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Optimal Design of Grid Connected Photovoltaic System at UTHM using HOMER Software

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Abstract: This paper presents an optimal grid-connected photovoltaic (GCPV) system design at the UTHM by using HOMER Software. The main purpose of this project is to reduce UTHM's annual energy usage and electricity bill. Based on the UTHM campus energy usage and electricity bill data reveal that the monthly utilization of electricity on the UTHM campus is very high and costly. Besides that, to reduce CO_2 emissions emitted from producing electricity. Therefore, this paper proposed the development of a GCPV system for the G3 Block building, Perpustakaan Tunku Tun Aminah (PTTA) building and Fakulti Kejuruteraan Awam and Alam Sekitar (FKAAS) based on Monocrystalline PV modules. The total proposed of GCPV system capacity can be installed up to 4351.17 kW and simulated using HOMER software. The simulation results show that the grid-connected PV system can significantly reduce the UTHM campus annual operating cost by 10% per year, UTHM campus annual grid purchase cost by 10.3% per year, UTHM campus Average Grid Purchase kWh by 11.5% per year and the carbon dioxide emission by 10.3% per year. As a result, the proposed GCPV system at the UTHM campus can be reduced up to RM 2,263,651 per year.

Keywords: Grid-Connected PV System, Homer Software, CO_2 Emissions

1. Introduction

In today's sustainable development environment, renewable energy is the most economic green energy technology [1]. The critical energy sources in Malaysia include oil, natural gas, hydropower, and coal, while solar power and biomass are good instances of renewable energy sources currently being used. [2]. The rising demand for electricity has resulted in a rapid depletion of non-renewable energy supplies. [3]. Thermal power plants, on the other hand, emit a variety of gases, including Sulphur dioxide (SO_2), nitric oxide (NO), carbon dioxide (CO_2), and airborne inorganic [4]. Electricity generation using renewable energy (RE) has been widely used to overcome the gas emission problem from fossil fuel generation, increase in load demand, fluctuating oil prices, and gradual depletion of fossil fuels [5].

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The Photovoltaic (PV) system is one of the famous REs that are widely used in the world as green power resources. There were several types of PV technology used to harvest solar energy such as Amorphous Silicon, Monocrystalline Silicon, Polycrystalline Silicon, Copper Indium Disulfide (CIS), and Heterojunction Incorporating Thin (HIT) Film [6]. These PV technologies can be utilized to generate electricity at a low cost by converting the energy from the sun to useful electricity using an inverter. The grid-connected photovoltaic (GCPV) system can be utilized to minimize the current electricity bill and reduce gas emissions from conventional thermal generation. Since the electricity bill in UTHM in keeps increasing every year due to the high demand, the GCPV is one of the alternative solutions to reduce the electricity bill from the power utility. Therefore, the main objective of this paper is to design a GCPV system using Homer for a selected UTHM building. The details technical, economic and emission analysis are conducted to evaluate the feasibility of the proposed GCPV system in UTHM Parit Raja, Johor, Malaysia.

2. Materials and Methods

The proposed GCPV model has been developed and simulated using HOMER software to obtain the results of an economic analysis of the net present cost (NPC) and cost of energy (COE) of a renewable energy system. Figure1 shows the flowchart for the whole project planning.

