Energy efficiency through façade design model of Nobel house building

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Abstract. One of the triggers to global warming is the increase of CO₂ trace caused by fossil energy consumption. The escalation of fossil energy consumption in urban area comes from industrial sector, housing sector, and commercial sector. Commercial buildings in urban area play a major contribution in CO₂ production level. That is why, electricity efficiency efforts are needed. The high energy consumption in commercial buildings are commonly caused by less precise façade construction, either on its design, material, and orientation. The objective of this research is to evaluate the effect of façade design on energy efficiency level at Nobel House Building. The participation of Nobel House to lower CO₂ is actually an effort to improve GBCI green building certification valuation result, from Gold to Platinum. Energy aspect is a priority in certification valuation to improve their rank. The research method utilized in this research is a descriptive qualitative method with OTTV analysis on 15 Nobel House Building façade models. The research is further narrating the initial 15 models with gold certifications. The result of this research is used to determine 4 façade model with energy efficiency below the base line. (SNI 6389-2011, GBCI,2013) with two main considerations which are easy in construction and maintenance work.

1. Introduction
At this moment, energy consumption level has reached 60% and is predicted to reach 80% on 2040. If the consumed energy comes from fossil energy, the unavoidable impact would be the increase of carbon dioxide/CO₂ production as pollutant that would leads to global warming which will endanger the lives all over the world [1]. Indonesian energy consumption on industrial sector is at 36%, on housing sector is at 31%, on transportation system at 28%, meanwhile the commerce and service sectors are at 5% [2]. Energy consumption level of buildings in urban area contribute up to 43%, industrial at 25%, and transportation at 32%. Whereas, these buildings are categorized into 5% of industrial building, 17% of commercial building (one of them is rented office), and 21% of residential buildings [3].

Urban building performance evaluation must be conducted with reference of: (1) Regulation of Public Works Minister Number 29 Year 2006 on Building Technical Requirements [4], (2) Regulation of Minister of Environmental Issues Number 8 Year 2010 on Eco-Friendly Building Criteria and Certification [5], (3) Regulation of Ministry of Public Works and People Housing Number 02/PRT/M/2015 on Green Building Construction [6], (4) Regulation of Governor of Jakarta Number 38 Year 2012 on Green Building [7]. For the area of Jakarta, all of these four regulations are mandates for new building design with certain area and function.
To complete the government regulation on new building construction, Green Building Council Indonesia (GBCI) will provide Green Building Certification on the design after conducting an evaluation on the design based on 6 criteria. These 6 criteria are shown in Table 1.

### Table 1. Six criteria of green building evaluation rank [8].

| Criteria                              | Total Value | Percentage |
|---------------------------------------|-------------|------------|
| ASD - Appropriate Site Development    | 17          | 17%        |
| EEC - Energy Efficiency and Conservation | 26          | 26%        |
| WAC - Water Conservation              | 21          | 21%        |
| MRC - Material Resource and Cycle     | 14          | 14%        |
| IHC - Indoor Health and Comfort       | 10          | 10%        |
| BEM - Building Environment Management | 13          | 13%        |
| **Total**                             | **101**     | **100%**   |

Source: GBCI 2013

The main requirement of energy efficiency valuation by GBCI is the external heat load on the building façade which is measured with Overall Thermal Transfer Value (OTTV) method. OTTV is a valuation of external thermal/heat transmission on building façade surface influenced by façade design (W/m²). The submission of green building certification, OTTV analysis has become a perquisite for valuation of energy efficiency. When the original façade design is unable to fulfill the minimum/base line requirement (the required minimum OTTV value according to GBCI is at 35° Watt/m² of façade area and according to Indonesian National Standard is at 45 Watt/m²). That is why façade design that would fulfill evaluation level $\leq$ the baseline is required [8].

The effort to improve energy efficiency is conducted by air conditioning with the right passive façade design (the right material usage, orientation, and shading application on building façade, color and tecture). This research is focused on energy efficiency through façade design accuracy. We can see that the energy efficiency aspect is a prioritized scale.

