Optimization of Energy Usage of the Building Envelope Material at the Rental Office Buildings

M R Nurlette and B Paramita
Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229 Bandung 40154 Jawa Barat – Indonesia
rabbaninurllette17@student.upi.edu
betaparamita@upi.edu

Abstract. This study aims to determine the effect of materials used in building envelopes on energy use in office buildings. To obtain energy use analysis data, ASHRAE 90.1 - 2013 based parameters are used in the Sefaira Building Simulation application. The building analyzed will be simulated, using variables such as sunlight conduction with roofs, walls, building window ratios, gap ratios in buildings, and use of electrical equipment per square meter. Based on the analysis carried out, the use of building energy by using standard material specifications from the application reaches 180 kWh / m² / yr from what is supposed to be 79 kWh / m² / yr. After being analyzed, a specification change is given to the liquid application so that the results of the analysis are 89 kWh / m² / yr. So that the energy that can be reduced reaches 91 kWh / m² / yr. This proves that the selection of building material specifications can affect energy use in rental office buildings.

1. Introduction
Leasing offices in Indonesia generally use more wasteful energy than rental office buildings in Japan. Wasteful energy use is caused by the use of electrical energy to cool the room temperature in the room. It was noted that the use of office energy buildings in the City of Jakarta, Indonesia reached 240 kWh / m². This is inversely proportional to office buildings in Tokyo City, Japan using the energy of 140 kWh / m² in rental office buildings. Efficient use of energy in office buildings in Japan is supported by government policies. In addition, the material from the building influences the efficiency of energy use in the office. So that this needs to be considered by architects to use materials that can reduce energy use in buildings [1]
Wasteful energy use is caused by several factors, including the use of cooling & heating systems, fan systems, conduction of solar radiation with glass coating, walls, floors and roofs, cracks in buildings, and the duration of sun exposure on each side of the building. Generally, the use of energy in high buildings due to the use of air conditioning systems does not run optimally and efficiently. [2] Factors that can affect efficiency are exposure to radiation received by buildings through building envelopes. Thus, the need for special handling on the building envelope in order to be efficient in the use of air conditioning systems.
The building envelope has several main parts that have an influence on the energy use of rental office buildings, including walls, glass layers, roofs, and building floors. Based on this section, it should be
noted about the specifications of the material used, including wall insulation, floor insulation, roof insulation, U-Factor Glazing, and Solar Heat Gain Coefficient [3]. Specifications on the material to be used can affect energy use in buildings.

2. Research Methods

Building Model Information

![Figure 1 Visualisation Building Model](image1)

![Figure 2 Sefaira Data 1st Analysis](image2)

The building model is the basic design of the building that is used for the analysis of the sefaira application. The location set in the building is located in Jakarta because Jakarta is a city with many high-rise buildings. According to data from BI regarding the growth of Office Property Supply, Jabodetabek has increased by increasing 22 points from 115 points [4].

| KETERANGAN | 2015 I | 2015 II | 2015 III | 2015 IV | 2016 I | 2016 II | 2016 III | 2016 IV | 2017 I | 2017 II | 2017 III | 2017 IV | 2018 I | 2018 II |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Jabodetabek | 351.19 | 351.54 | 350.27 | 350.07 | 350.05 | 350.25 | 350.04 | 350.07 | 350.03 | 350.02 | 350.01 | 350.00 | 350.00 | 350.00 |

The area of the building is 17,600 m2. The use of energy in buildings by using the material specification standard of sefaira is 180 kWh / m2 / yr, this is due to the use of energy used is dominated by the segment of the air conditioning system.
Table 2. First Analysis of Sefaira

| Building Factor      | Spec     | Status            |
|----------------------|----------|-------------------|
| Wall Insulation      | 3.3 W/m²-k | No Insulation     |
| Floor Insulation     | 1.83 W/m²-k | Poorly Insulation |
| Roof Insulation      | 0.3 W/m²-k | Insulated         |
| Glazing U-Factor     | 2.85 W/m²-k | 2 Pane (low-e)   |
| Solar Heat Gain      | 0.25 SGHC | Reflective        |
| Coefficient          |          |                   |
| Equipment            | 25.1 W/m² | Poor              |
| Lighting             | 10.1 W/m² | Good              |

