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Design Strategies For Low Energy Building Challenge: A Case Study Toward Net Zero Energy Building In UniKL

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Abstract: In developed nations, a building itself utilise up to a third of total energy consumption and proper management of energy is vital to offset wastage via utilization of renewable energy generation devices at the building. In line with Malaysia energy policy, the new UniKL's building will be designed based on Net Zero Energy Building (NZEB) concept [1]. Thus, the point lies in its ability to be self-sufficient with power generated from the own building with Integrated Photovoltaic (BIPV) systems. It is the easiest and most reliable way to get the Net Zero Energy objectives. The NZEB concept consists of orientation on the site, passive and active components so that the total amount of energy used is equal to amount of renewable energy created on the site. Therefore, the propose approaches can improve the energy efficiency on building toward zero Building Energy Index (BEI). Also, this research focuses on how the impact of semi-trans PV on the overall building's energy performance, taking into account similarities and differences between Conventional PV and Semi-Transparent PV for the use in a NZEB scenario and to achieve zero Net Building Energy Index (NET BEI) without affecting the building occupants thermal and visual comfort and/or imposing operational burdens on the occupants.
The analysis and outcome from this paper demonstrates that the building integrate with semi-transparent PV modules contribute to the building's net zero energy consumption.

Keywords: *Net Zero Energy Building, Semi-transparent PV modules, BIPV, NET BEI. Zero Energy Building, Semi-transparent PV modules, BIPV, NET BEI.*

1.0 INTRODUCTION

The recent dramatic increases in fuel prices have had a major impact on electricity prices. As such, design strategies and techniques of using energy from the sun as a power source for our buildings are under development worldwide and is becoming an increasingly viable alternative. Building integrated photovoltaic systems can apparently provide clean, renewable power, reducing electricity bills for the end-user as well as cutting CO2 emissions.

The Malaysia itself, has introduced its own Feed-in-Tariffs (FiTs) in April 2011 and recently (November 2016) has implemented the Net Energy Metering (NEM) that will complement Feed-in-Tariffs to promote the deployment of renewable energy and payments for the electricity generated by the solar photovoltaics.

There is range of factors that affect performance, such as the type of module as well as orientation and pitch. To create truly low energy buildings, or 'zero energy' buildings, careful design concept development at the earliest stage of the project must be undertaken on active components.

Net Zero Energy Building to make building become super energy efficient with deployment of on-site renewable energy technology. It is steps ahead towards achieving 100% renewable energy.

To illustrate the practical planning and design considerations of NZEB, some examples of pilot project is shown in Figure 1 and Table 1.

Reduction of energy demand must be the first goal. Common energy efficiency (EE) features include daylighting, EE lighting, EE office equipment, EE ventilation, controls and sensors, orientation, insulation

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and energy management. Figure 2 shows the strategies for net zero energy building. A balance between energy conservation and energy generation should be considered carefully.

Figure 1: UniKL's Net Zero Energy Building

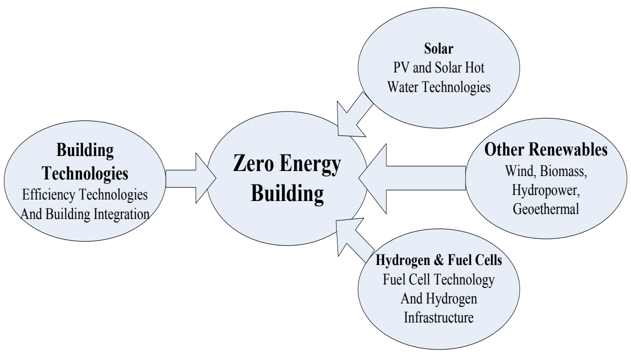

Figure 2: Strategies for Net Zero Energy Building

In general, net zero energy building is applied to buildings that use renewable energy sources on-site to generate energy for their operation, so that over a year the net amount of energy generated on-site equals the net amount of energy required by the building. Thus, for energy balances in zero energy building, usually grid connection is allowed and necessary.

2.0 METHODOLOGY

In this case study, base case and alternative variations of proposed Photovoltaic (PV) module technology models intended to improve the buildings performance developed within the ESP-r simulation platform were numerically modelled and simulated to better understand the impacts of semi-transparent PV windows in extrapolating the performance in term of potential energy saving and electricity generation resulting from artificial lighting consumption, heating and cooling energy consumption and PV energy generation when integrated in parts of the building envelope at Kuala Lumpur, Malaysia's weather and climate conditions.