This research is aimed to evaluate Nobel House Building façade design based on its energy consumption efficiency. Nobel House Building involvement to lower CO₂ level is aimed to improve its certification level on GBCI green building certification valuation. The initial design with gold certificate is aimed to be improved into platinum by analyzing 15 façade design models through OTTV method. Based on the OTTV analysis on the 15 façade models, we are hoping to obtain: (1) heat transmission value that would represent energy consumption level, while also considering the comfort temperature of 24-25°C with humidity level of (RH) 60-70% [9]; (2) determine several models that appropriate with the baseline; (3) determine 4 models with the highest energy efficiency level out of the available 15 models. Four façade models are chosen with analysis consideration of the ability to minimize OTTV value based on the utilized baseline, with two main considerations which are easy in construction and maintenance work.

### 2. Methods

The method utilized in this research is a descriptive qualitative method through 2 phases of activities which is divided into; (1) Phase 1 which includes; (a) conducting data compilation of micro climate characteristic of the building to obtain output of average temperature on the hottest months and the coldest months (draught and rainy seasons); (b) average humidity level, vegetation element on the footprint according to its outer design; (c) building orientation (façade design direction), considering that the heat value of each directions are different, and Nobel House Building façade design directions are specifically made, not only facing 4 directions, but facing 8 directions (east, west, north, south, south west, south east, north west, north east); (d) façade area measurement and material utilization of Nobel House Building original façade design; (e) illustrating 15 façade models as references on OTTV value analysis measurement; and (2) Phase 2 which includes the analysis and calculation comparison of 15
models OTTV measurements to determine 4 chosen models. The scheme of the method is illustrated below:

![Figure 1. Scheme of research methodology.](image)

3. Results and discussion

Nobel House Building is a commercial office building which is located in Lingkar Mega Kuningan Street at South Jakarta. The building is fitted with 32 main floors, and 4 floors of basements used as parking areas and utility rooms. The orientation and building height data can be seen in the following figure 2:

![Figure 2. Nobel house building layouts and height data.](image)

The details of processed data based on field physical and initial design measurements is as follow:
3.1. Façade area measurement and original direction design

Table 2. Nobel house building façade area data.

| Façade       | Square/ Dimensions |
|--------------|--------------------|
|              | North | East | South East | South | North West | West | South West |
| Wall (lt. GF) | 386.19 | 0.00 | 0.00 | 0.00 | 115.57 | 0.00 | 0.00       |
| Wall (lt. 5)  | 0.00   | 0.00 | 0.00 | 0.00 | 0.00   | 0.00 | 0.00       |
| Wall (lt. 6-30) | 436.54 | 0.00 | 0.00 | 273.48 | 0.00   | 0.00 | 0.00       |
| Wall (lt. 19) | 23.27  | 0.00 | 0.00 | 14.58 | 0.00   | 0.00 | 0.00       |
| Wall (lt. 31-32) | 42.30  | 0.00 | 0.00 | 26.50 | 0.00   | 0.00 | 0.00       |
| Glass (Fl. GF) | 0.00   | 71.68 | 220.93 | 724.00 | 0.00   | 0.00 | 143.78     |
| Glass (Fl. 5) | 312.78 | 41.34 | 156.48 | 332.52 | 0.00   | 62.94 | 78.72      |
| Glass (Fl. 6-30) | 6303.46 | 2331.29 | 2453.06 | 5931.94 | 1129.01 | 125.50 | 126.50     |
| Glass (Fl. 19) | 312.68 | 193.00 | 130.74 | 316.14 | 60.17  | 78.72 | 126.50     |
| Glass (Fl.31-32) | 568.50 | 365.90 | 237.70 | 574.80 | 109.40 | 125.50 | 126.50     |
| Total         | 8385.70 | 3003.20 | 3198.91 | 8193.95 | 1414.15 | 1724.06 |
| WWR           | 89%    | 100% | 100% | 96% | 92%    | 100% | 100%       |
| Total WWR     | 95%    |       |       |     |        |       |            |

3.2. Façade model to be analyzed with OTTV measurement

Determining 15 façade models as negotiated by the architect and Nobel House Building owner with the following criteria; (1) modern façade looks; (2) determining façade orientation/direction according to its environmental potential and building visualization based on urban view with sun heat as consideration factor. Orientation or direction with lower heat factor is preferable. The data is presented in table 3 below.

