

Optimization of Building Energy Consumption in Universitas Negeri Padang Using Building Energy Simulation Program

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ABSTRACT

Energy consumption of a building is one of the biggest sources of energy use today. Green Building Committee Indonesia (GBCI) has launched a concept of energy consumption saving in a nationally standard building. Audit Building energy audit is the way to know how actual building energy consumption is and find alternative solution to decrease energy consumption in order to fulfill the energy saving building criteria. Two types of HVAC systems will be run in the Energy Plus simulation, split AC and central AC. The previous research proved that central AC is better than split AC system for energy saving in the building with 20 floors. The simulation results show that by using a certain energy system, a more efficient energy system will be achieved and can still maintain the comfort of the room at a temperature of 24 °C and relative humidity according to the Green Building Indonesia standard reference.

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1. INTRODUCTION

In today's modern era, one form of environmentally friendly is by doing greening and minimizing the effects of global warming. One of the creative solutions to global warming that has recently been promoted is by applying green buildings [1]. Green building refers to the structure and use of processes that are environmentally responsible and resource-efficient throughout the life cycle of the building from site selection, design, construction, operation, maintenance, renovation and demolition. This practice extends and complements classic building designs in terms of economy, utility, durability and comfort.

For getting green building certification in Indonesia, there are some building requirements including Energy Efficiency Index (EEI) for the last 6 months maximum and temperature control. EEI maximum value for an office is 250 kWh/m².year [2]. Temperature control value is between 24 °C - 27 °C and relative humidity between 55 % - 65 % [3].

In this paper, we present some recommendations in order to fulfill the building criteria as saving energy building based on the result of some simulations. The objective of our study is to develop a few optimization methods to obtain the optimum electrical energy for different techniques such as air conditioning and lighting control. In order to contribute to the green building certification, we used three optimization criteria: cooling energy needs, relative humidity comfort, and cost.

2. METHODS

The proposed method is based on the following steps:

- Reduction of simulation time by removing the unnecessary door dan roof;
- Complete building construction data is chosen from EnergyPlus;
- The data on HVAC, lighting, and other equipment used in buildings are getting from Revit;
- Parameters the number of people and occupancy in each area of the building are getting from Revit;
- Thermostatic parameters for the specification of the air conditioning are getting from SNI.

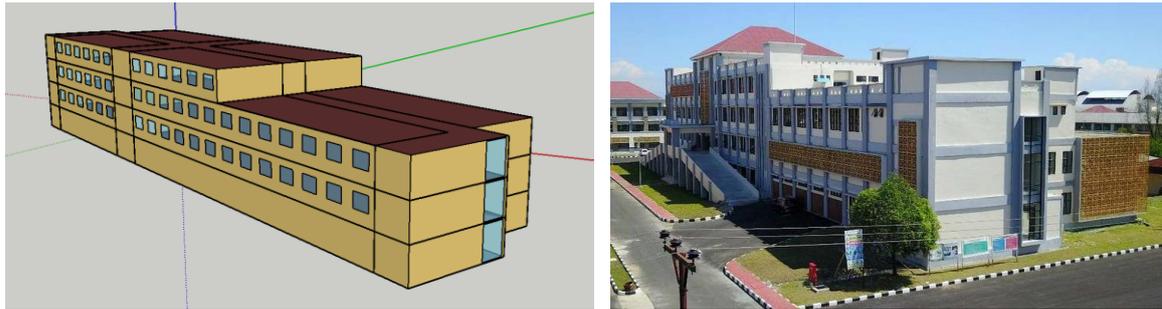


Figure 1 : Schematic views of the building model

2.1. Case Study and Building Parameters

The building that will be simulated in this study is already standing and in operation (existing building). This building was built with the aim of being lecturer rooms, staff rooms, and auditorium. This public university engineering faculty building consisting of four floors located in Padang. It is located at 0.898° latitude and 100.35° longitude. It is at an altitude of 3 m above sea level and located at 113° from the north.

2.2. People Schedule

Lighting schedule also depends on the schedule of people attendance. Fig. 2 shows a chart of the people schedule and we used in the EnergyPlus simulation obtained from Revit Autodesk 2020 [4]. There are two different charts is used including on weekdays and Saturday because Saturday is not as busy as weekdays.

