

# Implementation of Passive and Active Design Strategies for Energy Efficient Office Building (Case Study: VOZA Office Tower Surabaya, Indonesia)

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## ABSTRACT

According to EECCHI 2012, the building sector absorbs 40% of total energy worldwide. Even in Indonesia, the building sector is responsible for 50% of total energy expense and more than 70% of total electricity. These issues make the energy efficiency are significantly important to reduce the energy consumption and cost, also to reduce carbon emission especially in a building sector. Office building become a potential electricity consumer in commercial sector. Office building also become one type of building which has 25% of energy efficiency potential, greater than other types of buildings. Based on SNI data in 2000, the average energy consumption of rental offices in Indonesia are 250 kWh/m<sup>2</sup> per year, but in 2017 UN International Forum of Sustainable Development, the building energy consumption was targeted to 90 kWh/m<sup>2</sup> per year by 2030. VOZA Office Tower Surabaya will become a case study of office building type to be analyzed. The energy consumption of the existing building will be simulated with EDGE Software. The result will be the baseline to conduce the passive and active design strategies recommendation which will reduce the building energy use, so the building will reach maximum energy efficiency.

**Keywords:** *Energy efficiency, Rental office, Building energy simulation.*

## 1. INTRODUCTION

There are two main issues related to energy efficiency in the building sector. Firstly, Indonesia is the biggest energy consumer in the Southeast Asia which consumed 36% of the Southeast Asia's total energy use, or equal to the energy use of Thailand, Malaysia and Singapore combined together [1]. The increase of Indonesia economic growth prediction, will be leads to the escalation of electricity consumption until it reaches 491 terawatt hours in 2030. Thereby will be predicted if the electricity generator capacity needs to increase the capacity up to 4.1 gigawatts per year, while 50% of the total newly installed electricity generator, still using fossil fuel [2].

Secondly, the building sector absorbs 40% of total energy worldwide. Even in Indonesia, the building sector is responsible for 50% of total energy expense and more than 70% of total electricity consumption [3]. From the massive energy use, the building sector also contributed to 30% of greenhouse gas emission, because this sector uses the electricity from the fossil fuel-based electricity power generator.

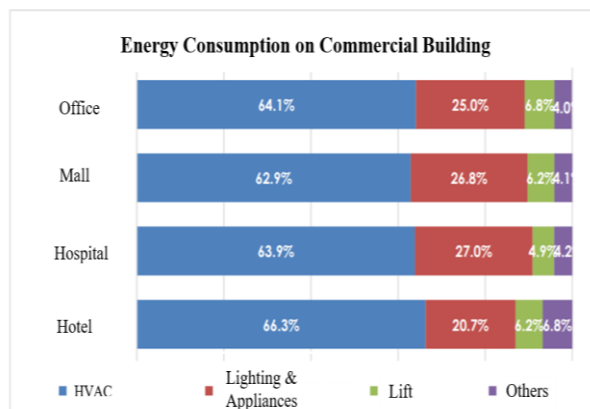
From the data above, there are two issues which can be concluded, first is the dependency of fossil fuel as an electricity source which faced with the increasement of electricity consumption. Second, this condition will also affect to the increase of carbon emission from fossil fuel-electricity generator which mostly used by building sector. This situation makes the energy efficiency policy and the use of renewable energy sources become an urgent issue. Energy efficiency is significantly important to reduce the energy consumption and cost, also to reduce carbon emission especially in a building sector.

Prior to this issue, based on 2017 UN International Forum of Sustainable Development, primary energy use in buildings conditioned spaces, including heating, ventilation, cooling and hot water, can be limited to 45 kWh/ m<sup>2</sup> -a or, including plug in loads (appliances), to 90 kWh/ m<sup>2</sup>.

