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A STUDY OF BUILDING RENOVATION TO BE A NET ZERO ENERGY BUILDING: CASE STUDY OF ENERGY MANAGEMENT AND INNOVATION OFFICE, BUILDING AND FACILITY DIVISION, KHON KAEN UNIVERSITY

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ABSTRACT

Energy consumption in Khon Kaen University, Thailand, has each year increased due to the demand for facility and buildings. The Energy Management and Innovation Office is the main sector that has a responsibility to promote and organize energy use within the campus. Renovation its building to be net-zero energy building will be a learning case for students and community. Energy saving factors are also taken into the consideration. The record showed that the average of energy consumption in this building is 21,735.4 Kilowatt-hour per year or 59.55 Kilowatt-hour per day. So, by using 300 watts solar-cell panel, the number of solar panel for supporting the energy use in this building is 86 panels. The building has available roof area for the photovoltaic system installation comprising 86 solar panels faced to the south with service space between the panels. Finally, the result shows that the Energy Management and Innovation Office building can be a net zero energy building. This study result will be used as information for the future plan of the university.

1. INTRODUCTION

Khon Kaen University is the largest university in the north-east region of Thailand. Energy consumption in Khon Kaen University increases due to the demand for facility and buildings each year. Khon Kaen University set up policies for saving energy on the campus including the renewable energy for the building. The Net Zero Energy Building is one of the solutions that have been done by the university. The office of Communication Affairs Division building, Khon Kaen University officially became the first Net Zero Energy Building in Thailand funded by Energy Policy and Planning Office, Ministry of Energy, Thailand. This building is successfully renovated the unused office building within the campus. It proved that the renewable energy, solar-cell, can

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substitute the energy use in the building, annually. Moreover, this building becomes the success example that draw the attention of other organizations countrywide to visit the university.

The Energy Management and Innovation Office, Building and Facility Division office is the sector in Khon Kaen University that has a responsibility to promote and organize energy use within the campus. The office is an existing building that once used as a vehicle repair shop, sited next to the university president office building. The university has a plan to develop this location to be an “Energy Park” purposed to promote an innovation of energy saving and renewable energy using within the campus as well. To renovate this building to be a Net Zero Energy Building will be another project following the goal of the green and smart university. Furthermore, the building will be a learning case study for students and community.

The research aims to study a possibility to renovate the Energy Management and Innovation Office, Building and Facility Division office, Khon Kaen University, to be a net zero energy building. The study uses photovoltaic solar-cell system as the source of renewable energy for the building. The renovation will base on the minimum change of the existing structure and building form.

2. NET ZERO ENERGY BUILDING

Ministry of Energy had Thailand 20 year Energy Efficiency Development Plan (2011-2030) aimed to increase the energy efficiency of the government and private buildings beyond the Building Energy Code (BEC) toward Net Zero Energy Building (NZEB) within 2030.

The Zero Energy Building concept is the idea that buildings can meet all energy requirement from low-cost, locally available, nonpolluting, renewable sources (Torcellini et al., 2006). Medium and large scale, cost effective zero energy buildings are expected to be viable in the next 15-20 years. However, rapid building technology development and determined building owners and designers had made medium and large-scale buildings successful today. (Yimprayoon, 2016)

The research study of the parking building in Khon Kaen University shows that the rooftop solar-cell can generate enough electricity for the energy use of the public space of the parking building in case that the building can reduce energy use by 10% (Reangseree and Boonyaputthipong, 2017).