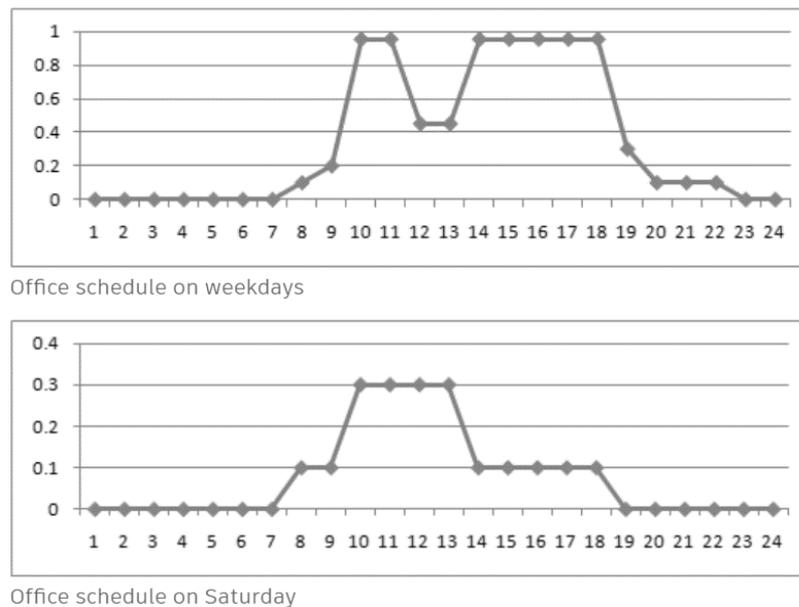


Figure 2 : Office schedule from Revit Autodesk 2020

2.3. Space Type Schedule

Other things that greatly affect the cooling load are the internal gain of people, lighting, and also the infiltration of air entering the room. For this building, the lighting data used is not yet known, so it is assumed that the building uses lighting according to ASHRAE standards. The following are the indoor standards (Space Type Data) based on ASHRAE obtained from Revit Autodesk [5]. Revit Autodesk also give some other information such as occupancy schedule, power schedule, and must be converted information into the following equation:

$$1 \text{ People}/100 \text{ sq. M.} = 0,01 \text{ Person}/\text{m}^2$$

$$1 \text{ W}/\text{sq. ft.} = 10,8 \text{ W}/\text{m}^2$$

Table 1: Office type schedule

Parameter	Value
Occupancy schedule	8 am – 5 pm
Power schedule	6 am – 11 pm
People/100 sq. M.	50.0
People sensible heat gain (Btu/hr.)	250
People latent heat gain (Btu/hr.)	200
Lighting load density (W/sq. ft.)	1
Power load density (W/sq. ft.)	1.5
Electrical equipment radiant (%)	0.3

2.4. Luminaire Type

The fraction contained in the light object is obtained from the standard indoor lamp installation [6]. The fraction value depends on the luminaire type of lighting. The following types of luminaire are commonly used.

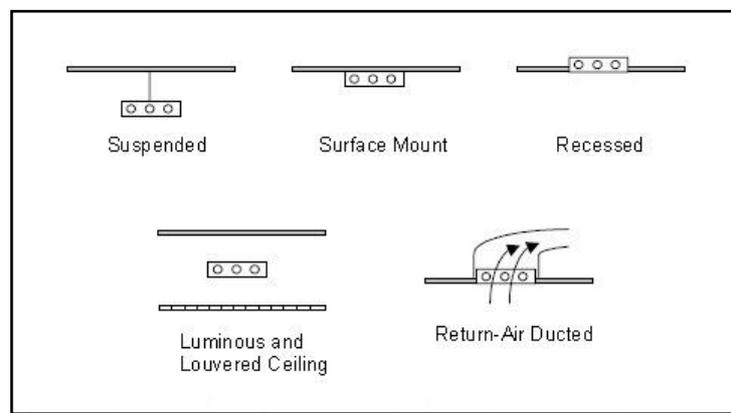


Figure 3: Luminaire type on ceiling

The luminaire type used in buildings is the recessed type (located inside drop ceiling). And there are four fractions including return air fraction, radiant fraction, visible fraction, and convected fraction. All the value of fraction is used to get lighting configurations.

Table 2: Luminaire configuration

Data	Luminaire Configuration, Fluorescent Lighting				
	SP	SM	RC	LL	RA
Return Air Fraction	0,0	0,0	0,0	0,0	0,54
Radiant Fraction	0,42	0,72	0,37	0,37	0,18
Visible Fraction	0,18	0,18	0,18	0,18	0,18
Convected Fraction	0,40	0,10	0,45	0,45	0,10

Note:

SP = Suspended

SM = Surface Mount

RC = Recessed

LL = Luminous and louvered ceiling

RA = Return-air ducting

2.5. Temperature Setting (Thermostat)

The desired working temperature is regulated based on SNI 03-6390-2011 standards [3] concerning energy conservation of building air conditioning systems, namely to meet the thermal comfort of building users, a room temperature of 24 ° C is used.

