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Identification of existing office buildings potential to become green buildings in energy efficiency aspect

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Abstract

The rise of the issue of climate change and the energy crisis makes the building must perform energy saving measures in order to reduce the adverse effects on the environment. *Green Building Council Indonesia* (GBCI) has set the criteria named *Greenship* for Green Building, including on aspects of Energy Efficiency and Conservation that with regard to energy consumption savings. High-rise office buildings located in major cities, like in Jakarta, are encouraged to meet that criterion. Three hypothetical office building models are created and simulated to obtain the Energy Efficiency Index (EEI) and then classified into intensive, standard, and efficient cases. Alternative savings are then applied in simulation to meet the *Greenship* which is divided into two categories, namely saving alternatives without cost such as changing room temperature setpoint, air conditioning operating schedule, and chilled-water setpoint and alternative savings with cost such as replacement of lamp, glass, and chiller, window film installation. These efforts can produce big savings of EEI up to 40% with the attainment of maximum *Greenship* score of 36.

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Keywords: existing office building; green building; EEI; building energy simulation

1. Introduction

Buildings become one of the largest contributors of greenhouse gases, namely CO_2 into the environment by 40%, causing global warming and climate change [1]. In addition, 48% of the total supply of energy in the world is consumed by the building [2]. In Indonesia, Green Building Council Indonesia (GBCI) has formulated criteria of green building named *Greenship* which has some aspects of assessment, one of these is the aspect of Energy Efficiency and Conservation (EEC). This aspect dominates *Greenship* score with a total score of 36 out of maximum 117 or 30% of the maximum score. Meanwhile, Jakarta has the largest number of high-rise buildings in Indonesia and 30% of them are office buildings. Looking at this *Greenship*, then existing office buildings are encouraged to meet the Greenship and be awarded as green buildings. Various efforts can be carried out which result in energy saving potential achievement levels. The purpose of this study was to determine the saving potential achievement levels of the existing office buildings to meet the EEC *Greenship* rating system.

2. Theory

Green building criteria includes six aspects, namely Appropriate Site Development, Energy Efficiency and Conservation, Water Conservation, Material and Resource Cycle, Indoor Health and Comfort, and Building and Environment Management. Performance indicator of the energy use in a building is measured in Energy Efficiency Index (EEI). The *Greenship* set the minimum value of EEI of 250 kWh/m^2/year for existing office buildings [3]. EEI formula can be written as follows:

$$\text{EEI} = \frac{\text{Total energy consumption in one year (kWh/year)}}{\text{Total building conditioned area (m}^2\text{)}} \quad (1)$$

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In office buildings, commonly 50 – 60% of the total energy consumption dominated by the air conditioning system (AC). Cooling load in the buildings consists of external and internal loads. The external load includes heat into the room through the building envelope. Factors affecting the amount of external loads are type of construction materials, Window to Wall Ratio (WWR), U-value and Solar Heat Gain Coefficient (SHGC). WWR is the ratio of window area to the total area of the building envelope, U-value shows the amount of heat conduction through the wall and SHGC denotes the amount of incoming solar radiation through the glass material. Internal load comes from lighting system, occupancy, and electrical equipments. The EEI and cooling load of the buildings can then be calculated using *Energyplus* software.

3. Data and Simulation

3.1. Hypothetical existing office building

The first step of this study is modeling the building. The hypothetical building models are built identical and divided into three cases according to the *Greenship* criteria, namely :

1. Building with EEI over 300 kWh/m^2/year (intensive case)
2. Building with EEI between 250 – 300 kWh/m^2/year (standardach case)
3. Building with EEI less than 250 kWh/m^2/year (efficient case)

The model is square shaped consisting of 30 floors with dimension of 44 × 44 meters. The total floor area of the building is 58,080 m^2.

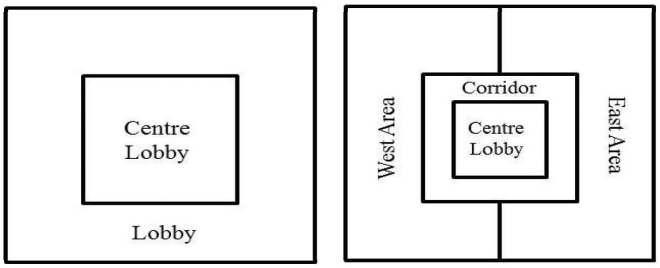

Fig.1. Floor plan of hypothetical building model

Figure 1 shows the floor plan of the building model which consists of lobby in the 1st floor and office areas from 2nd to 30th floor. Corridor is set as unconditioned area.

The next step is determining external and internal load inputs for the model. The input values are determined from Indonesian National Standard (SNI), ASHRAE, and a survey result from existing office building in Jakarta. The building envelope characteristics is shown in **Table 1** and **Table 2.**

Table 1. Building envelope materials and characteristics [4]

Construction	Wall	Roof	Floor	Ceiling
Material	Bata Celcon + Plaster	Heavy roof concrete	Floor ceramic	Lightweight concrete
	Plaster	F05 Ceiling air space resistance	F05 Ceiling air space resistance	F05 Ceiling air space resistance
		Gypsum	Lightweight concrete	Floor ceramic
U-value (W/m^2.K)	2.402	1.901	1.184	1.184

Table 2. Glass materials and characteristics [5]

Building case	EEI > 300	EEI 250 – 300	EEI < 250
Construction	Clear glass 8mm	Tinted glass	Low-e glass
U-value (W/m^2.K)	4.94	5.8	4.54
SHGC	0.82	0.6	0.4
Visible transmittance	0.89	0.57	0.57

Furthermore, internal load input for the model is shown in **Table 3**.