OTTV value. The researcher made observations on the building envelope of UPJ Building B to find out whether the building envelope worked effectively through OTTV value analysis. Based on the results of calculations and study that the researchers did, the value of OTTV Building B Universitas Pembangunan Jaya is 71.68 W/sqm. That means the building envelope is not functioning effectively because, based on SNI 6389:2011, the building envelope is functioning effectively if The OTTV value is not more than 35 W/sqm. Researchers do a green retrofit in Building B, of Universitas Pembangunan Jaya. The green retrofit that the researchers do is changing the glass material, changing the slope of the external shade, and reducing the percentage of the WWR.

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