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Net Zero Energy Low Rise Apartment in Jakarta

Maria Josephine Gunawan[1], Budijanto Chandra[1] and Rudy Trisno[1,a)]

[1]*Department of Architecture, Tarumanagara University, S. Parman No. 1, Jakarta 1140, Indonesia*

[a)]*Corresponding author: rudyt@ft.untar.ac.id*

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Abstract. In Indonesia, there is a growing movement to implement energy-efficient and energy-saving building designs to combat the excessive use of fossil fuel and carbon usage that will help minimize the impact of global warming, climate change, and carbon emissions. This paper will discuss the implementation and planning of a Net Zero Energy (NZE) in low-rise apartments with zero dependence on an external source of energy in Jakarta, by approaching energy-saving components with passive and active design as well as renewable energy with solar panel photovoltaic (PV). This research was conducted using a mixed-method and assisted by the help of energy simulation software technology to be the design indicator. The purpose of the research is to learn the design process and the feasibility of implementation, assembly, and development of NZE in Low rise apartments in Jakarta. The result of the study is low-rise apartment design that can achieve Net Zero Energy in Jakarta.

INTRODUCTION

Climate change with phenomenon global warming impacts on earth are unquestionable and have been a major issue for decades. As an architect, we need to take an active role to reduce the carbon emissions and carbon footprint in the buildings we design. Indonesia predicted urban population growth of up to 70% of its population approximately 220 million people by 2045 [1]. With the current state and conditions of climate change as well as the increasing urbanization rates, Indonesia has committed to contribute to reducing climate change and increasing the use of electrical energy while moving away from fossil fuels. The proposition is to develop and educate more people on the use of Net Zero Energy (NZE) buildings. NZE buildings reduce energy and greenhouse gases produced or reaching zero or nothing and will help to mitigate climate change [2].

The Advanced Zero Energy design guidelines that have been applied globally and become mandatory guidelines for NZE buildings in the United States and become one of the guidelines recognized by the US Department of Energy, Zero Energy Buildings [3], there are 2 principles to achieve good NZE building design: high- performance building, and the use of renewable energy [4]. National Renewable Energy Laboratory in 2007 reported that the percentage of buildings from floor area that can achieve Net Zero change based on the total number of floors, the higher/many floors, more floors, then more difficult to reach NZE. Therefore, reaching Net Zero is very difficult for buildings with more than four stories due to the more coverage of the energy is insufficient with the limited generated energy area at the roof [5]. Therefore, it can be concluded, residential apartment buildings with a height of no more than 4 stories, with a focus on thermal comfort and ventilation of air and natural light, can be key to fighting global warming, climate change, and solving the increased urbanization. Further implementation and guidance for NZE Low-Rise Apartments in the local context are needed in Indonesia. Because the NZE requirement is very low energy consumption and the potential energy gain needs to be maximized, the initial design is highly successful and achieved global recognition in a relatively short time [3]. This was possible by conducting research using Software Energy Simulation to determine the maximum building efficiency that can be implemented in NZE buildings.

The aim of the study is to attest that NZE Low-Rise Apartments in Indonesia have a high potential to succeed because it has easy access to an abundant and clean renewable energy source in the form of sunlight that shines fully throughout the year and passive designs with natural cross ventilation and good natural sunlight will also create healthy and comfortable homes for residents.