The base case and proposed PV module technologies installed at the building were then carried out and compared to rectify a solution on the demand supply matching[2] and overall building's NET BEI[3,4,5] in relation to PV electricity generation and energy consumption for heating, cooling and artificial lighting with the influence of system settings and modeling assumptions such as lighting, heating and cooling control strategies, solar heat transmission, visible transmittance and PV efficiency without affecting the building occupants thermal and visual comfort

3.0 COMPUTER MODELLING

It appeared that building specific design parameters influence the most suited PV module layout largely. Therefore for each project an optimization of the best PV-module design is still desired.

The programs used in this study were WINDOW 5, ESP-r and RADIANCE. The inputs to the building energy simulation programs were ascertained through precise measurements and simulations. To run the energy simulation by ESP-r, the optical properties of the glass used of the PV layer were required. It can be obtained and modeled from the glass library software program WINDOW 5, developed by the Windows & Daylighting group of the Lawrence Berkeley Laboratory, USA shown in Figure 3.

A daylight modelling approach have been developed which is based on the direct conflation of the ESP-r and RADIANCE systems providing the overall supervisory control at simulation time. The model created for thermal and electrical simulation by ESP-r can readily be transferred to RADIANCE through the use of an established link between the two programs.

4.0 CASE STUDY BUILDINGS

This case study provides an example of PV modules integrated into UniKL's NZEB[6,7,8,] The building is located at UniKL BMI which is one of the branch campus UniKL shown in Figure 1.

At the equinox, the orientation and pitch of the systems is facing south and 7 degree of tilt angle maximizes its exposure to the sun's path. Renewable energy and energy efficiency from passive strategies will be incorporated through various encompassing facets of the building

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overall design. Foremost is the integrated PV system on the roof of the building, namely a Building Integrated PV System (BIPV).

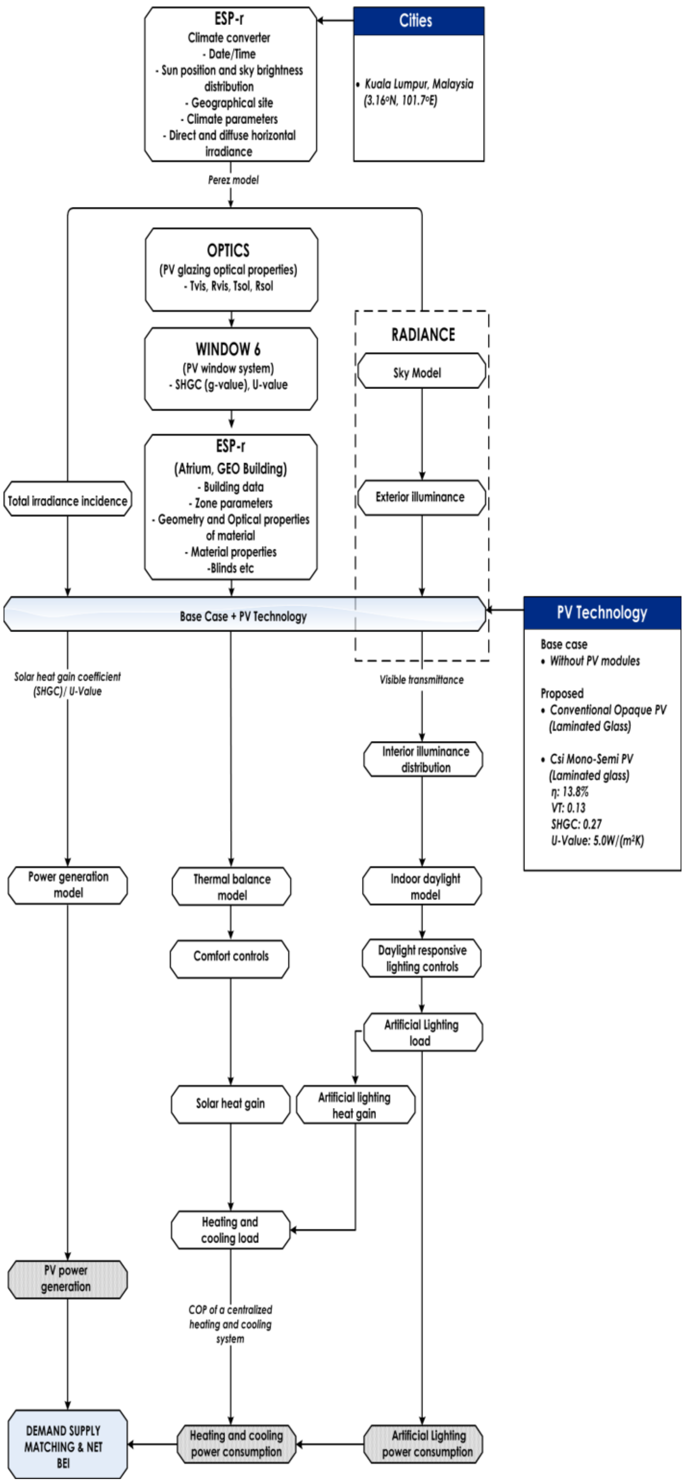

Figure 3: Flow chart of a case study net zero energy building (NZEB) in UniKL, Malaysia

Energy from the sun is harnessed through this PV system and would address all electricity needs of the building.