Table 3. Façade opening dimension, orientation, heat value, and horizontal shading application data analysis.

| (Opening Area*SC*SF) | Opening Area (m²) | Solar Factor (SF) | Shading Coefficient (SCk) | Shading Coefficient Effective (SCeff) | Shading Coefficient (SC=SCk*SCeff) | OTTV | A*OTTV |
|----------------------|-------------------|-------------------|---------------------------|-------------------------------------|----------------------------------|------|--------|
| North                | 568.50            | 130               | 0.93                      | 1.00                                | 0.93                             | 120.90 | 68.731.65 |
| East                 | 365.90            | 112               | 0.93                      | 1.00                                | 0.93                             | 104.16 | 38.112.14 |
| South East           | 237.70            | 97                | 0.93                      | 1.00                                | 0.93                             | 90.21  | 21.442.92 |
| South                | 574.80            | 97                | 0.93                      | 1.00                                | 0.93                             | 90.21  | 51.852.71 |
| South West           | 109.40            | 176               | 0.93                      | 0.59                                | 0.93                             | 96.70  | 10.579.21 |
| West                 | 125.50            | 243               | 0.93                      | 1.00                                | 0.93                             | 225.99 | 28.361.75 |
| North West           | 126.50            | 211               | 0.93                      | 1.00                                | 0.93                             | 196.23 | 24.823.10 |

| Total Solar Heat Gain (Watt) | 243,903.47 |

3.3. Obtaining minimum OTTV value on the façade

(a) choosing low value U façade wall material; (c) material with low absorption coefficient value; (c) shading utilization; (d) double wall/glass utilization [10]; (4) categorizing the façade models into two groups which are; (a) curtain wall looks façade design combined with 80 cm parapet and 140 cm spandrel, (b) façade design group that utilizes a combination of 80 cm parapet, 70 cm horizontal shading made of aluminum material as penetration, glass and 140 cm spandrel. By replacing several materials, we were able to determine 15 façade models, one of them is an initial gold ranked façade design.

Out of the produced 15 models, either by replacing or stimulating several types of glass with certain characteristic with low energy glasses such as Stopsol glass, Double glass T sun, Double glass Stopray with several level of thickness as shown in Table 4.
Table 4. Details of alternative glasses.

| Glass Specification                                                                 | SHGC | SC  | U Value | VLT  | VLR |
|-------------------------------------------------------------------------------------|------|-----|---------|------|-----|
| 8 mm Stopsol Super Silver Dark Blue #2 + AS.12 + FL6                                   | 0.30 | 0.34| 2.80    | 32.0 | 15.00|
| 8 mm T Sunlux CS 140 (on Clear) #2 + 12 mm AS + 6 mm Planibel G#3                    | 0.31 | 0.36| 1.90    | 29.00| 19.00|
| 8 mm Stopray Ace 52/26 (Neutral Bluish Silver) #2 + AS 12 + 6 mm Clear                 | 0.26 | 0.30| 1.50    | 52.00| 24.00|

The 15 façade models that has been analyzed with OTTV calculation is compared to obtain 4 models (with criteria of low OTTV value, fulfill GBCI Standard and National Indonesian Standard 6398, 2011; with consideration of construction and maintenance facilitations and efficient Life Cycle Cost). The results of comparison analysis on 15 façades are as follows.

