The importance of iterative process in facade design optimization for a green office building in South Tangerang City

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Abstract. Currently, climate change and wellbeing provoke buildings to have higher sustainable performance. So, the condition expects that buildings can tackle those issues that benefit and less impact the environment and its occupants. This particular target needs integrated design approach that the role of the iterative process is necessary. The study focuses on the process of facade design for the buildings that are targeted to have sustainable performance. So, the design of the building facades shall be in accordance with the green building standard issued by GBC Indonesia, Greenship NB Version 1.2. The optimization of facade design was conducted based on three parameters: OTTV, daylight, and outside view. The minimum requirements for each parameter are 35 Watts/sqm for maximum OTTV, 30% for a minimum active area covered by daylight, and 75% for a minimum active area with an outside view. One of the aims of this study is to give a depiction of how to conduct a design process by using an iterative way. In addition, it is to identify the critical keys in enabling the building to the requirements.

1. Introduction
The idea of sustainable building is to change our behavior practices in the construction and property sector to overcome the problems that may appear due to climate change. The parameter of sustainable building has been changing from time to time. Recently, World Green Building Council or WGBC has set the target to assure that all new buildings will be designed and constructed with net-zero carbon principle in 2030. The definition of net-zero carbon building or NZHB is a building with highly energy-efficient with all remaining energy from on-site and or off-site renewable sources [1]. The target has escalated that in 2050 all new and existing buildings will be designed, constructed, and operated with net-zero carbon principle. However, due to the pandemic Covid 19, a healthy built environment becomes another goal that needs to be addressed. Therefore, a sustainable building promotes health and well-being to the building occupant while also is to be highly efficient in energy, so the dependency on fossil energy sources may decrease significantly.

In order to cope with this situation, buildings are expected to perform in a sustainable manner. At this stage, green or sustainable building standards have essential role in guiding throughout building life cycle: design; construction; occupancy; and; demolition. One of the green building standards issued by Green Building Council Indonesia or GBC Indonesia is Greenship Rating Tool. Like any other green
building rating tool, Greenship stands for promoting resources efficiency, minimizing the environmental impacts, and improving occupants’ health-comfort.

This paper aims to show how the iterative process, as one of the integrated design process components in design stage, can give an effective and optimal result to reach sustainable building performance. Optimization in the design process shall be taken to bridge the issues that commonly become a paradox between energy efficiency and health-comfort issues. The focus point of this study takes place on the facade design process. The building itself is an office building in South Tangerang City that is in the process of pursuing Greenship New Building (NB) Version 1.2 certification with gold predicate as a target. The study highlights the iterative process that can determine the optimized louver panels design as a secondary facade. The design process and the essential keys that affect the building performance, specifically in energy efficiency and occupants’ health-comfort improvement, will be explained throughout this paper.

2. Literature review
Commonly, the purpose of most urban building facades is to be a “pretty face” to the public eye [2]. On the other hand, the current climate challenges provoke building facade design plays an important role to assure the building performance in a sustainable manner. Instead of aesthetic issues, it is expected that facade design shall respond to the changing environment to promote energy efficiency, protect the building occupants from unwanted situations, and collect renewable energy sources.

2.1. Designing facade for energy efficiency
In hot and humid climate areas, a cooling system becomes essential for occupants’ thermal comfort, particularly in public buildings. In terms of energy consumption, about 50% of cooling load comes from exterior heat gain, which is from building facade [3]. Meanwhile, 56% of building energy consumption is from air conditioning system [4]. So, it is necessary to consider in a design process to minimize the heat gain from the exterior environment. Based on SNI 6389.2011 about Energy Conservation in Building Envelope, the heat gain of the building facade can be calculated by using the formula of Overall Thermal Transfer Value (OTTV). It is the sum of conduction heat gain from the opaque wall with equation \[\alpha \times U_w \times (WWR-1) \times TDek\], conduction heat gain from the fenestration wall with equation \[U_f \times WWR \times \Delta T\] and radiation heat gain from the fenestration wall with equation \[SC \times WWR \times SF\]. So, the formula of OTTV [5] as a whole is

\[
OTTV = [\alpha \times U_w \times (WWR-1) \times TDek] + [U_f \times WWR \times \Delta T] + [SC \times WWR \times SF] \quad (1)
\]

According to SNI 6389.2011, the maximum OTTV for efficient facade design is 35 Watts/sqm. Greenship Rating Tools for New Building Version 1.2 refers to this figure as a baseline for external heat gain calculation. Besides the building form and orientation, the ratio between fenestration wall area and total facade area or WWR value and the material properties of the fenestration wall express in shading coefficient (SC) value will significantly determine the amount of heat transfer from the facade. Both lower WWR value and SC value will generate lower OTTV, thus will reduce the cooling load that leads to efficiency in building energy consumption.