Based on the standard specifications of the Sefaira, there is a building insulation that has an insulating power of 3.3 W/m²-k, with information without insulation. This can be illustrated by a brick wall with conventional construction. For the floor, insulation has a value of 1.83 W/m²-k. That way, the floor has a low insulation quality. For glazing U-Factor using Material with a value of 2.85 W/m²-k. Glazing U-factor is the ratio value regarding the durability of the glass layer to the heat conduction from solar radiation to be transmitted into the room. Then for SGHC (Solar Heat Gain Coefficient) indicates that the resistance of the glass layer to exposure to sunlight, so that the sun's heat does not penetrate the glass and enter the room [5]. Then for SGHC (Solar Heat Gain Coefficient) indicates that the resistance of the glass layer to exposure to sunlight, so that the sun's heat does not penetrate the glass and enter the room. The equipment energy used in this analysis is as large as 25.1 W/m². This can be categorized as wasteful energy use. For standard usage according to the 1992 Building Building Standard of 240 kWh/m²/yr. For lighting use, it can be reduced by using wide windows but using specs with good insulation, so that exposure to sunlight can be minimized.

3. Result and Discussion

Figure 3 Sefaira Data 2nd Analysis

Table 3. Second Analysis of Sefaira

| Building Factor      | Spec     | Status            |
|----------------------|----------|-------------------|
| Wall Insulation      | 0.1 W/m²-k | Well Insulated   |
| Floor Insulation     | 0.1 W/m²-k | Well Insulated   |
| Roof Insulation      | 0.1 W/m²-k | Well Insulated   |
| Glazing U-Factor     | 2.81 W/m²-k | 2 Pane (low-e) |
| Solar Heat Gain      | 0.21 SGHC | Reflective        |
| Coefficient          |          |                   |
| Equipment            | 8.7 W/m²  | Good              |
| Lighting             | 7.6 W/m²  | Good              |

- Wall Insulation
  Wall insulation gives the effect to hold the wall from exposure to radiation exposure to the wall directly. The use of wall insulation has an effect on reducing the radiation entering the building [6]. So,
solar radiation can be restrained by wall insulation so that it can provide efficiency to the air conditioning system so that it can adjust the air temperature effectively and efficiently without being disturbed by solar heat caused by radiation from the wall. Spec that can insulate heat conduction well by 0.1 W / m²-k [7].

Examples of materials that can be used with the following specifications:

- **Floor Insulation**
  For the floor, insulation has a value of 1.83 W / m²-k. That way, the floor has a low insulation quality. For glazing U-Factor using Material with a value of 2.85 W / m²-k [8].

Examples of materials that can be used with the following specifications:

- **Roof Insulation**
  Roof insulation gives the effect to withstand conduction received from exposure to sunlight affected on the roof of a building. The roof can provide heat conduction on the top floor, thus affecting the use of the air conditioning system and the comfort of the room temperature [9].

Examples of materials that can be used with the following specifications:
Figure 6 Roof Insulation Visualization

- Glazing U-Factor & Solar Heat Gain Coefficient
  Glazing U-Factor is a ratio that indicates the ratio of heat lost in the window/glass layer. The lower the U-Factor value of the glass, the better the resistance to heat flow. The low value of U-Factor is important in a climate dominated by heat. This is to help the air conditioning system to work efficiently without the influence of heat flow from the conduction of solar radiation in the building envelope.

Figure 7 Visualization SGHC System

SGHC (Solar Heat Gain Coefficient) is the value of the power of the light channel that a window has, whether the window can transmit light and absorb sunlight [10]. SGHC is important because it can withstand heat conduction from solar radiation in the window.