Table 5. Comparation analysis on 15 façades.

| Alt | Specification                                      | OTTV   | Preliminary Design Analysis | Minimum OTTV |
|-----|----------------------------------------------------|--------|----------------------------|--------------|
|     | Massive                                            |        | Work Capability             | Cost Efficiency | Maintenance | OTTV |
| 1   | Original design                                    |        | Ok                          | Ok            | Ok          | Not Ok |
| 2   | Original design                                    |        | Ok                          | Ok            | Ok          | Not Ok |
| 3   | Original design                                    |        | Ok                          | Ok            | Ok          | Not Ok |
| 4   | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 37.83 | Ok                          | Ok            | Ok          | Not Ok |
Based on the analysis above, the alternative design that categorized as preferable designs are: (a) alternative 6: façade design alternative with building cover materials of pure glass with glass type of Low e (Stopray Ace 52/26) Neutral Bluish Silver; (b) alternative 7: façade design alternative with building cover materials of pandrel, 12 mm stopsol super silver glass, and plastered brick parapet; (c) alternative 8: façade design alternative with building cover materials of pandrel, 12 mm T-Sunflux glass and plastered brick parapet; and (d) alternative 9: façade design alternative with building cover materials of pandrels, 12 mm Stopray AC clear glass, and plastered brick parapet.

Table 5. Cont.

| No. | Spandrel Type | Building Cover Materials | Rating | Acceptability | Acceptability | Acceptability | Acceptability |
|-----|---------------|---------------------------|--------|---------------|---------------|---------------|---------------|
| 5   | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 8 mm T-Sunlux CS 140 (on Clear) #2 + 12 mm AS + 6 mm planibel G#3 | 36.51 | Ok | Ok | Ok | Not Ok |
| 6   | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 8 mm Stopray Ace 52/26 (Neutral Bluish Silver) #2 + AS 12 + 6 mm clear | 30.25 | Ok | Ok | Ok | Ok |
| 7   | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 8 mm Stopsol Super Silver Dark Blue #2 + AS 12 + FL 6 | 29.04 | Ok | Ok | Ok | Ok |
| 8   | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 8 mm T-Sunlux CS 140 (on Clear) #2 + 12 mm AS + 6 mm planibel G#3 | 28.04 | Ok | Ok | Ok | Ok |
| 9   | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 8 mm Stopray Ace 52/26 (Neutral Bluish Silver) #2 + AS 12 + 6 mm clear | 23.37 | Ok | Ok | Ok | Ok |
| 10  | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 8 mm Stopsol Super Silver Dark Blue #2 + AS 12 + FL 6 | 36.76 | Not Ok | Ok | Not Ok | Not Ok |
| 11  | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 8 mm T-Sunlux CS 140 (on Clear) #2 + 12 mm AS + 6 mm planibel G#3 | 35.36 | Not Ok | Ok | Not Ok | Not Ok |
| 12  | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 8 mm Stopray Ace 52/26 (Neutral Bluish Silver) #2 + AS 12 + 6 mm clear | 29.30 | Not Ok | Ok | Not Ok | Ok |
| 13  | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 8 mm Stopsol Super Silver Dark Blue #2 + AS 12 + FL 6 | 28.25 | Not Ok | Not Ok | Not Ok | Ok |
| 14  | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 8 mm T-Sunlux CS 140 (on Clear) #2 + 12 mm AS + 6 mm planibel G#3 | 27.20 | Not Ok | Not Ok | Not Ok | Ok |
| 15  | 1.4 m Spandrel (Lisplank pre-case + isolation + gypsum) | 8 mm Stopray Ace 52/26 (Neutral Bluish Silver) #2 + AS 12 + 6 mm clear | 22.67 | Not Ok | Not Ok | Not Ok | Ok |
4. Conclusion

Based on the analysis result and discussion above, the conclusions are as follows:

- Building energy efficiency can be obtained by designing the façade based on low U orientation and material usage. This result is obtained by dominating the façade surface with low U value glass materials.
- Minimizing OTTV on façade as an effort to decrease energy consumption of air conditioning as the highest consumption of energy in rural area is effective to lower carbon emission trace.
- The highest rating value as an effort to improve green building certification rank is conducted by prioritizing Efficiency Energy Consumption/EEC.
- The determination of 4 façade models is not only based on its ability to minimize OTTV, but also by considering the work capability of construction, maintenance, and comfort for the building inhabitants.

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