Another critical role of the building facade in energy efficiency is daylight penetration from exterior to interior. The more occupied area exposed by daylight, the less energy building consumption for artificial lighting usage. According to Greenship Rating Tools for New Building Version 1.2 it is expected that 30% of the occupied area can be penetrated by daylight for the whole operation hours. It depends on the WWR and the material properties of the fenestration wall that express in value of Visible Light Transmission (VLT). Another step is to provide grouping strategies that may differentiate the lighting groups between daylight and non-daylight area. The goal is to ensure that the artificial lights in the daylight area can be off once the sky is clear without considering the need for those lights in the non-daylight area.
2.2. Designing facade for health and comfort

The importance of daylight penetration is not only dedicated for energy efficiency purposes. It also takes part in determining the quality of health and comfort for the building occupants. Daylight has a positive impact to the human body by reinforcing its circadian rhythms [6], and some studies have shown that the access of daylight in working areas can increase productivity in office buildings [7]. So, these are some depictions that the performance of the fenestration wall is quite strategic to determine building facade as a whole.

In addition, humans spend about 80% to 90% of their time indoors [8]. It is necessary for building occupants who have more indoor activities are enable to have a visual connection with the outdoor condition. Building occupants who can visually connect with outdoor environments while performing everyday tasks experience greater satisfaction, attentiveness, and productivity [9]. From the early design stage, it is essential to ensure that the fenestration wall, particularly in vision height, shall be free from any obstruction. Louver or perforated metal, tinted or fritz glass, and built in or moveable furniture can be identified as visual obstructions if the installation of those gives visual disturbance. In order to comply Greenship NB Version 1.2, the building shall have a minimum 75% of the total occupied area that has visual access to the exterior.

2.3. Iterative process in design optimization

As it is important to understand that buildings shall be treated by considering its life cycle, an integrated approach shall be taken at the early design stage. The integrated design approach stands for sustainability performance while minimizing the potential of incremental cost and sticking within the schedule. One of the essential factors to implement this approach successfully is by conducting the design process iteratively. This process is different from conventional design approach which is conduct in a linear process by making upstream decisions and developing unchallenged assumptions. An iterative process ensures that decisions reflect the broader team’s collective knowledge, that interactions between different elements are considered, and that solutions go through the steps needed for optimization [10].

3. Methodology

3.1. Research method

This study was conducted with a case study method on the buildings that are designed for full active occupancy. These buildings have been targeted to implement green building principle in accordance with Greenship NB Version 1.2. The research was used a quantitative approach by doing a study through calculations and simulations on four scenarios that were applied to the facade design. The scope of this study was placed on three parameters to define sustainable facade design: OTTV, daylight, and outside view. The detailed methods for both simulations and calculations are written in the following three paragraphs below.

The OTTV Calculation was conducted in accordance with SNI 6389-2011. Since recommended maximum OTTV by SNI 6389-2011 that also stated in Greenship NB Version 1.2 is 35 Watts/m2, the calculation was conducted to assure whether the design facade has complied with the standard. In terms of energy efficiency, the lower of OTTV is better for facade performance. It is because the facade design shows a contribution in building energy efficiency from the air conditioning system by reducing external heat gain from the facade.

The daylight calculation was conducted in accordance with Greenship NB Guideline Version 1.2 within two steps. The first step was doing a daylight simulation to know the depth coverage of daylight in the active area. The simulation was conducted at 09.00 a.m. and 03.00 p.m. in equinox months. The second step was doing a calculation by comparing the total occupied area with daylight coverage and the total occupied area in the building. Since recommended minimum daylight area for green buildings is 30% of the total occupied area, these simulations and calculations were conducted to assure whether the design facade has complied with the standard. In terms of energy efficiency and occupants’ health and comfort, the wider occupied area that penetrated with daylight is better for facade performance. It
is because the facade design shows a contribution to building energy efficiency by reducing artificial lighting load and in occupants’ health and comfort by increasing the daylight area within the occupied area.

