Efficiency Energy on Office Building in South Jakarta

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Abstract. South Jakarta is the center of business in Indonesia. As a business center, energy consumption in office buildings in South Jakarta is very high. An office building can consume energy up to 250 kWh/m²/yr. Energy consumption can be analyzed using building performance applications such as Sefaira. Sefaira is used as a method to simulate building energy that allows energy to be efficiently utilized. An energy analysis study was conducted to determine energy efficiency in an office building. The standards and guidelines of energy efficiency are based on ASHRAE 90.1 – 2013 on Sefaira. Efficiency energy is needed to achieve the Sefaira 2030 energy target of 90 kWh/m²/yr. In the previous analysis, the building consumed energy of 186 kWh/m²/yr. Architectural treatment on the building facades is needed, such as providing canopies, double-skin facades, and materials to reduce energy consumption by 96 kWh/m²/yr.

1. Introduction
Over the last decades, more people are moving closer to towns and cities to acquire economic services which followed by the increasing demand for jobs. These phenomena become urbanization issues caused much pressure on energy, resource, and environment [1]. The energy use is getting higher, especially in high-rise buildings in urban areas. Some ways that can be done to reduce energy consumption, including type of typology of buildings, building facades that respond to sunlight, the use of energy-saving technology, the use of materials and others [2].

The objective of this study is focusing on analyzing the energy consumption for achieving energy efficiency targets for office building in South Jakarta. The energy analysis can inform the total energy use of a building and what needs to be changed to get energy efficiency.

2. Performance-Based Design
Performance-Based Design (PBD) is a building that considers performance as building design. PDB can help the process of designing. Building performance is influenced by making decisions such as building shape, orientation, building envelopes, and building facades. In the process of designing a building, decision making is made from the initial sketch to the construction. This decision will affect the performance of the building. Decisions taken from PDB are solutions that have a high demand because of the decision that responds to the climate.

Sefaira Plugin is a Performance-Based Design application for SketchUp/Revit modeling that use to analyze and simulate the energy consumption of a building through analysis of the effects of climate on the building envelope and building shape. Before conducting the analysis, it is essential to choose the type of the building and it’s climate.
Table 1. ASHRAE 90.1 – 2013 Baseline

| Variable                       | Energy Standard |
|--------------------------------|-----------------|
| ASHRAE Climate Zone            | 4               |
| Wall Insulation                | 0.59 W/m².k     |
| Floor Insulation               | 0.32 W/m².k     |
| Roof Insulation                | 0.2 W/m².k      |
| Glazing U-Factor               | 1.99 W/m².k     |
| Visible Light Transmittance    | 0.41            |
| Solar Heat Gain Coefficient    | 0.4 SHGC        |
| Infiltration Rate              | 7.2 m³/m².h     |
| Ventilation Rate               | 15 L/s.person   |
| Equipment                      | 25 W/m²         |
| Lighting                       | 10 W/m²         |

Table 1 shows the baseline used in the analysis of the object study using ASHRAE 90.1 – 2013 Baseline. The standard is a guide in analyzing building energy consumption in several variables.

2.1. Building Information
The object of the study is an office building located in South Jakarta, DKI Jakarta, Indonesia. Office locations are in the Tropical Climate region with an average air temperature of 24°C-32°C, average rainfall of 118 mm, and humidity 83%.

![Location of the object study](image1)

Figure 1. Location of the object study

The office has five floors as a podium and two towers, each of the tower has 25 floors as offices, so the total floor is 30 floors. The building has two building cores in each tower. Inside the building core, there are elevators, fire stairs, utility shafts, and toilets.

2.2. Energy Performance Analysis
Energy analysis uses the Sefaira Plugin in SketchUp modeling. The first analysis is an analysis of the basic shape of the building. The results of the first analysis of energy consumption will be a feedback design whether the building requires design efficiency to achieve the goals of energy consumption.
Figure 2. Office building mass modelling uses SketchUp application with the Sefaira Plugin entity before analysis.

Table 2. Energy analysis

| Indicator               | Energy Value                          |
|-------------------------|---------------------------------------|
| Total Area Floor        | 87,958 m$^2$                          |
| Energy Use Intensity (EUI) | 186 kWh/m$^2$/yr                      |
| Heating                 | 9 kWh/yr                              |
| Cooling                 | 7,414,173 kWh/yr                      |
| Lightning               | 1,826,166 kWh/yr                      |
| Equipment               | 4,565,415 kWh/yr                      |
| Fans                    | 2,562,685 kWh/yr                      |
| Under Lit               | 11%                                   |
| Well Lit                | 53%                                   |
| Overlit                 | 36%                                   |
| East Solar              | 3,033,180 kWh/yr                      |
| West Solar              | 2,247,264 kWh/yr                      |
| North Solar             | 1,733,515 kWh/yr                      |
| South Solar             | 1,326,932 kWh/yr                      |
| Glazing Conduction      | 1,248,666 kWh/yr (gains)              |
|                         | 130,723 kWh/yr (losses)               |
| Wall Conduction         | 88,964 kWh/yr (gains)                 |
|                         | 78,654 kWh/yr (losses)                |
| Roof Conduction         | 91,846 kWh/yr (gains)                 |
|                         | 88,088 kWh/yr (losses)                |
| Floor Conduction        | 3,056 kWh/yr (gains)                  |
|                         | 17,724 kWh/yr (losses)                |
| Infiltration            | 1,140,854 kWh/yr (gains)              |
|                         | 413 kWh/yr (losses)                   |
| HVAC Cooling            | 318,750 kWh/yr (gains)                |
|                         | 10,876,708 kWh/yr (losses)            |
Table 2 shows energy consumption in several factors. It can be seen that the energy use for the cooling system is at most 7,414,173 kWh/yr compared to Equipment and Fans energy using. The percentage of lighting that goes into the building includes the Well Lit category of 53%. The energy analysis performed on buildings using the Sefaira Plugin produces energy of 186 kWh/m²/yr. This is not in accordance with the energy consumption target of Sefaira 2013, which equal to 90 kWh/m²/yr, so there is 96 kWh/m²/yr of energy value that must be efficient.