3. RESEARCH METHODOLOGY

The methodology of this study begins with the surveying and collecting the building configuration and the energy consumption. The information will be used for analyzing the energy saving solutions focusing on the renovation of building components and equipment. Furthermore, the energy consumption data of the building will be used for the calculation of renewable energy needs. The Solar Photovoltaic Energy is selected for this study because Thailand has relatively high levels of solar insolation which makes the panels efficient to use. (MacDonald, 2012) A number of solar-cell panels will be used for designing the suitable location on the building roof. The possibility of the renewable energy use and installation will make the conclusion of the study. (Figure 1)

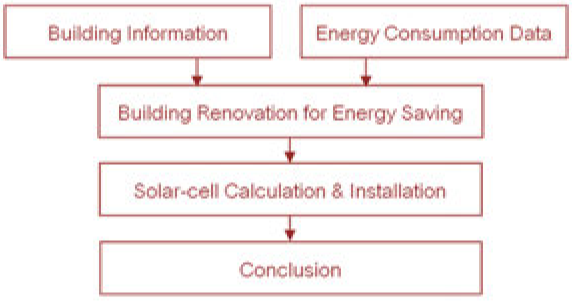

Figure 1: Research Methodology Diagram.

4. THE BUILDING INFORMATION

This building is previously used by the university vehicle repair and maintenance shop. After the university set up the new office, the Energy Management and Innovation Office, this building is selected to serve for its workplace and research facility. The building is located next to the university president building. Related to the university plan, this location will be developed to be an energy park to show one of the main policies of the university, green and smart campus. Furthermore, the opposite side of this building, there is the first net-zero energy building on the campus, the Communication Affairs Division building.

4.1 FLOOR PLANS

The building of the Energy Management and Innovation Office is a two-storey building. The first floor includes office rooms, restrooms and shop space. The second floor is a mezzanine with the functions of offices, restroom and a meeting room. The shop space located on the first floor is an open two-storey height. (Figure 2)

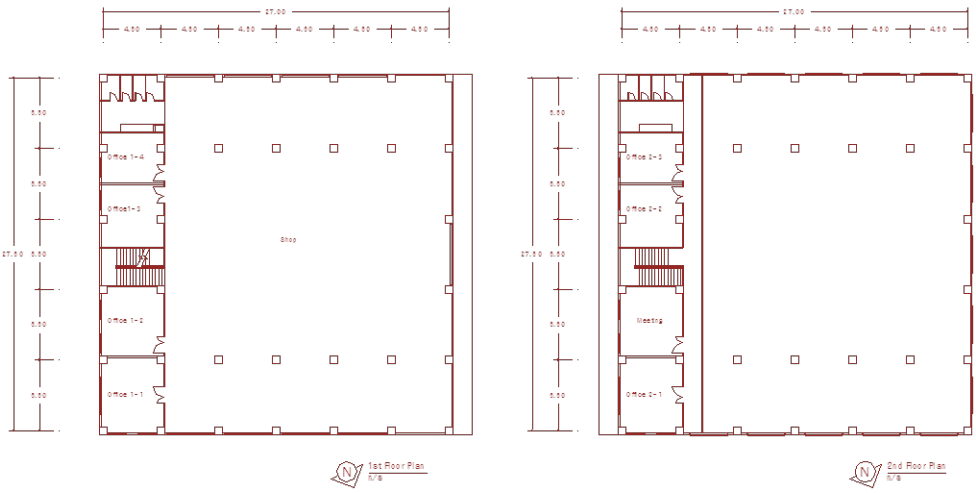

Figure 2: Building Floor Plans.

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4.2 ELEVATIONS

Building elevations (Fig.3-4) show that the north and south sides of the building have five big rolling shutters each. The top of the wall are metal louvers run around for natural ventilation. The west side of the building has one big rolling shutters and metal louvers on the top and masonry wall for the rest. The east elevation shows that there are wood frame glazing windows for each room. Most of the building walls are masonry with light colour painted.

