Re-designing facade of kadin tower building (application of retrofit programme with OTTV)

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Abstract. This study aims to retrofit facade of existing buildings that have not applied green building standards, specifically the value of OTTV (Overall Thermal Transfer Value) which is a mandatory point that must be owned according to SNI 6389:2011. This paper describes several retrofit options commonly used, such as Recladding, Over-Clading, Double Skin, and Replacement applied to the example of the case study of Menara Kadin, Jakarta. The respective components of the strategy are calculated OTTV by using the OTTV Calculator. The results show that the reclading strategy was not successfully applied to the case study building, on the other hand. Over-Clading strategies have been successfully applied to just a few sides. The double skin strategy is successfully applied to all sides, and replacement strategies can produce maximum results. The result of this study can be used as reference in planning retrofit facade in existing building.

1. Introduction
The World is facing global warming problem caused by Green House Gas (GHG) [1]. Buildings use a highest energy of total energy usage in the world, which amounts to 50 percents. Thermal transfer from facade is a burden for the greatest cooler namely amounting to 45 percent, infiltration 20 percent, user 18 percent, heat from the wall 9 percent, lighting 8 percent and room heat 3 percent [2].

The Green Building Council Indonesia (GBCI) has mandated Overall Thermal Transfer Value (OTTV), which regulates the amount of solar radiation insulation on the surface of a building envelope with a value of ≤ 35 Watt/m². Meanwhile in the OTTV assessment there are design criteria, design procedures, energy conservation and recommendations of building envelopes in optimal building, so that energy use can be efficient without sacrificing occupant comfort and productivity.

Many high-rise buildings in Jakarta that currently do not meet these standards. Destroying buildings and rebuilding them requires high costs and is very difficult to do in big cities like Jakarta. One of efforts able to conducted by retrofit the building facade. Building facade which is a big factor in determining energy saving efforts. By conducting facade retrofit based on green building standard (OTTV) can help for energy saving and help increase overall building performance.
2. Methods and Materials
The method used in this study was to compare the value of OTTV existing conditions of the building with OTTV values after the facade retrofit strategy was applied. The OTTV calculation is done using the OTTV calculator. The calculation was carried out by sorting out the components of each of the facade retrofit strategies related to OTTV such as SC 1, SC 2, and WWR values.

2.1. Retrofit facade
There are 4 (four) strategies in research of a retrofit facade namely:
   a. Recladding
      This approach does not require full replacement; otherwise retrofit can be limited to selective replacement of facade or cladding material.
   b. Over-Cladding
      A different approach in order to wipe out from the available facade, involving framing system making and/special panel designed directly as above as already available.
   c. Double Skin
      A strategy of designing holds uniqueness by adding second skin removable or separated by the furthest distance from the first distance, therefore it creates hollow or space made deliberately between the old and the new. That hollow can be used to affect building envelope performance. As an additional layer, double skin can be a good buffer for interior building against the weather and elements.
   d. Replacement
      This approach is the most complete because it involves the removal of facade components and related building components, even to the structure of the building. The old material was removed, the completely new curtain wall facade system can be designed and installed.

2.2. OTTV
The Overall Thermal Transfer Value is a number indicating thermal gain due to solar radiation exceeding per meter square of the width of building veil. OTTV is needed as designing guidance in aim at obtaining design if energy saving (IFC Guide, 2012). According to SNI 03 6389 2000, a formula to calculate OTTV is as follows;

\[
\text{OTTV}_{\%} = \alpha \{U(1-WWR) \cdot \Delta Teq + (SC)(WWR)(SF)\} \text{ W/m}^2
\]

- \(\alpha\) = absorption of solar radiation on the wall surface
- \(U\) = wall transmittance
- WWR = window-to-wall ratio or comparison between window and width of overall wall level on the same orientation
- \(\Delta Teq\) = difference with the equivalent temperature between the outer and inner sides
- SF = solar factor or solar radiation (W/m²)
- SC = shading coefficient or shade penetration coefficient system (openings)

3. Result and Discussion
After collecting data on existing conditions, the supporting variables for OTTV calculation are facade orientation, facade area, and opening area to obtain Window to Wall Ratio (WWR) data, as shown in Table 1.

| Façade Orientation | Area of Facade | Area of Openings | WWR |
|--------------------|---------------|-----------------|-----|
| South East         | 49.02         | 73.75           | 81.6|
| South West         | 41.87         | 63.3            | 70.26|
| North west         | 41.23         | 63.05           | 70.19|
With the data above, the OTTV value of existing buildings is calculated as shown in Table 2.