**Table 1.** Building type and energy consumption in Indonesia (SNI, 2000)

No.	Building Type	Energy Consumption (kWh/m <sup>2</sup> per Year)
1.	Office	240
2.	Mall and Retail	330
3.	Hotel & Apartement	300
4.	Hospital	380

Thus, in Indonesia, based on SNI (Table 1), the energy consumption average standard is 312.5 kWh/ m<sup>2</sup> or almost 3.5 times of the energy limitation which stated by UN International Forum of Sustainable Development.



**Figure 1** Energy consumption on commercial building (B2TKE – BPPT, 2020).

Office building become a potential electricity consumer in commercial sector. In 2020, B2TKE did the survey of commercial building energy consumption which included more than 200 commercial buildings in 7 big cities at Indonesia (Figure 1).

The result can be seen at the diagram above. Office building become the second biggest energy consumption for HVAC after hospitality building, even bigger than hospital. Office building also become the building type to spend the most energy on vertical transportation such as lift and escalator. In the use of energy for lighting and appliances, office building become the third.

From the survey by B2TKE above, the energy consumption standard for efficient office building is 180.95 kWh/m<sup>2</sup>/year. It's better than the SNI 2000 standard in 240 kWh/m<sup>2</sup> per year. But, it's still half by the standard UN International Forum of Sustainable Development which is 90 kWh/m<sup>2</sup>/year.

Based on the data above, in 20 years, the office buildings energy consumption standard in Indonesia is increasing from 240 kWh/m<sup>2</sup>/year to 180.95 kWh/m<sup>2</sup>/year. With the right design strategies which including passive and active design strategies, office

building still have the possibility to reduce the energy consumption to reach maximum energy efficiency.

## 2. AIMS

This research aims to give the passive and active design recommendation on study case building at VOZA Office Tower Surabaya and to conduce about how far those design strategies implementation could reduce the building energy consumption.

## 3. METHODOLOGY

A case study to perform the building energy simulation are presented. After collecting data from the case study which include building information and the weather data on case study location, those data will be use to calculate the existing building energy consumption with EDGE software. Then, the design strategies will be conduce based on the existing building energy consumption to make the building more energy efficient. The next step, is doing final simulation with EDGE software after the implementation of the design strategies which include passive and active design strategies to the building. The final simulation goal is to conduce about how far those design strategies implementation could reduce the building energy consumption. The target of the final building energy use after the implementation of passive and active design strategies is less than 90 kWh/m<sup>2</sup>/year, in accordance with the 2017 UN International Forum of Sustainable Development benchmarking.

## 4. CASE STUDY DATA

### 4.1. Building Information

The case study is VOZA Office Tower, a grade A rental office which located in Surabaya, Indonesia and completed in 2017. This building has 3,945 m<sup>2</sup> site area and 60,000 m<sup>2</sup> total floor area with 2 basements, 7 parking floor and 23 rental offices. The widest side of the building which is 55 meters long, is facing the east and west side (Figure 2).



Figure 2 VOZA office tower (www.vozatower.com ).

#### 4.2. Weather Data

The study case building is located in Surabaya which has a hot climate as seen on diagram below, which average temperature is about thirty-two degrees Celsius when it reaches its maximum point. The wind speed is on a range between 1.6-3.4 m/s

With a lot of sunlight, the building should be able to maximize the use of natural lighting and proper shading at the window so it won't cause glare and could also reduce the heat absorbed by the building. The hot climate also makes possible the use of solar panels as options for renewable energy sources for energy efficiency (Figure 3).



Figure 3 Weather data (www.meteoblue.com ).

### 5. ENERGY CONSUMPTION ON EXISTING BUILDING

With the building information and weather data, the next step is doing the simulation of the existing building energy consumption with EDGE software.