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Prior Research

Table 1. Previous research

Title	Description
A review of Net Zero Energy Buildings with reflections on the Australian context [6]	Identify some generally documented limitations of current research and development that can be considered as drivers of future growth of NZE buildings with some of the following challenges and limitations. 1. There is no agreement on the definition of NZE which results in different ways to get to NZE. 2. Inconsistent governance of energy efficiency standards around the world 3. There is a lack of research on holistic accounting for embodied energy 4. Even though NZE buildings are realistic considering the current state of building design and energy technology, research is still being carried out to validate the economic feasibility of NZE buildings. 5. Targeted policies for residential and non-residential buildings are required. Policies should advocate for stronger building codes and ensure much higher levels of compliance.
Net Zero Energy Buildings: Variations, Clarifications, and Requirements in Response to the Paris Agreement [7]	1. NZE design principles can be realized accordingly at the building level 2. Converting a building to an NZE requires clarification and fully verified parameters and strategies 3. The integration of energy-saving strategies, renewable technologies, and optimization of approaches will lead to shifts in source and consumption patterns. Net Zero is becoming an increasingly important topic for responding to the climate, by reducing energy consumption and emissions while simultaneously using renewable energy so that more individual and community buildings can move towards full electrification; and developing new methods and technologies to enable the achievement of NZ by 2050 requires substantial contributions from government and policy makers as well as communities and builders to achieve these goals.
Energy efficiency within mid-rise residential buildings: A critical review of regulations in Australia [8]	After exploring the regulatory framework for energy efficiency in mid-rise residential buildings in Australia. It is recognized that the vast geographical nature of the country and the significant differences in climate between the eight climate zones make it difficult to establish energy efficiency regulations. However to accommodate climatic zones with targets that address these variations, established regulations must allow for fair treatment in all areas. Not all states are willing to adopt national regulations. The bigger concern is that the trajectory forward for regulation fails to establish a pathway to clean zero energy or clean zero carbon. Failure to effect significant energy savings in medium-sized residential apartments, and ADG in allowing the proportion of each development to avoid being designed for passive design principles.
Application of Near Zero-Net Energy to Apartment Residential Buildings [9]	In this study, it is discussed that in order to deal with the energy crisis phenomenon which is the result of ineffective energy use and processing, it is necessary to handle and make changes to energy consumption by fixing and creating a new energy cycle system that is more effective that provides benefits for the community. human and nature. In addition to making buildings that use energy effectively, users must also be made aware and actively involved in these efforts. Apart from being designed to use and utilize natural energy for its sustainability, apartment users are also used as an energy source. The presence of the proposed object is expected to be a trigger for surrounding buildings to be able to change the old energy use system with a healthier and better system.
Net Zero Energy Apartment [10]	In the buildings discussed in the study, observations were made on several aspects of energy use, namely: The return on capital costs of solar panels can reach 28 months or about 2 years and 4 months and can generate 82% of the power requirement. While the installation of biogas can meet 17% of the building's electricity needs. The other 2% is supported by the use of wind turbines. The total savings in water demand per year is around 60% by installing Rain water harvesting, using low plumbing fixtures and recycling water from STP. Although the initial investment is higher for net zero energy buildings in the long term, net zero energy buildings prove to be more beneficial and economical not only in environmental aspects but also social aspects by increasing user comfort and health.

State of the Art

That there is no building or research that explains the Net Zero Energy (NZE) Low-Rise Apartment in Jakarta, Indonesia. Therefore, the novelty of this research is a novelty in the field of architecture, especially in Indonesia.

THEORY

In the NZE design of this low-floor apartment, there are 3 reference theories that are the focus of the design of this apartment, namely:

1. Net Zero Energy Building: Optimizing the energy requirements of a well-designed building exponentially helps reduce power demand and the amount of power to produce or offset over a yearly period of time [11].

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   a. High Performance Building: a building that integrates and optimizes all the key attributes, including energy efficiency, durability, life cycle performance and occupant productivity [12].
   b. Renewable Energy: energy from sources that are naturally replenished but whose flow is limited; Renewable resources are almost inexhaustible in duration but limited in the amount of energy available per unit of time [13].
2. Passive and Active Design: Passive design is a method of saving energy by utilizing energy from nature without the use of electrical equipment, while active design is using technology or electrical equipment to reach thermal comfort [14].
3. Low Rise Apartment: a multifamily residential housing building with a height of 3 and less than 7 floors and using stairs as a means of vertical transportation [15].