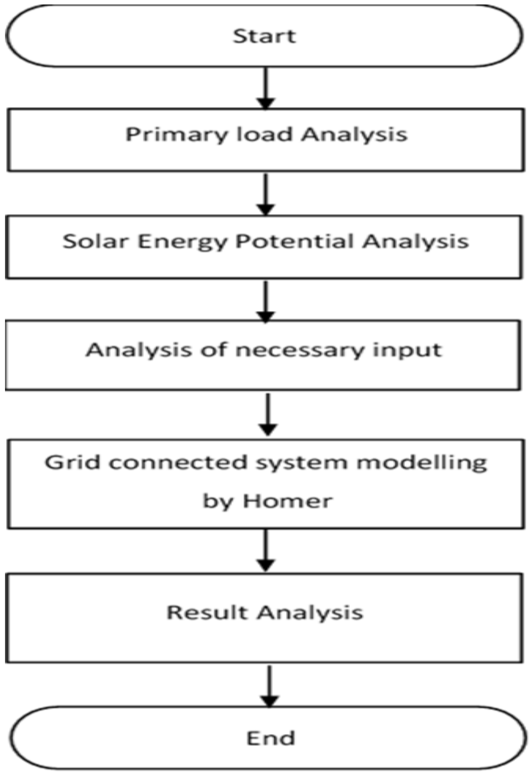

Figure 1: Flowchart grid connected analysis using HOMER

The rooftop area data will be used to measure the size of the PV system and to estimate the total number of PV modules, and the size of the inverter that will be used in the PV system. The rooftop area of each building is measured using the Google Maps website. A PV system, a converter, an AC load, and a grid system are the main components in designing a grid-connected PV system on the UTHM campus, as illustrated in Figure 2. The PV system, which represents the total PV system installed on the UTHM campus, is connected with the converter through a DC link, and then the converter will then convert the DC power of the PV system into AC power. The AC power generated by the converters is sent into the grid system and the load is through the AC link. In this model, the PV system is connected to the grid system without any limit from the utility provider, Tenaga Nasional Berhad (TNB). The PV system can be delivered its maximum power to the load and grid system. The load component represents the load demand on the UTHM campus.

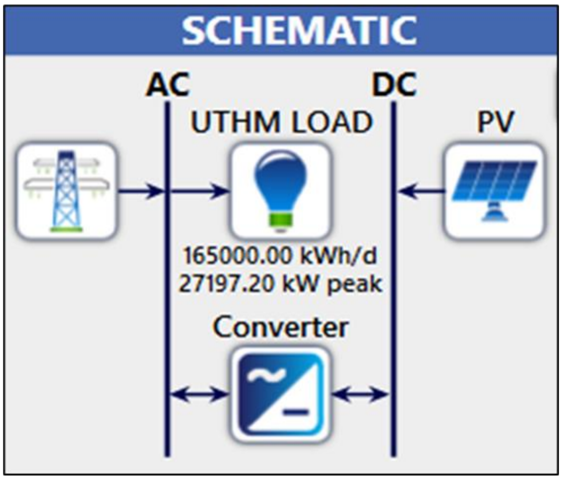

Figure 2: Grid-connected PV system model

For each system setup, these energy balance measurements are performed by HOMER. It then decides whether a configuration is practical, whether, under the conditions specified, it can accommodate the electrical demand, and calculates the cost of building and running the device over the project lifespan. Costs such as capital, replacement, service and maintenance, power, and interest are accounted for in the computer cost estimates [7].

The daily load profile data of the UTHM campus taking from the UTHM Property Administration Office. The primary load input in HOMER software is set according to the daily load data, as shown in Figure 3. The data is developed starting from January to December.

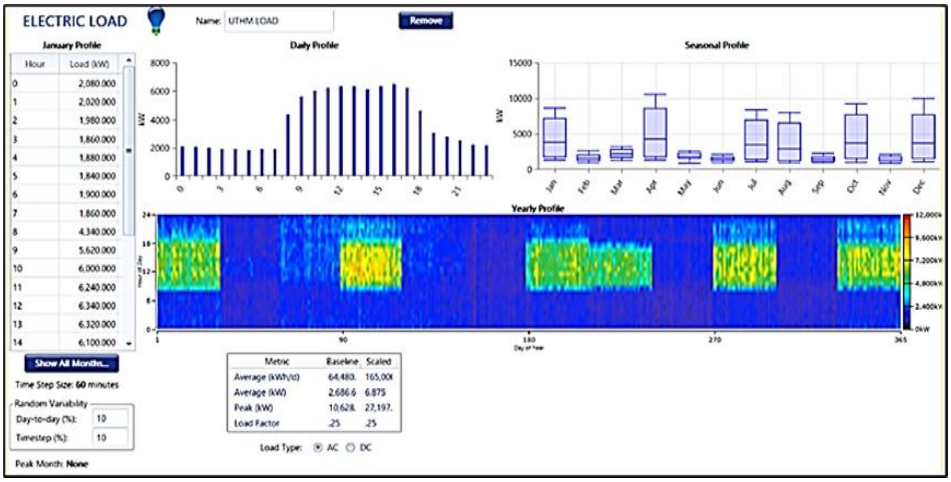

Figure 3: UTHM campus weekdays and weekend load profile

Figure 4 shows the solar resources parameter setting in HOMER software. The daily radiation data and clearness index data are set from National Renewable Energy Lab in HOMER. Based on the clearness index and daily radiation data, the HOMER software automatically produces a bar chart of global horizontal radiation.