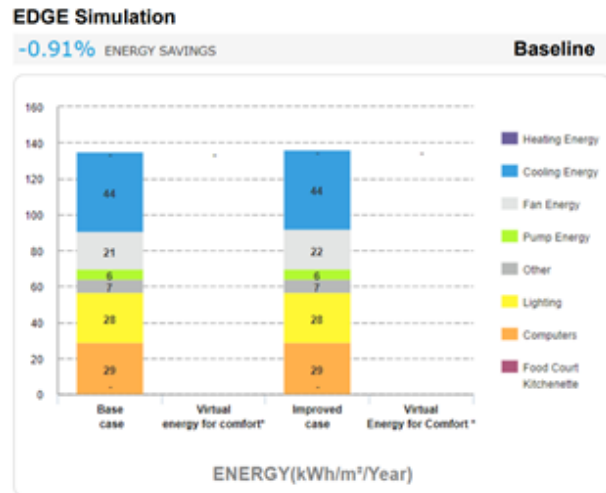


Figure 4 EDGE software.

Based on the energy simulation result as showed on the diagram, the total energy use of the existing building is 136 kWh/m<sup>2</sup>/year (Figure 4). It's much better than the SNI standard which is 240 kWh/m<sup>2</sup>/year. But, the energy consumption result still doesn't meet the 90 kWh/m<sup>2</sup>/year target in accordance with 2017 UN International Forum of Sustainable Development, as the benchmark.

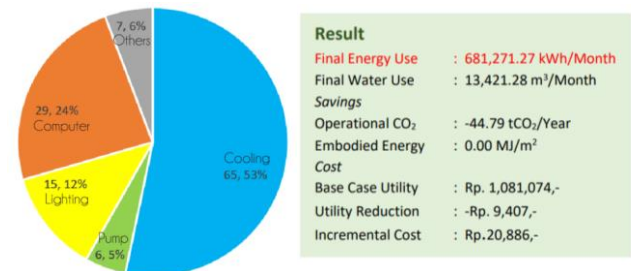


Figure 5 Weather data (www.meteoblue.com).

As we seen on the diagram (Figure 5). The most energy consumption is for the cooling system which reach 65%. This happen mostly because the orientation of the widest side of the building which is 55 meters long, is facing east and west. Plus, most surface area of the building envelopes are made of curtain wall which using glass as the material.

The second most energy consumption is for the office appliances by 29%. Mostly, it's influenced by more than 80% area for each floor which is used as a rental office with 10 hours of working time for Monday until Friday and 7 hours for Saturday.

Then the less energy consumption is for the lighting, mainly because there is more than enough natural lighting through the curtain walls which made of glass.

## 6. DESIGN STRATEGIES

Based on the result of the existing building energy consumption, the biggest energy is use for cooling, mainly because the orientation of the widest side of the building is facing east and west. This issue leads to higher heat transfer from outside space to the building due to the sunlight, which also makes the energy consumption for cooling get higher too.

To reduce the energy consumption which caused by this issue, passive design strategies are required. Passive design strategies help us maintain thermal comfort inside a building without the use of electricity as heating and cooling require the most [4]. While active design strategies are required to help reduce the energy consumption by using energy efficient appliances and to provide the electricity from renewable energy sources. Thus, the building can reach the maximum energy efficiency.

### 6.1. Passive Design Strategies

The proposed passive design strategies, are mainly for minimizing the heat transfer through the building by:

#### 6.1.1. Reduce Window to Wall Ratio (WWR)

Window to wall ratio define as the ratio of total glazing area (including mullions and frames) and divided by the gross exterior wall area [5]. Glazing area is the all the glass on the building envelope while exterior area is sum of the building envelope area, including wall windows and doors. If the building has high percentage of WWR, the building will transfer more heat through the glazing area to the building interior. As the WWR get higher, it means the glazing area on the building envelope are get wider too. Reducing WWR, helps the building to be more energy efficient because it could reduce the building cooling load. But, the balance between WWR and natural lighting or natural ventilation need to be considered because it's all about minimize the heat transfer to the building to reduce cooling load and maximize natural daylighting or natural ventilation to reduce the energy consumption.

#### 6.1.2. External Wall Insulation

Insulation is used to prevent heat transmission from the external environment to the internal space for warm climates and from the internal space to the external environment for cold climates. Insulation aids in the reduction of heat transmission by conduction, so more

insulation implies a lower U-value [5]. External wall insulation helps to lower the energy use for cooling.