Figure 3: North Side (Left) and East Side (Right)

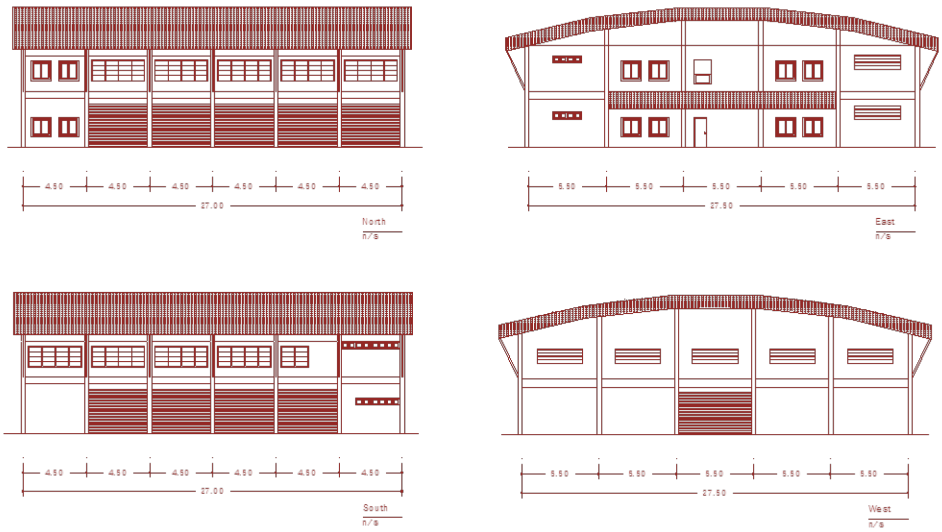

Figure 4: Building elevations.

4.3 SECTION

Building sections (Figure 5) show that the first floor has a 4.00 meters height from floor to floor while the height of the second floor is 3.00 meters. The open space of the shop is 8.50 meters height. The total of the building height is 10.00 meters. The metal sheet is the material of the building roof. The roof insulation, 2 inches fiberglass, is installed for the meeting and office rooms only.

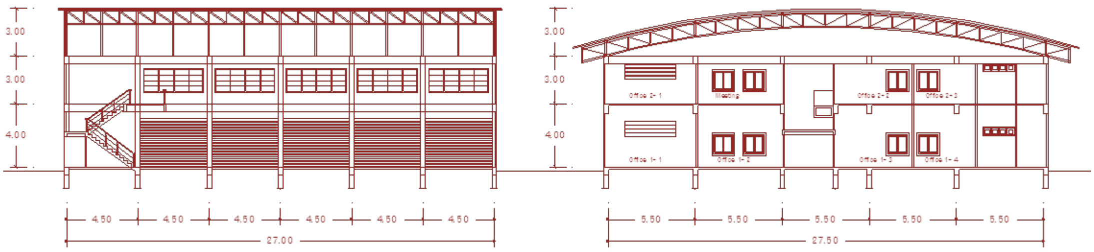

Figure 5: Building Sections.

5. ENERGY CONSUMPTION

From the five years data (Figure 6), it found that in 2011 the building consumed electrical energy of 40,160 Kilowatt-hour and the building consumed the electrical energy of 33,903.80 Kilowatt-hour in 2012. After connected the solar-cells on the parking roof to the building, it found that the building consumed the electrical energy of 18,880.88 Kilowatt-hour in 2013 and 19,953.25 Kilowatt-hour in 2014. However, during the mid of 2015, the shop is temporarily installed some machines for the rubber oil research, the electrical energy consumption increase to be 26,342.00 Kilowatt-hour in the year 2015.

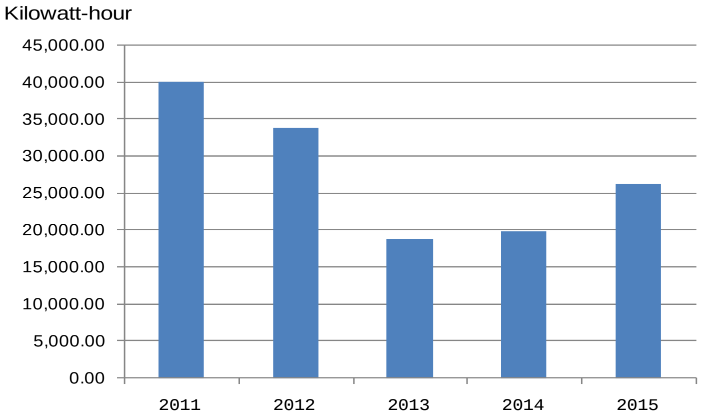

Figure 6: Energy Consumption.