3. RESULTS AND DISCUSSION

3.1. Building Utility Performance

This report presents in detail the use of energy for a period of a year (annual period) and also details the data based on the total area of the building and the area of the building that is conditioned.

Table 3: Building area

	Area [m ²]
Total building area	9.173
Conditioned building area	6.664
Unconditioned building area	2.509

Unconditioned building area appears because there are some spaces that is not set for lighting and air conditioning system like corridors. The space like that is still drawn in order to keep heat transfer going through between its walls.

Table 4: Energy distribution in the ideal loads air system

	Energy/conditioned area [kWh/m ²]	Energy/total area [kWh/m ²]
Lighting	45	32,69
HVAC	District cooling 244,35	District cooling 177,51
Total	289,35	210,2

In the table above, in HVAC there are two possible districts will be shown. There are heating district and cooling district. Because Padang is one of the cities in a tropical country, Indonesia, no heating will be required.

3.2. Comparing AC System

By comparing the results obtained from the simulation results in the following table, it can be seen that by using the unitary cooling system, the total energy used is 1,902.1 MWh, while by using the VAV system the total energy use is 3,636.5 MWh.

Table 5: Energy distribution in the unitary and VAV system

	Unitary System [kWh/m ²]		VAV System [kWh/m ²]	
	Energy/ total area	Energy/ conditioned area	Energy/ total area	Energy/ conditioned area
Lighting	32,69	45,00	32,69	45,00
HVAC	174,67	240,43	363,75	500,70
Total	207,36	285,43	396,44	545,69
Total Energy	1.902,1 MWh		3.636,5 MWh	

The energy consumption is the sum of the building's energy consumption, which consists of lighting and air conditioning. The distribution of energy consumption can be divided by Energy Plus based on the total area of the building and also the area that is conditioned. From the simulation data table above, it can be said that energy consumption will be lower by using the unitary system (split air conditioning) compared to the VAV system (central air conditioning).

Table 6: Differences in energy consumption of each cooling system

	Unitary system	VAV system
Total energy (MWh)	1.902	3.636,5
Energy/total area (kWh/m ²)	207,36	396,44
Energy/conditioned area (kWh/m ²)	285,43	545,69
Electricity cooling (MWh)	1.318,65	2.577,96
Electricity interior lighting (MWh)	299,86	299,86
Electricity fans (MWh)	283,56	205,33
Electricity pumps (MWh)	0	495,45
Electricity heat rejection (MWh)	0	57,91

In the table above, it is clear that the difference between the two systems is seen from the use of energy (electrical energy) during a period of one year. The use of electrical energy is divided into several main components, namely energy for lighting and energy for air cooling. The energy for lighting is the same for the two systems used, but different for air cooling energy. Energy for cooling the air using the unitary system is 1,318.5 MWh and using the VAV system is 2,577.96 MWh.

From the table it can also be seen that the lowest total energy use is using the unitary system about 1,902 MWh, while for the VAV system about 3,636.5 MWh. With this value, it can be concluded that the unitary system is more efficient for this building cooling system. Based on the requirements for energy-efficient buildings in accordance with the criteria of the Green Building Council Indonesia, this building does not meet the requirements either if it uses the unitary air conditioning system or the VAV system. When viewed from the energy per area conditioned by the unitary system is 285.43 kWh/m². While the criteria from the Green Building Council Indonesia for office or school buildings are 250 kWh/m².

3.3. Optimization Method Using Daylighting Control

The conditioned zone is given an illuminance setting (lighting) of 500 lux for one point per zone where there are up to 10 points that can be positioned in a zone. Meanwhile, there are 3 types of daylighting control used to complete the simulation of the unitary system template, namely the lighting control type: continuous, continuous-off, and stepped [7]. The following table shows the simulation results of the unitary system template using the three types of daylighting control.

Table 7: Differences in energy consumption of each cooling system

System	With no DC	Using daylighting control		
		Cont	ContOff	Stepped
Total site energy (MWh)	1.902,1	1.796,3	1.766	1.817,97
EPCA (kWh/m ²)	285,43	269,56	265,02	272,8
Cooling (MWh)	1.318,65	1.300,7	1.295,5	1.305,8
Lighting (MWh)	299,86	212,45	187,4	228,6

We compare the energy per conditioned area (EPCA) in four cases (with no daylighting control, using continuous, continuous-off, and stepped daylighting control). Fig. 4 dan Fig. 5 shows the effect of using daylighting control on the cooling and lighting energy consumption.