Examples of materials that can be used with the following specifications:

Figure 8 Glazing Insulation Visualization
4. Conclusion

When a rental office building uses standard building specifications, it will influence the working system of air conditioning. The room temperature will be hotter due to the conduction of radiation that flows in the building envelope, including Glass Coating, walls, floors, roofs. As a result, the cooling system works more extra so that energy use does not run efficiently. For equipment that works and the installed lamp becomes a contributor to energy for the building, if the working system is not environmentally friendly. So, equipment and unused lights will waste energy. The solution to this problem can be solved by recommending the specifications of the material that will be used in the building envelope and environmentally friendly systems owned by Equipment and Lighting. Use of insulation on the walls, roof, and glass so that it can withstand the flow of heat from exposure to solar radiation so as not to penetrate in the room. So that it can produce buildings with energy use reaching 89 kWh / m² / yr. This proves from the analysis that has been done give influence to energy building uses.

For further research, a more in-depth explanation of the specifications contained in the material in Indonesia is needed, so that it can adjust to the conditions of available natural resources. The use of local materials can reduce the costs used from accommodation shipping to distribution costs.

5. References

[1] Fathana, A. A. (2016) ‘Ternyata, Gedung di Jakarta Lebih Boros Listrik daripada Jepang’.
[2] Nikolaou, T. (2015) ‘Office Building Simulation Models and Simplified Audits’, (Simulation Building).
[3] Karlsson, F. (2007) ‘Measured and predicted energy demand of a low energy building: important aspects when using Building Energy Simulation’, Building Serv Eng Res Technol, 28, p. 223.
[4] BI (2018) Perkembangan Properti Komersial. Bandung. Available at: https://www.bi.go.id/id/publikasi/survei/properti-komersial/Pages/PPKom_Tw2_2018.aspx.
[5] Efficientwindows (2018) Measuring Performance: Solar Heat Gain Coefficient (SHGC). Available at: https://www.efficientwindows.org/shgc.php (Accessed: 26 September 2018).
[6] Lee, J., Alshayeb, M. and Chang, J. D. (2015) ‘A Study of Shading Device Configuration on the Natural Ventilation Efficiency and Energy Performance of a Double Skin Façade’, Procedia Engineering. Elsevier B.V., 118, pp. 310–317. doi: 10.1016/j.proeng.2015.08.432.
[7] Heynen, H. and Van Herck, K. (2002) ‘Journal of Architecture: Introduction’, Journal of Architecture, 7(3), pp. 221–228. doi: 10.1080/1360236021000031507.
[8] Sattari, S. and Farhanieh, B. (2006) ‘A parametric study on radiant floor heating system performance’, Renewable Energy. doi: 10.1016/j.renene.2005.09.009.
[9] Tabares-Velasco, P. C. and Srebric, J. (2012) ‘A heat transfer model for assessment of plant based roofing systems in summer conditions’, Building and Environment. doi: 10.1016/j.buildenv.2011.07.019.
[10] Hertwich, E. G. et al. (2015) ‘Integrated life-cycle assessment of electricity-supply scenarios confirms global environmental benefit of low-carbon technologies’, Proceedings of the National Academy of Sciences. doi: 10.1073/pnas.1312753111.
[11] Abduh, N. (2017) ‘Teknologi green pada bangunan berkelanjutan’, Seminar Ilmiah Nasional Teknik Sipil Universitas Bosowa, pp. 1–17.
[12] Chen, F. et al. (2012) ‘Solar heat gain coefficient measurement of semi-transparent photovoltaic modules with indoor calorimetric hot box and solar simulator’, Energy and Buildings. doi: 10.1016/j.enbuild.2012.06.005.

Acknowledgements
This article is presented at the International Conference on Smart City Innovation 2018 that supported
by the United States Agency for International Development (USAID) through the Sustainable Higher Education Research Alliance (SHERA) Program for Universitas Indonesia’s Scientific Modeling, Application, Research and Training for City-centered Innovation and Technology (SMART CITY) Project, Grant #AID-497-A-1600004, Sub Grant #IIE-0000078-UI-1.