In other words, the building will set a new standard of energy efficiency by generating sufficient electricity to the entire electricity load (i.e. classrooms and laboratories) and simultaneously minimize the building energy consumption through PV shading device. The PV system attach to the roof of the building is Laminated Safety Glass (LSG) semi-transparent PV modules with a capacity of 120kWp.

Another sustainable design feature for the UniKL BMI NZEB would be the utilisation and application of high performance glazing and strong insulation instead of the brick structure that predominates on UniKL BMI's buildings. The BMI new building propose will be wrapped with double-glazed glass wall in harnessing of the natural daylight resource while eliminating to a great degree of the unnecessary heat radiation into the building so that it increases energy efficiency for the building while at the same time heightening general productivity as a result of the greater preservation of physical well-being for those who work within.

The floors of the building are also a key part of the sustainable design element due to their role in the storage of cooling for the building at night time. This works by embedding tubes within the concrete floor slabs, allowing the floors to effectively cool down at night. In the day, this stored cooling will thus be released from the floor slabs to the rooms above and below them, providing part of the building's cooling load during the day, which will also be supplemented by conventional air cooling systems.

The performance indicator to evaluate the building's net energy consumption in Malaysia shown in Equation (1) and Equation (2) [5].

$$\text{BEI} = \frac{\text{Total Net Energy Consumption [kWh/year]}}{\text{Total Net Floor Area [m}^2\text{]}}$$

Equation (1)

$$\text{NET BEI} = \frac{\sum \text{Engy.Consump.} - \sum \text{Engy Gen. by PV [kWh/year]}}{\text{Total Net Floor Area [m}^2\text{]}}$$

Equation (2)

5.0 RESULTS

The NET BEI applies in Malaysia for the NZEB is zero kWh/m^2.year. Based on our finding the NET BEI for

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the UniKL BMI NZEB is -5.20kWh/m^2.year shown in Table 1 and Figure 4.

Table 1: Summary of results for annual building's net energy consumption for Kuala Lumpur's hot and humid climate conditions

Load and BEI	Units	Without PV (Base Case)	Conventional PV (120wp)	LSG Mono-Semi PV (120Wp) n = 8% VT=25%
Cooling	kWh/m².year	70.58	70.58	50.79
Lighting	kWh/m².year	1.78	1.78	1.80
BEI	kWh/m².year	72.36	72.36	52.60
BEI PV	kWh/m².year	0.00	-38.23	-57.80
NET BEI	kWh/m².year	72.36	34.13	-5.20

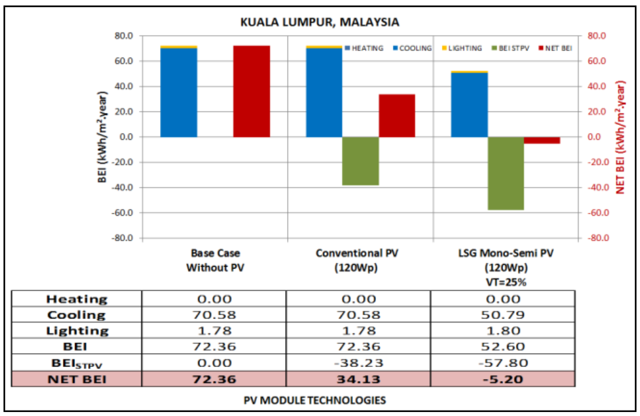

Figure 4: Annual building's net energy consumption of base case and PV technology models for Kuala Lumpur's climate data.

6.0 DISCUSSIONS

Table 1 and Figure 4 show that the consumed energy of the UniKLBMI building without PV is 72.36kwh/m^2.year and the total Net BEI is 72.3636kwh/m^2.year. However, the consumed energy of the UniKLBMI building with conventional PV is 72.3636kwh/ m^2.year and the total Net BEI is 34.13 kwh/m^2.year was deteriorated 47.2% energy consumption of the building is due to energy generated from conventional PV.

In contrast, with Laminated Safety Glass (LSG) mono semi PV the building consumed about 52.60kwh/m^2.year and the total Net BEI is -5.20kwh/ m^2.year due to the impact of semi-transparent PV install to the building. Therefore, LSG mono-semi PV has the lowest energy consumption compared with others.

7.0 CONCLUSIONS

An energy modelling analysis of the NZEB with integrate mono semi-transparent PV case study is -5.20kWh/m^2.year and it is creating surplus energy through net energy metering basis. Also, the results of this study are considerably achievable, reliable and conveniently applied to the buildings in Malaysia.

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