Solar Power Assessment for Photovoltaic Installation in Malaysia University Campus

Ghaithan Ghaithan Sadeq
Kulliyyah of Architecture and Environmental Design,
International Islamic University Malaysia, Kuala Lumpur, Malaysia
ghaithan2014@gmail.com

Aliyah Nur Zafirah Sanusi
Kulliyyah of Architecture and Environmental Design,
International Islamic University Malaysia, Kuala Lumpur, Malaysia
aliyah@iium.edu.my

Fadzidah Abdullah
Kulliyyah of Architecture and Environmental Design,
International Islamic University Malaysia, Kuala Lumpur, Malaysia
fadzidah@iium.edu.my

***Abstract*— This research was carried out as preliminary studies before installing photovoltaic solar panels on the roof of the International Islamic University Malaysia (IIUM) Mosque. Poor application strategies for saving energy in mosques constitute high energy consumption and cost. Due to their functional and operational characteristics, Mosques consume relatively more power than other types of buildings. The first objective is to determine energy consumption in IIUM Mosque. The second objective is to assess the Solar Photovoltaic power potential in the International Islamic University Malaysia (IIUM) Campus. The research methodology was carried out through literature review and fieldwork measurement of the available solar power on the International Islamic University campus. The total amount of solar energy collected has shown the potential of installing Photovoltaic Solar Panels in IIUM, aligned with the Sustainable Campus initiative.**

Keywords—solar power, photovoltaics, sustainable campus

I. INTRODUCTION

The Sultan Ahmad Shah Mosque of the International Islamic University Malaysia (IIUM) is located in Gombak, Selangor. The construction of this mosque which can accommodate 9,000 congregational members, began in February 1995 and was completed on 12 October 1995. With a total cost of RM19.4 millions, The mosque displays Islamic architectural philosophy with Arabic influence.

Solar systems are effective systems in the environment, and These systems are used as sources of friendly energy to the environment. Solar design is a process that involves simulating natural light sources, such as the sun and the sky. It is used in various artistic and scientific disciplines for qualitative and quantitative evaluations of surfaces and spaces with varying spatial and temporal resolution and precision. Architects can employ solar design tools to create photorealistic visual representations that emphasize design, item geometry, or textures while achieving precise light effects and ambiance [1]

Photovoltaic Installation on building integration provides a chance to scale back energy consumption, improve energy efficiency, and increased the usage of renewable energy sources. Photovoltaics is often incorporated into the casing of the building because it is easy to use for traditional building materials and replaced by the Solar Photovoltaic Technology (PV). Building Integrated Photovoltaics (BIPV) is a term used to describe the integration of photovoltaics (PV) into the building envelope. BIPV improves the looks of buildings. This BIPV offers an attractive solution for efficient and sustainable adaptation of building casings, saving materials and consuming traditional electricity at an equivalent time, and improving energy efficiency in buildings [2].

Fig. 2: Sultan Ahmad Shah Mosque, International Islamic University Malaysia.

The mosque showing in figure1 can be a net product of electricity to reduce the consumption of generated electricity by fossil fuels and provide sufficient energy to the mosque operation. However, the architectural and aesthetic character of the mosque must be preserved. The first objective is to determine energy consumption in IIUM Mosque. The second objective is to assess the Solar Photovoltaic power potential in the International Islamic University Malaysia (IIUM) Campus.

II. LITERATURE REVIEW

A. Solar Photovoltaic (PV) Technology

PV technology has multiple features, some of which produce energy by using clean and countless sunlight energy, working over several years with slight problems after installation. They do not demand continuous maintenance, and they are resistant to different weather circumstances. In addition, PV is a module system; therefore, it can be expanded and extended according to the increase in energy needs. PV cells are manufactured from sensitive semiconductor materials that use photons to free electrons to drive an electric current. Figure 2 shows the Common PV module technologies. Two prime categories of PV technology are

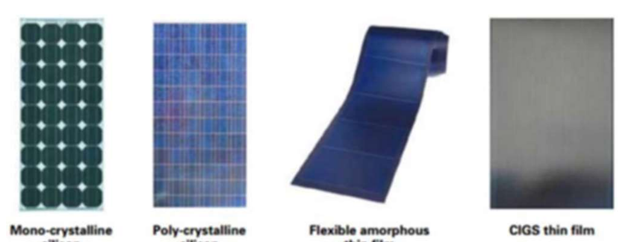

Fig. 1: Various types of Photovoltaic modules [3]

crystalline silicon (monocrystalline silicon cells and polycrystalline silicon cells) and thin film [3].