#### 6.1.3. External Shading Device

External shading devices are provided on the building façade to protect the glazed elements (glass windows and doors) from direct solar radiation to reduce glare and to reduce radiant solar heat gain in cooling dominated climates [5].

#### 6.1.4. Higher Thermal Performance Glass

The use of efficient energy glass for the glazing area, also helps to reduce cooling loads for the building. Higher thermal performance glass means, the use of double-triple glazing glass or low-E coated glass. Higher thermal performance glass can reflect the thermal energy from the outer space of the building to reduce the heat transfer.

## 6.2. Active Design Strategies

Active design strategies are required to help reduce the energy consumption by using energy efficient appliances and to provide the electricity from renewable energy sources. The proposed active design strategies are by using:

#### 6.2.1. Cooling System Efficiency

Water-Cooled Chiller; For the cooling system, the use of water-cooled chiller is more efficient than air cooled chiller. Air-cooled chillers use air to cool the condenser and are suitable for climates where water supply is scarce or high humidity reduces the efficiency of the cooling towers [5]. The water-cooled chiller use water to provide condenser cooling. The efficiency of water-cooled chillers is typically higher because of the higher heat capacity of water compared to air [5].

#### 6.2.2. Energy Efficient Lighting System

Efficient lamps produce more light with less power compared to standard incandescent bulbs. This helps to reduce the building's energy use for lighting, because due to the waste heat reduction from efficient lamps, heat gains to the interior space are also lowered, which in turn reduces cooling requirements.

#### 6.2.3. External Shading Device

The hot climate on the case study building location, also makes the use of solar panels as options for renewable energy sources, possible. The energy generated from onsite renewable energy sources could reduce the electricity from fossil fuel.

## 7. FINAL ENERGY USE

After conduct the passive and active design strategy based on the existing building energy consumption, the next step is doing the building energy simulation with EDGE software while implementing the passive and active design strategy to the case study building.



Figure 6 Final energy simulation with EDGE.

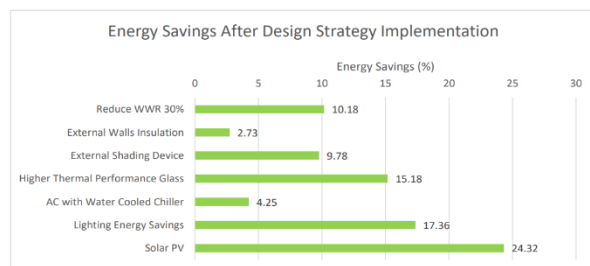


Figure 7 Summary of Final Energy Simulation with EDGE.

The average energy consumption for offices in Indonesia based on SNI data in 2000, is 250 kWh/m<sup>2</sup> (Figures 6 and 7). This research aimed to reach the standard based on 2017 UN International Forum of Sustainable Development, which building energy consumption was targeted to 90 kWh/m<sup>2</sup> per year by 2010.

After the implementation of passive and active design strategies at VOZA Office Tower Surabaya as the study case, the energy consumption is reduced by 55.95% from 136.25 kWh/m<sup>2</sup> (Baseline) to 59.48 kWh/m<sup>2</sup>, which is even greater than the target (90 kWh/m<sup>2</sup>).

The most significant energy savings is from the use of solar PV as renewable energy sources, following by lighting energy savings and the use of higher thermal performance glass then by reducing WWR by 30%.

## 8. CONCLUSIONS

From the implementation of passive and active design strategies in the study case building, we could conclude:

1. The active design strategies have the most impact to reduce energy consumption, especially the use of renewable energy and energy efficient lighting system.
2. The use of higher thermal performance glass has the most impact to reduce energy consumption, compared to other passive design strategies.
3. The implementation of passive and active design strategies are effective to reduce energy consumption at the study case office building by more than 50%.

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