METHODOLOGY

Research Method

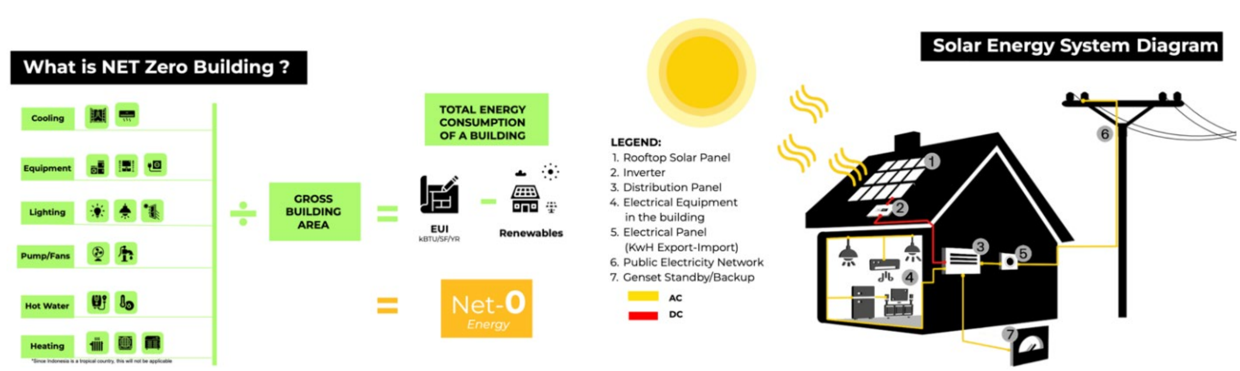
This research was conducted using Mixed Method, according to According to researcher Nancy L. Leech, mixed methods research is research that involves the collection, analysis, and interpretation of quantitative and qualitative data in a single study or in a series of studies investigating the same underlying phenomenon [16]. The Mixed method discussed in this thesis is based on:
Quantitative Research through test results and simulation analysis of FormIt, EDGE, and CoveTool applications.
Qualitative Research through descriptive analysis of data and information sources, reference theories, literature studies, and previous research.

Design Indicator

In this low-level apartment NZE design indicator, there are 3 analyzes through a software simulation application, namely: FormIt, Edge and CoveTool. The simulations carried out help determine the results of building optimization performance and help architects determine element design for passive designs and achieve Net Zero Energy.

Explanation of the simulation to be carried out:
1. Simulation of Mass Analysis, Orientation, Solar Radiation, Solar Panel Alignment: FormIt Software;
2. View Energy Calculations to meet Net Zero Energy Building: EDGE Software.
3. Simulation of Building Period Analysis, and Thermal Comfort: Cove Tool Software.

Achieving NZE is not fully dependent on building efficiency, instead, the most effective and cost-effective strategy to achieve NZE is to reduce energy costs and then utilize renewable energy to offset the remaining energy use requirements. In Figure 1, optimizing the energy requirements of a well-designed building exponentially helps reduce power demand and the amount of power to produce or offset over a yearly period [11]. The energy produced by the solar panel is forwarded directly to the inverter, then supplied to the distribution panel and distributed to electrical equipment in the building, or the extra energy gained will be exported to the Public Electricity Network in the area. Renewable Energy with the solar system has also become an affordable option, while the price of solar panels has decreased and become more accessible to the public [17].



(a) (b)

FIGURE 1. Net Zero Energy Building and the energy distribution of the solar panel.

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Based on ASHRAE Standard 90.2-2018, the Energy-Efficient Design of Low-Rise Residential Buildings Standard Code used in the USA, the first and foremost factor is choosing the right sizing system for the building [18]. This can be achieved by following safety factors in the design, applying the factors to a reasonable base case, and using simulation to model the design and predict the optimized requirements [18]. In the simulation, partial load performance must be considered. In addition, the designer should consider using high-efficiency lighting and control systems such as LED lighting, high-performance ballasts, dual-circuit duty lighting, occupancy sensors, and natural light dimming sensors [18]. During the design stage of the High-Performance Building, there are several important things to consider. High-performance buildings must be optimally oriented to minimize HVAC loads, with shade and roofs used to reduce direct sunlight. There are several options available such as roof overhangs, tents, and vegetation. To reduce heat gain through windows, designers should avoid glazing on east/west facades. Other measures to reduce heat gain are to increase insulation on opaque surfaces, use glass with a low coefficient of solar heat gain, use double-skin facades, and smoothen the building envelope to suit site conditions.