Photovoltaic (PV) cells are used to absorb solar energy and convert them into electrical energy. In the scientific term, the solar cell converts energy into photons of sunlight. It produces electricity using a photoelectric method, which originated in a few types of semiconductor materials such as silicon and selenium. Mainly, photovoltaic cells convert solar energy into electrical energy. Figure 3 shows the types of PV technologies [4]. These are the usual solar panels made from monocrystalline silicon or polysilicon and commonly utilized in conventional surroundings [5].

B. case studies of buildings in Malaysia

The Malaysian Energy Commission diamond building (Figure 4) is the present day and most advanced instance as Authorities' structures in Malaysia contain a comprehensive listing of energy-efficient features.

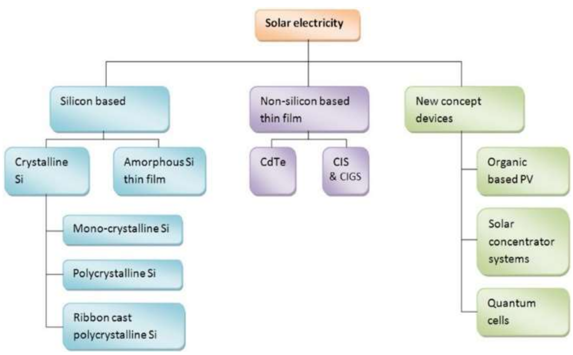

Fig. 3: Types of Solar PV energy conversion [4]

The thin-film module photovoltaic (PV) panels are installed with a total capacity of 71.4kWp atop the building. This full capacity generated was estimated to cover about 10% of the energy requirements in the buildings. In general, the generated projected electricity is 102,000kWh per year [6]

Fig. 4: Malaysian Energy Commission diamond building

GEO (Green Energy Office) Building is a pioneering project. This distinct building is famous for yet another milestone towards promoting and adopting the idea of sustainable construction in the Malaysian construction department (Figure 5).

Fig. 5: GEO building (Green Energy Office Building)

The structure was designed to promote the Zero Energy Building (ZEB) concept, which attempts to demonstrate energy self-sufficiency through the utilization of solar energy and sustainable technologies [7]

The building is designed to integrate with photovoltaic panels and has used four types of photovoltaic cells, as shown in Figures 6 and 7. Photovoltaic cells are used on the roof of the building or as parking protectors. The values generated by the PV panels vary according to the area covered by the PV panels and the efficiency.

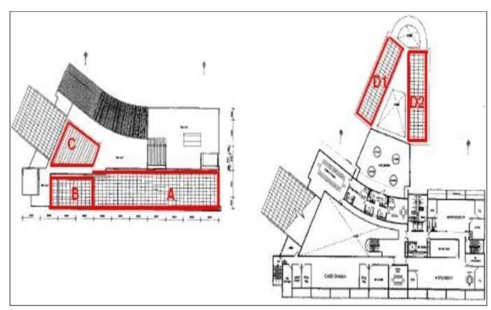

Fig. 6: Locations of BIPV system installed at GEO Building [8]

North-South Axis		
Types of PV panel	PV panel	information
Package A Poly-crytalline		• Panel 394 nos • Produce 47 kWp • 356 meter square
Package B Amorphous silicon		• Panel 95 nos • Produce 6kWp • 100 meter square
Package C Mono-crystalline, see through		• Panel 64 nos • Produce 12kWp. • 110 meter square
Package D Mono-crystalline		• Panel 150 nos • Produce 27 kWp • 200 meter square

Fig. 7: Types of PV Panels at GEO Building [7]

The two previous examples (case studies of buildings in Malaysia) of projects similar to the study give an idea about integrating photovoltaic panels with facilities in Malaysia.

C. *Building Energy Index*

There is no energy Index for mosques in Malaysia to calculate consumed energy in mosques, so the energy consumed is calculated based on the energy index for office buildings. Mosques' electricity consumption is near to office buildings, and office buildings may even consume more energy due to the extended operation of office buildings. Figure 8 shows the energy index adopted in Malaysia for some different types of buildings [9].