### Table 2. Existing OTTV Value

| South East | South West | North West | WWR  | North East |
|------------|------------|------------|------|------------|
| 49.02      | 73.75      | 81.6       | 54.03| 63.97      |

#### 3.1. Retrofit Facade: Recladding

This type of facade retrofit is calculated by replacing the glass value variable with several types of glass commonly used in building facades in Jakarta as follows:

| Glass Type | SHGC | SC  | U Value | VLT  | VLR  |
|------------|------|-----|---------|------|------|
| Stopsol Super Silver Dark Blue 8 mm #2 + A5.12+ FL 16 | 0.30 | 0.34 | 2.80   | 32.00| 15.00|
| T-Sunlux CS 140 (on Clear) 8 mm #2 + 12mm AS + 6mm Planibel G#3 | 0.31 | 0.36 | 1.90   | 29.00| 19.00|
| Stopray Ace 52/26 (neutral Bluish Silver) 8 mm #2 +AS 12+6 mm Clear | 0.26 | 0.30 | 1.50   | 52.00| 24.00|

After the OTTV calculation, type C glass recladding was successfully applied to the southeast and northeast, but did not result in a sufficient decrease in value on the southwest and northwest sides. As for OTTV on each type of glass under study, glass A received a total OTTV of 54.86, type B of 54.47, and type C of 51.84.

### Table 4. Value of OTTV Recladding

| Types of Glass | Southeast | Southwest | North West | Northeast | Total |
|----------------|-----------|-----------|------------|-----------|-------|
| Existing       | 49.02     | 73.75     | 81.6       | 54.03     | 63.97 |
| Type A         | 41.87     | 63.3      | 70.26      | 46.21     | 54.86 |
| Type B         | 41.23     | 63.05     | 70.19      | 45.65     | 54.47 |
| Type C         | 39.31     | 59.96     | 66.76      | 43.49     | 51.84 |

#### 3.2. Retrofit Facade: Over-cladding

On type of retrofit facade we can do OTTV calculation with glass material as in recladding. Result shows over-cladding with C Glass successfully applied on Southeast, Southwest and Northeast, but it does not produce a sufficient value diminution on Northwest. With glass type A has OTTV total in amount of 41.2, type B is 40.22, and type C is 30.11.

### Table 5. OTTV Value Over-Cladding

| Types of Glass | Southeast | Southwest | North West | Northeast | Total |
|----------------|-----------|-----------|------------|-----------|-------|
| Existing       | 49.02     | 73.75     | 81.6       | 54.03     | 63.97 |
| Glass A        | 31.15     | 73.64     | 53.26      | 34.49     | 41.2  |
| Glass B        | 29.55     | 47.01     | 53.07      | 33.09     | 40.22 |
| Glass C        | 22.36     | 34.97     | 39.56      | 24.91     | 30.11 |

#### 3.3. Retrofit Facade: Double Skin

In the next facade retrofit type, double skin panel is added as a shading component that helps reduce the surface of the building's skin exposed to solar radiation heat. After calculating OTTV with the double skin type, it can be seen that SC 0.6 has a total OTTV of 42.8, SC 0.5 of 35.51, and SC 0.4 of 34.49.
Table 6. Value of OTTV Alternative SC2 Device

| SC2  | Southeast | Southwest | Northwest | Northeast | Total  |
|------|-----------|-----------|-----------|-----------|--------|
| Existing | 49.02    | 73.75    | 81.6      | 54.03     | 63.97  |
| SC 0.6 | 35.06    | 49.05    | 50.26     | 38.1      | 61.47  |
| SC 0.5 | 31.99    | 43.48    | 50.07     | 34.52     | 35.51  |
| SC 0.4 | 28.94    | 37.94    | 41.12     | 30.95     | 34.49  |

Meanwhile, alternative horizontal and vertical panel designs can be done using several vertical and horizontal shading models. The shading model can be done by an alternative number / distance of the panel, panel size and panel rotation, as shown in Figure 1.

![Figures 1. Alternative of SC2 Vertical and Horizontal Devices](image)

- Model 1, 2, 3 with alternative number / distance of the panel found not to reach the SC2 standard value
- Models 1A, 2B, 3C with an enlarged alternative panel width obtain a good SC2 value, but on the one hand there are deficiencies in this shading on wind and natural sunlight.
- Models 1X, 2Y, 3Z are re-rotated alternatives to produce SC2 values that are good and efficient. In this alternative the 3Z model, the panel size is 0.6, with a number of 5 horizontal panels, with a 20° rotation getting the best SC value which will be entered in the OTTV calculator.

![Figure 2. Alternative of SC2 Vertical and Horizontal Devices](image)

After finding the optimal model, the OTTV calculation is done again with the application of horizontal and vertical devices (Table 7 and Table 8).