Design Approach

1. High Performance Building of Low Rise Apartment
2. Design Passive
3. Active Passive

DESIGN RESULT

High Performance Building of Low Rise Apartment

The NZE low-rise apartment that has been designed all must consider the energy conservation and efficiency, Figure 2 shows the 4 building masses, each building mass is no higher than 4 stories floor, with no pressurized staircase and the use of the minimal mechanical system (a). Illustrated in the mass plan in Figure 2, building access is also friendly for pedestrians and persons with disabilities (b). In each building, there are also 2 lifts on each corridor, for access for people with disabilities and vertical transportation. Elevators and stairs that connect each floor also provide access to the roof of the building, where the solar panels are located. Each building mass has an 8m wide inner courtyard between units, to help cross ventilation and allow natural sunlight to enter to reduce the burden of AC power consumption and lights in each apartment unit. This inner courtyard also helps pedestrian accessibility.

Not only that, the floor plan shows a spacious unit and corridor plan, as well as the placement of a garden in the corridor of the building, which in addition to making a good first impression, also has an impact on natural air circulation. Thus, the use of cooling machines such as air conditioners can be reduced and help illuminate natural sunlight and reduce electrical loads. The space around the building is also filled with gardens and paths between buildings which makes it comfortable and desirable for visitors who want to do activities such as leisurely walks and sports (Figure 2).

(a) (b)

FIGURE 2. 3D apartment view an enlarged floor plan of the apartment.

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Passive Design

Illustrated in Figure 3, the facade design strategies applied to this development of NZE Low-Rise Apartment include:

- Vertical Fins on the workspace window, by providing spaced vertical lattices as shading elements to keep getting sufficient sunlight intensity from conditions of excessive sunlight intensity,
- Selection of Bouvenlight window to help air circulation and natural light in the toilet with a height of 1.8 meters so that it gets air circulation from outside to inside and vice versa,
- Exterior Moveable Partition Screen on the balcony with a screen concept that can be shifted and stacked according to the needs of residents who want thermal comfort in the interior,
- Shading elements or Overhangs on windows with a Box Frame design as wide as 50 cm from the window openings in the kitchen and bedroom windows, thus helping the self-shading effect to provide sufficient shade for the room, protection from exposure to rainwater and still get natural ventilation to cross-ventilation in some of these spaces,
- The usage of vertical naco glass on the stairs for general circulation with a slope of 45^o which can protect the corridor area from excessive sun exposure while still receiving enough sunlight during the day. Another benefit is reducing the use of electrical energy for lights and protecting the staircase area from exposure to rainwater while also providing air circulation into the building corridor from the gaps between these naco windows,
- In the corridor between units on each floor there is a garden as an open space to provide natural air circulation and greenery in the building.

All the 6 Façade Design Strategies for Passive Design that are applied to the NZE Low Rise Apartment are designed to help air circulation and allow natural lighting to shine while preventing excessive heat so that residents can achieve Thermal Comfort.