The outside view calculation was conducted accordance with Greenship NB Guideline Version 1.2 by comparing between total occupied area with visual access to the outdoors and the whole total of the occupied area in the building. Since recommended minimum outside view area for a green building is 70% of the total occupied area, this calculation was conducted to assure whether the design facade has complied with the standard. In terms of occupants’ health and comfort, the wider occupied area that has visual access to the outdoor is better for facade performance. It is because the facade design shows a contribution to occupants’ health and comfort by optimizing the size and location of the fenestration wall on the facade.

Those three parameters will be analyzed to determine which scenario meets with Greenship and the owner’s requirements. The results are used as decision making at the design stage to determine the most optimized louver design that can be applied on both building facades.

3.2. Data collection
The data that was used for this research is primary data and was collected by the writer as Greenship Professional (GP). During the design process, the role of GP is to give an assistance and advice to the project team at design and construction stages to meet the Greenship requirement. The data was taken from the minutes of coordination meetings, the design specification and the project drawings related to the facade design process. Design data that have been applied as constants to the four scenarios were building orientation, building form, properties facade materials, and reflectance factor of finishing surface for indoor area. Meanwhile, the four scenarios that have been taken to this research and perform as variables are:

1. Scenario 1, facade without louver panels.
2. Scenario 2, facade with louver panels that ratio between vision cavity and opaque 45mm/65mm;
3. Scenario 3, facade with louver panels that ratio between vision cavity and opaque 90mm/65mm;
4. Scenario 4, facade with louver panels that ratio between vision cavity and opaque 90mm/65mm but only 70% covered facade area;

4. Data and analysis
The project is located in South Tangerang City consists of five buildings within the site. Three from five buildings will be functioned as office buildings. Meanwhile, the other two are supporting buildings such as sport, café, warehouse and utility. The total site area is 28412 sqm with the detailed Gross Floor Area (GFA) and number floors of the buildings below:

| Code | Buildings             | Floors | Area (sqm) |
|------|-----------------------|--------|------------|
| A    | Main Office           | 4      | 6071.5     |
| B    | Annex 1 Office        | 4      | 1597.6     |
| C    | Annex 2 Office        | 4      | 1859.9     |
| D    | Sport + Utility       | 2      | 1474.5     |
| E    | Warehouse             | 3      | 17232.3    |
|      | **Total Building GFA**|        | **28235.5**|

Though the implementation of green performance for all buildings, the focus of the study will be on B and C buildings because the louver panels are installed on these buildings only. The position of both buildings in the project site is indicated by the blue lines that can be seen on the figure below.
Figure 1. Building site that indicate the position and location of research focus.

As Figure 1 shows that B and C buildings have a difference in orientation. B building has the bigger surface of the facade area on the West-East orientation, while C building has the bigger one on the North–South orientation. Since the solar factor is relatively higher on the West-East, the function of the louver may be effectively useful for sun shading that can reduce the exterior heat gain from the facade. However, there are several reasons behind in applying louver panels on C Building. First, it is because the building owner demands to maintain privacy related to visual access for both buildings that have orientation against the public street. Second, due to the similarity of the form and function between B and C Buildings, those become the architect’s basis of design to have uniformity in facade design.

Figure 2. Building elevation for each orientation for B Building.

The facade characteristic of B Building is curtain wall by using double glass Sunergy Blue Green 8mm High Strengthen + 12mm Air Space + 6mm Clear Annealed Glass as a majority. Meanwhile, the rest of the facade material uses light brick with paint finished. On the first floor, the height of floor to ceiling is 4,5m, whilst on the second, third, and fourth floors, the height of floor to ceiling is 3,75m. The
Glazing is designed with a unitized system and has two types based on its layers. The first type layer is vision glass that only consists of double glass that was already mentioned before as a fenestration area. Meanwhile, the second one consists of double glass with an additional layer behind with KalsiBoard panels as a backing spandrel. The louver panel is applied to West and South facades that can be seen on the overall facade design for B Building in Figure 2.

The facade characteristic of C Building is similar to B Building. However, on the second, third, and fourth floors, there is a balcony as a circulation area located on South Elevation that can perform as horizontal shading at the same time. The louver panel is applied on the North and South facade that can be seen on the overall facade design for C Building in Figure 3.