Energy uses in this building can be separated to be air-conditioning, lighting, office equipment and shop equipment. The air-conditioning is the main energy use that consumes 51% of the energy use in the building. Lighting and shop equipment consume 19% and 21% while office equipment consume 9% of the total energy use in the building. (Figure 7)

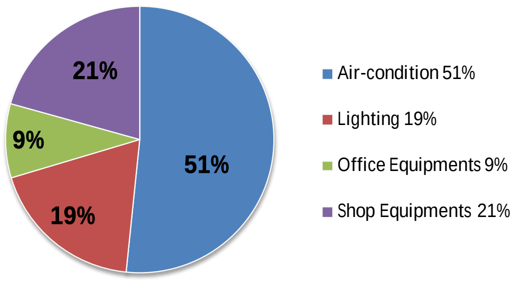

Figure 7: Energy use in the building.

6. ENERGY SAVING

6.1 SUN SHADING

East side of the building is the main part of the building that needs the sun-shading because all air-conditioning areas are located on this side. There are glazing windows without sun-shading. Due to the low angle of the morning sun, the solution will be a slat covering glazing windows and wall. (Figure 8).

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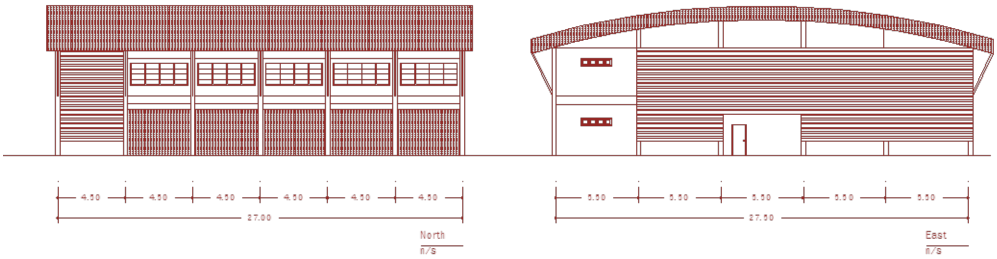

Figure 8: Sun shading on the east and north side.

6.2 INSULATION

The main part of the building that needs insulation is the roof because the roof is directly exposed to sunlight all day (Pongsuwan, 2009). The previous renovation of this building the roof insulation is added for the office function. So, the roof insulation for the shop space will be reduced the heat getting through the indoor area and part of the office area during the daytime.

6.3 WINDOW

All windows of the building are the old gazing ones with wood frame. Besides the heat pass through the glazing area, it is also air leak through the old wood frames as well. The solution will be changing all windows to be vinyl-frames with reflective glass because the vinyl-frame is a good insulation with less air leaking.

6.4 LIGHTING

There are different types of light tubes in the building. They will be replaced with LED (Light Emitting Diode) which can save energy down significantly. LEDs have proven to be extremely effective due to their long lifespan and increased efficiency (Karmakar et al., 2016)

6.5 AIR-CONDITION

Recently, all of the air-condition in this building are split-type system. From the case study of the office of Communication Affairs Division building, the net-zero energy building, it has been founded that VRF with cooling-path can save energy down as much as 20-30% (Soodphakdee et al., 2014). So, this solution will be used for this building as well.

7. RENEWABLE ENERGY

In Thailand, renewable energy that is typically used in the building is solar-cell because the sun-light is available mostly all year round. Moreover, the technology of solar-cell is higher quality while its cost becomes lower and available widely in Thailand.