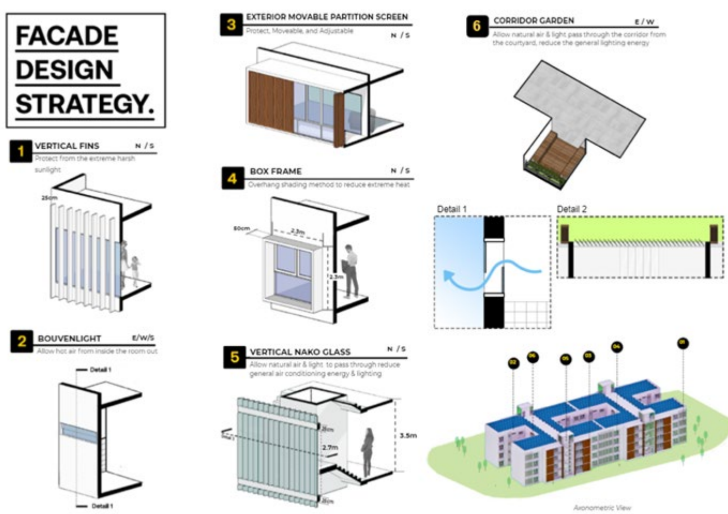

FIGURE 3. Passive Façade Design Strategy

It can also be seen in the 3D section of this apartment building (Figure 4), that each apartment unit has double-sided or double-sided glass window openings that promote natural air exchange or cross ventilation. The hot tropical climate in Indonesia necessitates glass openings that use limited or use Low-E (low-emissivity glass) glass which has high specifications and can withstand solar radiation because it has a low SC (Shading Coefficient) but still has the clarity of seeing out of the LT or LT glass. VLT (Visible Light Transmission) is not too dark. By using Low-E glass, it can reduce the glaring of sunlight entering and disturbing the comfort of residents.

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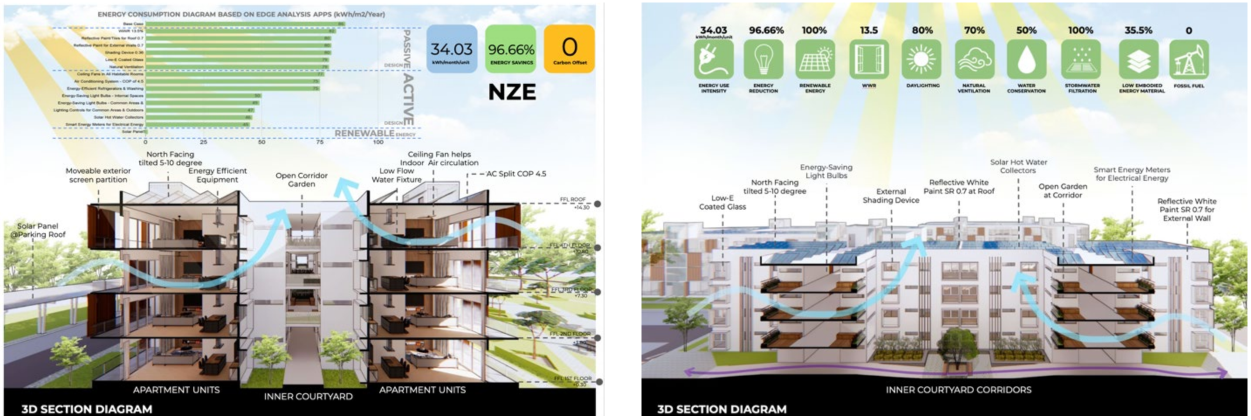

(a) (b)

FIGURE 4. 3D section diagram of the apartment

After the simulation results and analysis from EDGE (Figure 5), the Window to Wall Ratio can reach 13.5% and 0.36 on the Annual Average Shading Factor (AASF). Some of the aspects applied to the EDGE simulation are depicted in this snippet. This 4-story apartment building integrates communal areas and apartment units to allow for cross ventilation and help maximize natural lighting from sunlight. We utilize rainwater filtration and use sustainable materials such as the use of white paint that has Solar Reflectivity 0.7, energy-saving glass such as Low-E Coated Glass. Next, the solar panels are placed on the roof of the building facing north, with a slope of 5º – 10º for maximum sunlight absorption. The building does not use fossil energy thanks to the adjustment of environmentally friendly buildings that are safe, comfortable, and healthy for both residents and buildings.