Table 7. Value of OTTV : Alternative of SC2 Horizontal Device

| SC2  | Southeast | Southwest | Northwest | Northeast | Total  |
|------|-----------|-----------|-----------|-----------|--------|
| Existing | 49.02    | 73.75    | 81.6      | 54.03     | 63.97  |
| SC 0.4 | 28.94    | 37.94    | 41.12     | 30.95     | 34.49  |

Table 8. Value of OTTV Alternatif SC2 Vertical Device

| SC2  | Southeast | Southwest | Northwest | Northeast | Total  |
|------|-----------|-----------|-----------|-----------|--------|
| Existing | 49.02    | 73.75    | 81.6      | 54.03     | 63.97  |
| SC 0.41 | 35.06    | 49.05    | 50.26     | 38.1      | 61.47  |
3.4. Retrofit Facade: Replacement

3.4.1. WWR (Window to Wall Ratio)

The following is an analysis with a design scenario only to replace the facade by reducing the amount of openings (WWR).

| WWR     | Southeast | Southwest | Northwest | Northeast | Total |
|---------|-----------|-----------|-----------|-----------|-------|
| Existing| 49.02     | 73.75     | 81.6      | 54.03     | 63.97 |
| WWR 0.6 | 40.61     | 60.61     | 67.07     | 44.71     | 52.97 |
| WWR 0.5 | 33.71     | 49.66     | 54.96     | 36.94     | 43.4  |
| WWR 0.4 | 26.75     | 38.71     | 42.85     | 29.17     | 34.06 |

From the results of the analysis it can be seen that with the smaller WWR, the OTTV value is getting smaller, because it reduces the absorption of solar radiation on the glass/openings. However, a small WWR reduces natural light into the building and reduces the view from inside out. Meanwhile, the WWR types of 0.5 and 0.4 and 0.3 were successfully applied to the southeast and northeast, but could not achieve the desired results in the southwest and northwest. Overall, the WWR of 0.3 has achieved OTTV values of 34.06 so that $\leq 35$ kwh/m².

After analyzing with WWR 0.3, several alternatives were made to complete by adding SC1 with C and SC2 type glass with 3Z Horizontal panel and 3Z Vertical panel.
3.4.2. **Type 1 Glass + SC 2 Horizontal**

![Diagram of alternative WWR SC2: Horizontal & Vertical Devices](image1)

**Figure 5. Alternative of WWR SC2: Horizontal & Vertical Devices**

![Application of WWR SC2 Device Horizontal](image2)

**Figure 6. Application of WWR SC2 Device Horizontal**

| WWR                  | Southeast | Southwest | Northwest | Northeast | Total  |
|----------------------|-----------|-----------|-----------|-----------|--------|
| Existing             | 49.02     | 73.75     | 81.6      | 54.03     | 63.97  |
| WWR 0.5 + Horizontal + Type C Glass | 12.99     | 18.12     | 20.37     | 14.03     | 16.23  |
| WWR 0.4 + Horizontal + Type C Glass | 11.56     | 15.67     | 17.6      | 12.39     | 14.19  |
| WWR 0.3 + Horizontal + Type C Glass | 10.14     | 13.22     | 14.84     | 10.76     | 12.15  |

From several alternative horizontal models analyzed, the OTTV calculation results are obtained as shown in Table 9 above.

![Facade design alteration](image3)

**Figure 7. Alteration result of facade design with alteration of WWR SC2 Horizontal Device**
3.4.3. Type 1 Glass + SC 2 Horizontal

From several alternative vertical models analyzed, the results of OTTV calculation are as follows

| WWR           | Southeast | Southwest | Northwest | Northeast | Total  |
|---------------|-----------|-----------|-----------|-----------|--------|
| Existing      | 49.02     | 73.75     | 81.6      | 54.03     | 63.97  |
| WWR 0.5 + Vertical + Type C Glass | 13.36 | 18.81 | 21.15 | 14.47 | 16.8  |
| WWR 0.4 + Vertical + Type C Glass | 11.86 | 16.22 | 18.23 | 12.75 | 14.54 |
| WWR 0.3 + Vertical + Type C Glass | 10.36 | 13.63 | 15.31 | 11.03 | 12.49 |

Figure 8. Application of WWR SC2 vertical Device

Table 1. Value of OTTV WWR SC2 Vertical Device

After analyzing, it was found that the type of replacement with changes to the Window to Wall Ratio + SC1 (Glass Shading Coefficient) + SC2 (Shading Coefficient Device) was successfully applied on all sides, thus reducing OTTV value by 79% compared to existing conditions.

4. Conclusion

This research shows that facade retrofit efforts can encourage existing buildings to meet OTTV standards. Each facade retrofit strategy results in varying OTTV value changes because it depends on having different OTTV components. Factors that can affect OTTV from 4 (four) facade retrofit strategies are: orientation, type of glass material, magnitude of window openings compared to solid walls (window to wall ration) and coefficient shading.

The results of this study are expected to be one of the considerations for existing buildings that want to retrofit the facade.

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