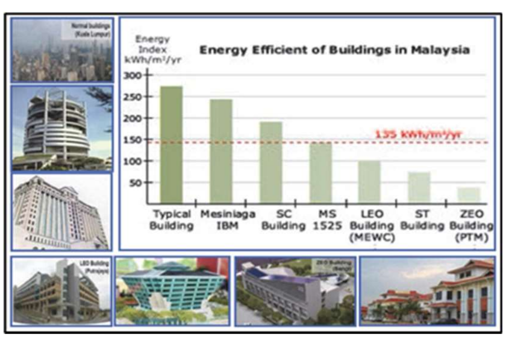

Fig. 8: Energy index adopted in office buildings in Malaysia[9]

III. METHODOLOGY

The research methodology was carried in two parts. One is through Literature Review, and the other part was on field measurements of the Solar Power in the proximity area of the Sultan Ahmad Shah Mosque IIUM. Findings were gathered and analyzed, which led to the conclusions (Figure 9).

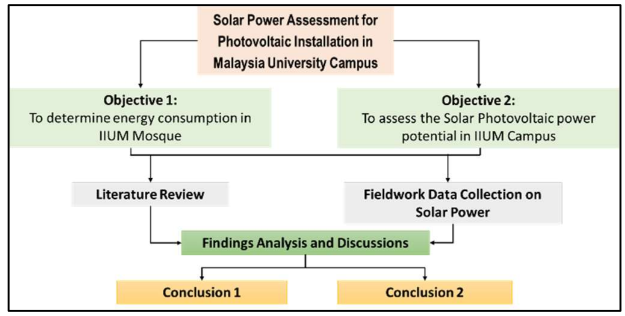

Fig. 9: Research Methodology Chart

Fig. 10: The Solar Panel at The Collection Data Site

Figure 10 shows the location of the data collection in the front yard of the mosque. The information was read every hour using a voltmeter. The type of solar panel that is used polycrystalline silicon with 0.08 m2 area (25 cm * 32 cm). After studying the sun path and shading around the mosque, the roof was chosen to integrate with photovoltaic panels. The front yard of the mosque was selected to research and collect data because it has the same conditions and is the closest place to the roof.

IV. FINDINGS AND DISCUSSIONS

A. *IIUM Mosque Energy Consumption*

Depending on the mosque's architectural plans, the floor area is calculated with four floors 23239 m2. Figure 11 shows the architectural plan for the fourth and final levels.

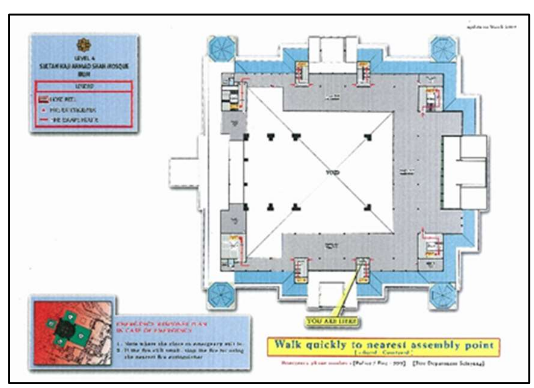

Fig. 11: IIUM Mosque 4th Floor Plan

Annual Energy consumed = Gross Floors Area $\times$ Building Energy Index (1)

Gross Floors Area = First Floor Area + Second Floor Area + Third Floor Area + Fourth Floor Area (2)

IIUM mosque Gross Floors Area = 8575 m2 + 8000 m2 + 3332 m2 + 3332 m2 = 23239 m2

Depending on energy index for office building

130 kwh / m2 / yr. [5]

So annual Energy consumed for IIUM mosque

= 23239 m2 $\times$ 130 kwh / m2 / Yr.

= 3021070 kwh / Yr (3)

It is predicted with Building Energy Index, IIUM Mosque consumes total energy of 3,021,070 kWh/yr. The energy index for office buildings was relied upon because there is no energy index for mosques in Malaysia. However, the electricity consumption in office buildings is more significant compared to the mosque because the office buildings require more services and extended operating hours.

B. Solar Photovoltaic Power Assessment

Figure 12 shows the annual sun path around the research project and the number of sun radiation hours which the research project (IIUM Mosque) exposed to.

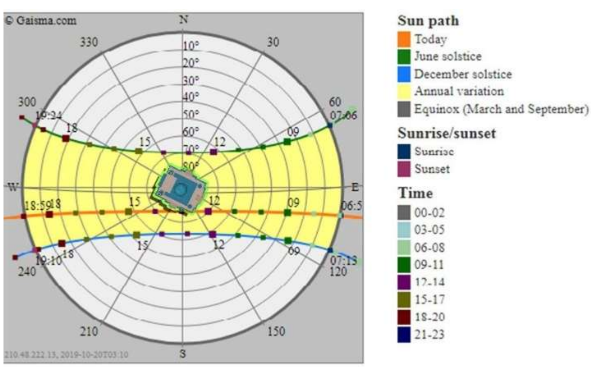

Fig. 12: The IIUM Mosque Sun Path

The graph shows the daily average electricity production during the months, which is shown in figure 13. The graph shows that the highest rate of electricity production is in February and March due to the clear climate during daylight hours. In comparison, the lowest rate of electricity production is in October and September due to the cloudy and rainy weather during daylight hours.