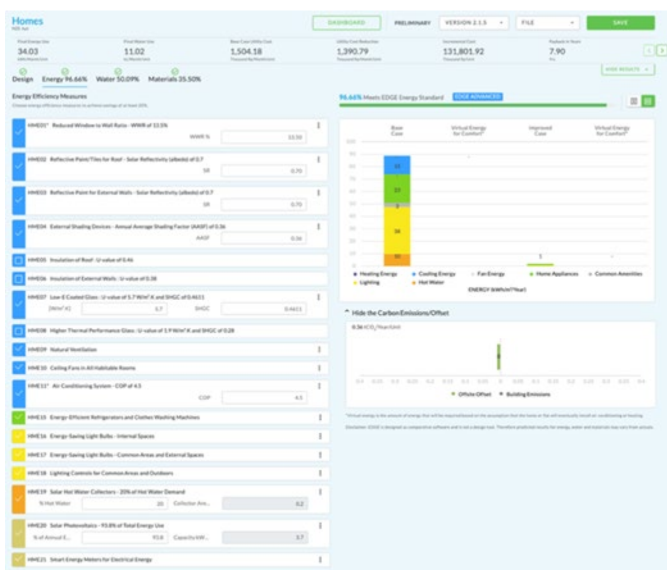

FIGURE 5. Building Energy Analysis Results Based on EDGE

Active Passive

Home Appliances that are used such as refrigerators and washing machines, must be ENERGY STAR certified which is proven to reduce utility expense from 10% to 50% each year. Lighting lamps in apartment units must also use energy-saving lamps such as LED (Light Emitting Diode). LED lamps also reduce unnecessary heat, thereby reducing the cooling load of the room as well. Long-term maintenance costs are expected to be significantly lower as LED lamp life is much longer than the common alternative. To help save electricity sensor lighting will be provided

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so that when indoor lighting reaches 300 lux, the lights will automatically turn off, reducing unnecessary electricity usage.

The choice of economical or low-flow sanitation can also reduce the burden of water use. The use of smart meters is needed to help residents become aware of electricity consumption. The energy smart meter must be able to show readings from the last hour, the last day, the last 7 days, and one year operational of electricity consumption, and this device must be readable at home. The use of renewable energy is very important in the design and construction of the NZE building. It is not only necessary to understand how much electricity consumption is needed, but further the electricity savings that can be achieved through using renewable energy. Based on the information and data that has been analyzed into the EDGE application, we can input many aspects of passive and active design, and EDGE will automatically simulate and calculate according to the needs and usage required. Based on accurate project data such as location, building area, unit area, room area, occupant capacity, and others, then cross-referenced with the building design. Figure 4 shows that the electricity savings from the use of solar panels are very significant and greatly affect and assist global warming management in reducing the use of fossil energy (Figure 5).

In table 1, the manual capacity calculation of the solar panel manually calculates the Kwp capacity or also known as the Kilo Watt Peak unit on the Solar Panel to the roof area. Based on table 1 an apartment unit requires 3.7 kwp, and 1 kwp requires about 10 m^2 area of solar panels. This means that we need solar panels on the roof with an area of approximately 1084 m^2, which is achievable because the roof area of each building prepared for solar panels is 1166 m^2.

Table 1. Details required of the peak power (Kwp) of a PV system or panel calculation table for roof area.

1 kW	**7m^2 – 10m^2**
1 building rooftop	1166 m^2
3,7 kW	93,8%
3,7 kwp * 10m^2 = 37 m^2 = 1 unit apartment	
1 building mass = 32 unit * 3,7 kwp = 118,4 kwp	
118,4 kwp * will occupy the roof area = 93% * 1166m^2 = 1084 m^2	

CONCLUSION

Net Zero Energy Building can be achieved in Indonesia by following:

- Energy-saving design focus and high-performance building design,
- Design Passive and Design Active that are effective and cost-efficient,
- Adequate calculation and use of renewable energy such as solar panels,
- Simulate energy consumption with a special energy simulation software,
- Achieve natural daylight and natural cross-ventilation in all unit apartments,
- The use of shading elements in the window openings helps to minimize the illuminate the sun's rays,
- Indonesia is located on the equator and makes it a tropical climate so that it gets abundant sunlight throughout the year, and the electrical load in facilities or general circulation areas, such as stairs, can take advantage of window opening elements such as nako glass for natural air exchange routes and also lighting from sunlight. natural sun,
- In the common corridor area, there is a corridor garden that is open to help natural ventilation from the wind and lighting from the sun,
- Communities can easily play an active role in helping fight climate change and global warming by choosing certified household appliances to reduce electricity costs,
- The use of a ceiling fan can help circulate air in the room and reduce electricity consumption in the Air Conditioner (AC).

In conclusion, the initial design is very important for Net Zero Energy buildings to ensure the building is highly optimized at the right angle and minimized the energy consumption as low as possible. The higher investment cost for Net Zero Energy buildings, in the long run will prove to be more beneficial for the environment, economical and could achieve thermal comfort for the residents.

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