There are design recommendations on several aspects of the building to reduce energy consumption [3].

2.2.1. **Building facades**
A climate-based façade creates comfortable conditions. For hot climate, it is suggested to use passive cooling, shaded walls and glazing, natural ventilation, reflected daylighting, light exterior colors, insulation R 16, and double glazing.

2.2.2. **Daylighting from multiple sides**
Daylighting from multiple sides provides more lighting and produces less glare around people and objects. Lighting from one side imbalance the light in the building. Daylight spaces from various sides can be applied by providing windows on opposite walls or providing a combination of wall and skylight.

2.2.3. **Shading devices**
Avoiding sunlight into the walls and glazing can reduce heat entering the building. External shading devices reduce heat gain through glazing up to 80%.

2.3. **Result**
From the result of the initial analysis, changes in building design are in accordance with design recommendations to reduce the energy use.

![Figure 3. Office building mass modelling uses SketchUp application with the Sefaira Plugin entity after analysis.](image)

Table 3 shows a comparison of energy value used as a standard reference for analyzing energy use in the object study. Beside the climate zone, there are indicators that change to achieve efficiency energy. These indicators relate to the use of materials and specifications of materials to be applied to the building.
Table 3. Baseline standard energy

| Variable                      | Energy Standard | Energy standard with change | ASHRAE 90.1 - 2013 | ASHRAE 90.1 - 2013 |
|-------------------------------|-----------------|-----------------------------|---------------------|---------------------|
| Baseline                      |                 |                             |                     |                     |
| ASHRAE Climate Zone           | 4               | 4                           |                     |                     |
| Wall Insulation               | 0.59 W/m².k     | 0.34 W/m².k                 |                     |                     |
| Floor Insulation              | 0.32 W/m².k     | 0.25 W/m².k                 |                     |                     |
| Roof Insulation               | 0.2 W/m².k      | 0.2 W/m².k                  |                     |                     |
| Glazing U-Factor              | 1.89 W/m².k     | 1.89 W/m².k                 |                     |                     |
| Visible Light Transmittance   | 0.41            | 0.41                        |                     |                     |
| Solar Heat Gain Coefficient   | 0.4 SHGC        | 0.21 SHGC                   |                     |                     |
| Infiltration Rate             | 7.2 m³/m².h     | 4.9 m³/m².h                 |                     |                     |
| Ventilation Rate              | 15 L/s.person   | 15 L/s/person               |                     |                     |
| Equipment                     | 25 W/m²         | 10 W/m²                      |                     |                     |
| Lighting                      | 10 W/m²         | 5 W/m²                       |                     |                     |

Table 4 shows the result of energy use after efficiency and the comparison with previous analysis. The use of energy in the object study decrease to 111 kWh/m²/yr with changes in floor area to 82,304 m².

Table 4. Final energy analysis

| Indicator                  | Energy Value |
|----------------------------|--------------|
| Total Area Floor           |              |
| Energy Use Intensity (EUI) |              |
| Heating                   | 9 kWh/yr     | 1 kWh/yr | Decrease |
| Cooling                   | 7,414,173 kWh/yr | 5,336,523 kWh/yr | Decrease |
| Lightning                 | 1,826,166 kWh/yr | 820,211 kWh/yr | Decrease |
| Equipment                 | 4,565,415 kWh/yr | 1,657,509 kWh/yr | Decrease |
| Fans                      | 2,562,685 kWh/yr | 1,347,063 kWh/yr | Decrease |
| Under Lit                 | 11%          | 10%      | Decrease |
| Well Lit                  | 53%          | 55%      | Increase |
| Over Lit                  | 36%          | 35%      | Decrease |
| East Solar                | 3,033,180 kWh/yr | 1,226,472 kWh/yr | Decrease |
| West Solar                | 2,247,264 kWh/yr | 576,393 kWh/yr | Decrease |
| North Solar               | 1,733,515 kWh/yr | 671,015 kWh/yr | Decrease |
| South Solar               | 1,326,932 kWh/yr | 551,157 kWh/yr | Decrease |
| Glazing Conduction        | 1,248,666 kWh/yr (gains) | 1,032,008 kWh/yr (gains) | |
|                           | 130,723 kWh/yr (losses) | 102,529 kWh/yr (losses) | |
| Wall Conduction           | 88,964 kWh/yr (gains) | 284,497 kWh/yr (gains) | |
3. Conclusion

From the result of the analysis on the object study in the form of an office building located in South Jakarta, the energy use changed after applying energy efficiency using design recommendations to achieve Sefaira 2030 energy use target. Energy analysis was conducted using Sefaira plugin with SketchUp modeling and ASHRAE 90.1 – 2013 as the standard energy baseline.

In the first analysis, the result of building energy reached 186 kWh/m²/yr. With these results, energy efficiency is carried out to reduce building energy use. After applied design recommendations to reduce building energy, energy use become 111 kWh/m²/yr.

Sefaira 2030 energy use target is 90 kWh/m²/yr become the goals of building energy. From the energy result of the object study, energy use is not reaching the Sefaira 2030 target, but energy use still can be reduce by 75 kWh/m²/yr.

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