![Figure 2. Building elevation for each orientation for C Building.](image)

### 4.1. OTTV calculation result and analysis

The B and C Buildings used vision glass as a fenestration wall with double glass unit. Respectively, SC and U values of the double glass unit are 0.32 and 2.1. The opaque wall of these buildings consist of spandrel with U value 0.53 and brick with U value 2.86. Since both buildings were designed typically, the WWR value is also relatively similar, which is 40% in average. These data were constantly applied to the OTTV calculation on the four scenarios. However, those different conditions applied to West orientation on B Building and North orientation on C Building only. The result of the calculation can be seen in the table below.

| Scenario Types | OTTV (watts/m²) | Heat Gain from West Facade (watts/m²) | OTTV (watts/m²) | Heat Gain from West Facade (watts/m²) |
|----------------|----------------|-------------------------------------|----------------|-------------------------------------|
| Scenario 1     | 29.93          | 10.60                               | 25.12          | 7.13                                |
| Scenario 2     | 23.50          | 4.33                                | 21.00          | 2.92                                |
| Scenario 3     | 25.32          | 6.15                                | 22.22          | 4.14                                |
| Scenario 4     | 28.43          | 9.26                                | 24.16          | 6.08                                |
The result shows that the presence of louver panels leads to the reduction of heat gain from the facade. The OTTV result of the B Building is slightly higher than C Building because its facade area is bigger on West-East orientation. Since Scenario 1, the condition without louver panels, has reached a figure that is quite further below 35 watts/sqm, the other scenario with louver panels get better results in terms of energy efficiency. There is a slight difference between the result of Scenario 1 and 4. It is because the Scenario 4 is not only applying wider cavity twice from the Scenario 2, but also reducing the louver panels up to 30% coverage area from Scenario 3. But still, overall of the results show that all scenarios are preferable to be implemented.

4.2. Daylight area calculation result and analysis
For the compliance of daylight and outside view criteria in both B and C buildings, the calculation was dedicated to the area that occupied more than one hour a day that is defined as an active area. These calculations constantly used the data that has been mentioned above and relevant for conducting daylight simulation, such as average WWR value 40%. Visible Light Transmission 37% were applied on the simulation as the daylight properties on the double glass unit that used similarly on OTTV calculation. The simulation also has considered that the reflectance value of the finishing material has corresponded to the material specification as the requirement of the building owner. The color of the ceiling, wall, and floor was medium grey with 38% for a reflectance value, and the color of the column was dark blue with 3% for a reflectance value.

### Table 3. Daylight area calculation result with four scenario types.

| Scenario Types | Building B | Building C | Total Average* |
|----------------|------------|------------|----------------|
| Scenario 1     | 71,94%     | 42,79%     | 46,13%         |
| Scenario 2     | 45,25%     | 22,17%     | 30,36%         |
| Scenario 3     | 57,55%     | 27,03%     | 36,08%         |
| Scenario 4     | 67,70%     | 33,42%     | 41,60%         |

(*) The average calculation was conducted by including the A Building, since A, B and C Buildings are the main focus for daylight and outside view performance in Greenship requirement.

The result shows that the presence of louver panels leads to daylight area reduction that reaches below 30% as Greenship requirement. B Building has a wider daylight area result than C Building because it has a bigger facade area on West-East orientation that penetrate more direct sunlight. Though the result of the total average area, both Scenario 2 and 3 still meet Greenship requirement. However, those are still less preferable options because when it was conducted partially, each of them did not meet the requirement. The preferable option is Scenario 4 because the daylight performance can be achieved in accordance with Greenship requirement and visual privacy issue that stated on owner project requirement can be accommodated by the presence of louver panels.

4.3. Outside view area calculation result and analysis
The calculation was conducted on all occupied areas in both buildings. Outside view areas will be claimed as the area that have direct visual from indoor to outdoor without any obstruction that prevent the visual connectivity. The biggest obstruction area on the design is the louver panels, whilst the rest is the brick wall. The result of the outside view area can be seen in the Table 4.

Though the vision cavity of louver panels is already wider on Scenario 3 than Scenario 2, it was still considered as an obstruction. So, the outside view area between these two scenarios is similar because the presence of louver panels covered a similar area. For Scenario 4, the outside view area is increased by the reduction of the louver panels. The 30% decreasing of the louver panels can give the occupied area with a direct view from indoor to outdoor increase about 7,68% for B Building and 9,01% for C Building. The improvement figures in percentage seem does not significantly give the impact in increasing outside view area. But if it is converted into the unit area (sqm), those percentages are equal with 72 sqm and 124 sqm. Furthermore, those two figures can affect 19 occupants since the density...
standard for the working area is 10 persons per sqm [11]. It means that there will be another 19 occupants who will get better working space with visual access to the outdoor, which will increase their productivity.