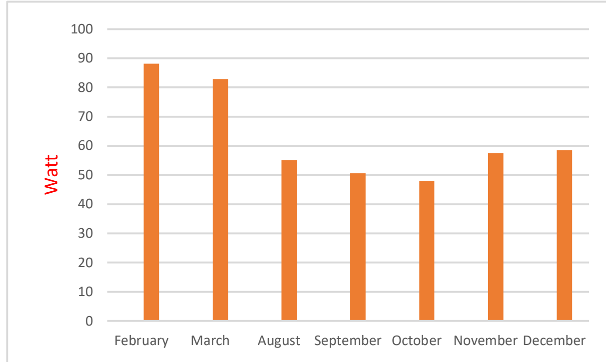

Fig. 13: Average daily electricity production from the given system Wh/day

Figure 13 confirms the potential of utilizing the solar energy resources is high during February and March, and it is good compared to the rest months. This finding proves that Malaysia has promising potential to establish solar energy projects and utilize them on a large scale [10].

TABLE 1 THE AVERAGE DAILY ELECTRICITY PRODUCTION FROM THE GIVEN SYSTEM (W/H/DAY).

MONTH	Wh / DAY
February	88.20
March	82.93
August	55.18
September	50.63
October	47.97
November	57.47
December	58.44

The table1 show the average electrical energy produced with polycrystalline silicon solar panel its capacity of 10 watts, and the area is 0.08 m2.

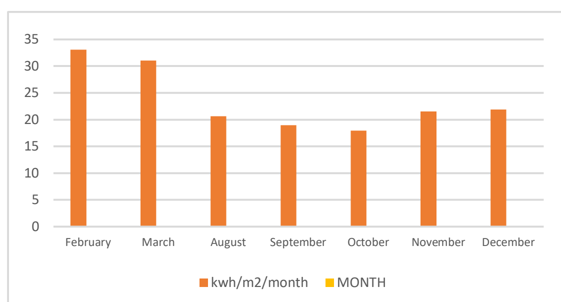

Fig. 14: Average monthly electricity production from the given system kWh/m2/month

Figure 14 shows the average monthly electricity production per meter square for the given system.

TABLE 2 THE AVERAGE ELECTRICAL ENERGY PRODUCED PER SQUARE METER.

wh/m2	wh/m2/day	wh/m2/month	wh/m2/Year	kwh/m2/Year
87.46	874.64	26239.29	314871.43	314.87

Table 2 shows the average electrical energy produced per square meter. Therefore, as in Equation 3, we will need 9554m2 to have enough electrical power to operate the mosque.

Figure 15 showing two proposals for the integration of photovoltaic panels with the university mosque. The first proposal is visible, which is the integration of photovoltaic panels with the sloping roof of the mosque. The panels have small sizes, and the colour is similar to tiles colour installed on the top of the mosque, not to affect the architectural beauty of the mosque. The second proposal is almost hidden, and the photovoltaic panels are integrated with the horizontal ceiling of the mosque and are not almost visible.

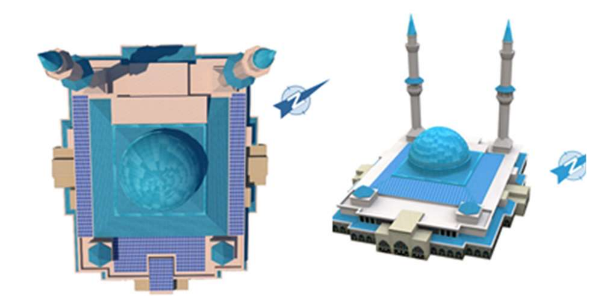

Fig. 15: The first and second proposals for integrating photovoltaic panels with the university mosque.

At least 40% of the mosque's electricity needs can be saved through the first or second proposal.

V. Conclusion

Malaysia has sustainability plans that enable the reduction of carbon dioxide emissions, including using solar panels as the primary source of electricity. The case study highlights benefiting from solar energy as the primary source of electricity. This study supports the importance of using photovoltaic panels to generate sufficient electrical energy to meet the requirements and needs of the mosque.

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