The study used the energy consumption during the last three years. The record showed that the average of energy consumption is 21,735.38 Kilowatt-hour per year or 59.55 Kilowatt-hour per day. This base number will be used for the solar-cell panel calculation. The energy consumption of 59.55 Kilowatt-hour per day or 59,550 Watt-hour per day will be used in Equation (1).

$$P_{cell} = \frac{P_L}{Q \times A \times B \times C / D} \quad (1),$$

Where

P_L = Electrical power need for one day

Q : Sunlight power per day in Thailand = 4,000 Watt-hour/sq.m.

A : Compensation for loss = 0.8

B : Heat loss compensation = 0.85

C : Inverter Efficiency = 0.85 – 0.9

D : Normal light intensity = 1,000 Watt-hour/sq.m.

So, P_{cell} = 59,550/(4,000x0.8x0.85x0.85/1,000) = 25,756.92 Watt or 25.76 Kilowatt

The 300 watt crystalline solar-cell panel is selected for the study. So, the number of solar panel for this building is 25,756.92/300 = 85.86 or 86 panels.

8. PHOTOVOLTAIC SOLAR PANELS INSTALLATION

The building roof is the best part of the building for solar-cell installation. In Thailand, the solar panel is expected to face to the south side with the angle between 10^o - 20^o (Altevogt, 2014). The building has an available area on the roof for the installation of 86 solar panels with service space between the panels. The incline metal frame is fixed to the existing roof structure for solar-cell attached. This solution is a simple and the low cost one. (Figure 9)

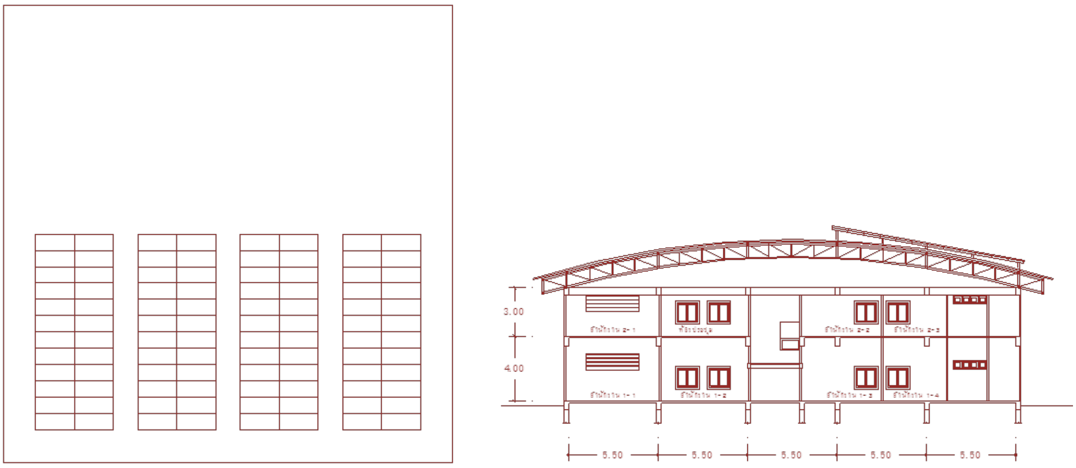

Figure 9: Roof plan (Left) and Section (Right) shows the Solar-cell installation.

The grid connection is selected for the study to avoid using a battery for stalling energy. The university has an electrical station, so this grid-connection system is the good solution for managing energy use in case of solar-cell cannot generate enough energy for the building. Moreover, in case that the solar-cell produces energy more the building use, the energy can transfer to nearby building automatically.

9. CONCLUSION

This study uses a simple process for renovation existing building to be a net zero energy building. The result shows that the Energy Management and Innovation Office, Building and

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Facility Division office, Khon Kaen University, can be a net zero energy building by the installation of the 86 solar-cell panels on the roof. The energy saving by improving the building element and equipments is for confirming the possibility of this project. The in-depth calculation and detail design will be further worked on the next study. The research will be used as information for the future plan of the university.

10. ACKNOWLEDGEMENTS

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