Table 4. Outside view area calculation result with four scenario types.

| Scenario Types | Building B | Building C | Total Average* |
|----------------|------------|------------|----------------|
| Scenario 1     | 98,61%     | 100%       | 99,68%         |
| Scenario 2     | 62,22%     | 54,94%     | 81,30%         |
| Scenario 3     | 62,22%     | 54,94%     | 81,30%         |
| Scenario 4     | 73,53%     | 63,95%     | 84,60%         |

(*) The average calculation was conducted by including the A Building, since A, B and C Buildings are the main focus for daylight and outside view performance in Greenship requirement.

4.4. Iterative process on the design stage

Refers to the third chapter, there are four different conditions that applied to this research. The number of the condition reflects the sequence of the design process. The picture below gives more depiction of the four conditions.

At the early design stage, Greenship consultant released design guidelines that tailored for this project in accordance with Greenship NB Version 1.2. The guideline was developed to give depiction to the involved project team on design stage about their roles and what needs to be considered. So, it will correspond to Greenship NB Version 1.2, with gold predicate that targeted by building owner. The architect proposed the facade design by applying the Scenario 1 to the building owner by considering the guideline. After the proposed design with Scenario 1 was released, Greenship consultant conducted OTTV, daylight area, and outside view area analysis to check whether the design has met the expected performance. The result of the OTTV, daylight area, and outside area calculation met the green performance.

In response to the proposed design with Scenario 1, Building owner agreed with the outline of the proposed design but at the same time raised the issues about the visual privacy that shall be accommodated on the B and C Buildings. The proposed facade design with Scenario 2 responds the building owner’s requirement by applying the louver panels on West orientation of the B Building and North orientation of the C Building. Greenship consultant conducted similar treatment on the proposed design with analyzing the proposed design with Scenario 2. Since the analysis was conducted for the whole buildings, the general result was still met the expected performance. However, if B or C Building is seen as a stand-alone, it did not meet the requirement. Then, both architect and Greenship consultant agreed that Scenario 2 still needs further design elaboration, particularly on daylight and outside view performance.

At this stage, the building owner agreed to put the louver panels but give the authority in detailed design to the architect for addressing the Greenship requirement. Then a proposed design with Scenario 3 was released as a result of the Scenario 2 elaboration by widening the visual cavity on the louver panels. The analysis showed there was an improvement on the daylight performance but not on outside view performance. So, the architect came up with a proposed design with Scenario 4 by reducing the louver panels up to 30% from the previous coverage facade area as a solution. Based on the analysis, the last design was able to cope with both environmental and privacy issues at the optimum state. So, as a result, B and C buildings have met the Greenship and owner requirements. Respectively, the result of OTTV, daylight area and outside area on both buildings are 28,43 watts/sqm and 24,16 watts/m²; 67,70% and 33,42%; 73,53% and 63,95%.

5. Conclusion

Energy efficiency, health, and comfort issues were the issues that need to be tackled to deliver sustainable performance on the facade design on B and C Buildings. For energy efficiency, the design
was optimized by conducting OTTV calculation to assure the external heat gain from facade does not exceed 35 Watts/sqm. At the same time, it was necessary to conduct daylight simulation and calculation to ensure that the daylight penetration from the facade design in order to reduce lighting energy consumption. It is because the bigger coverage daylight area may lead to the lesser dependency of artificial lighting in the building. For health and comfort, it was important to assure the illuminance level of daylight that penetrate to inside the building shall adequate for the vision health and comfort of the occupants in doing their activities. The illuminance level depends on the WWR value of the facade and VLT value of as fenestration wall performance. Meanwhile, the WWR value itself also determines the active area that has visual access from inside to outside.

Several essential keys that made an iterative process was run successfully because of the solidness of the design project team members. In this case, there was the architect and the Greenship consultant, who find the optimum result. The architect has shown an eagerness to find a solution. Another key that does not less important was a leadership. The building owner was committed to implementing green building principal on their property, so in this project, the decision was always made by considering the green building principle as one of the considerations.

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