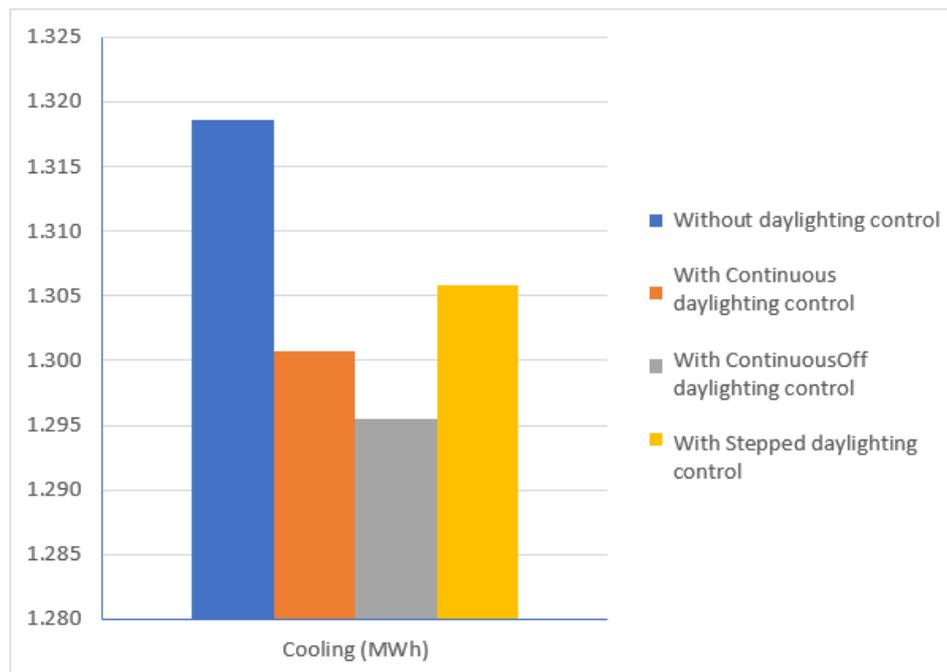


Figure 4: Effect of daylighting control on cooling energy

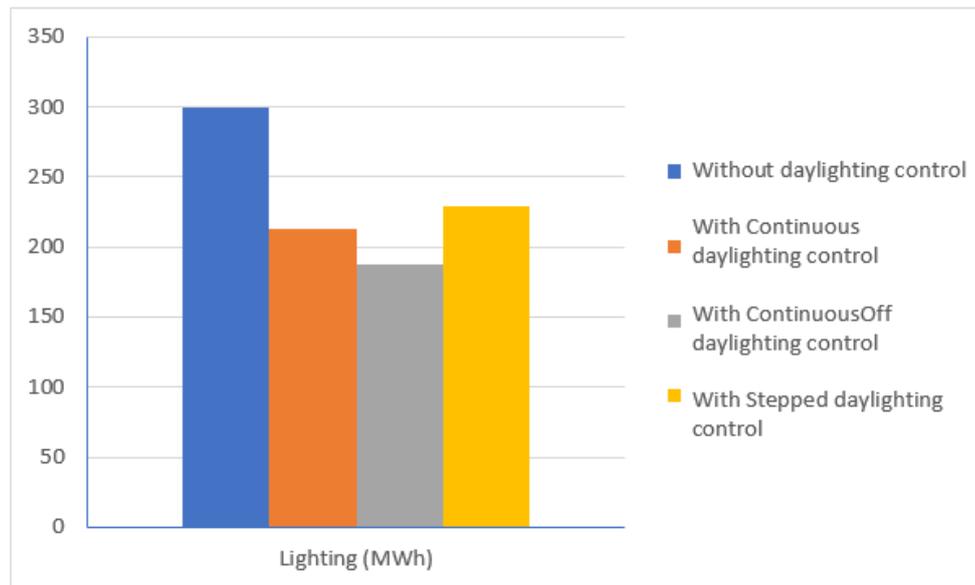


Figure 5: Effect of daylighting control on lighting energy

4. CONCLUSION

Based on the simulation results with the addition of daylighting control, it can be seen that there is not only a decrease in energy consumption in lighting but also in air cooling. This happens because the intensity of lighting also affects the increase in thermal heat in the room (internal gain). Thus, it can be recommended to use the most efficient air conditioning system for this building in the form of a unitary system or split air conditioning type which is commonly used and can be further optimized by adding a Continuous Off type of daylighting control in some conditioned rooms.

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