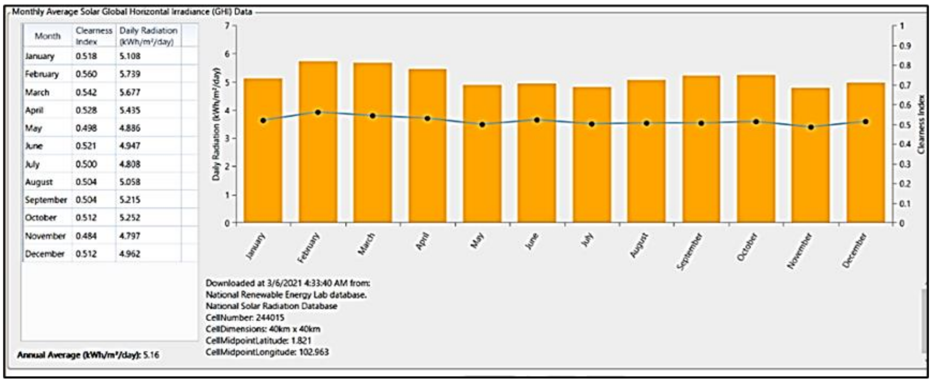

Figure 4: Solar resources parameter

3. Results and Discussion

The discussion will concentrate on the study of the grid-connected solar system's operating expenses, energy costs, the overall power output of the grid-connected photovoltaic system, and efficiency of the grid-connected photovoltaic system based on the total load of the UTHM campus. The comparison between the grid system and grid-connected PV system in this section is focused on the reductions that have been successfully reduced by the grid-connected PV system.

The total NPC of the grid-connected PV system in the UTHM campus for 25 years is RM290,334,200. This cost includes the cost of PV array installation, inverter cost, PV system operation and maintenance cost, and cost of electricity purchased from the grid system for 25 years of system operation. Next, the grid-connected PV system's annual operating cost in the UTHM campus is RM 19,701,760 per year as shown in Figure 5.

Total NPC:	RM290,334,200.00
Levelized COE:	RM0.3729
Operating Cost:	RM19,701,760.00

Figure 5: NPC, COE and operating cost of the grid-connected PV system and grid system

The electrical production of a grid-connected PV system is shown in Figure 6. There are two electrical sources in the grid-connected PV system: the PV array source and the grid system source. The total power generated from the PV array system is 6,546,126 kWh per year, representing 10.8% of the total power supplied to the UTHM campus load. Then, the grid system's total power purchases are 54,007,872 kWh per year, representing 89.2% of the total power supplied to the UTHM campus load. Therefore, the grid-connected PV system's total power production in the UTHM campus is 60,553,998 kWh per year. This total power production is 100% sufficient to be used by UTHM load.

Cost Summary | Cash Flow | Compare Economics | Electrical

Production	kWh/yr	%
Generic flat plate PV	6,546,126	10.8
Grid Purchases	54,007,872	89.2
Total	60,553,998	100

Figure 6: Electrical production of a PV device connected to the grid

PV system power level is colored orange, and the grid system power level is colored green. From the bar chart in Figure 7, grid system's electric production is much higher than the PV system. This situation is due to a small PV system size and higher UTHM campus load demand. The amount of electricity generated by a grid-connected PV system is determined by the UTHM campus's load demand. UTHM campus load demand for every month exceeds the PV system's capacity, which causes the PV system power to only provide 10.8% of the total load demand. The rest of the load, which is 89.2%, is supported by the grid system. Moreover, the PV system is only available during the daytime, and during nighttime, the load is fully using an electric supply from the grid system.

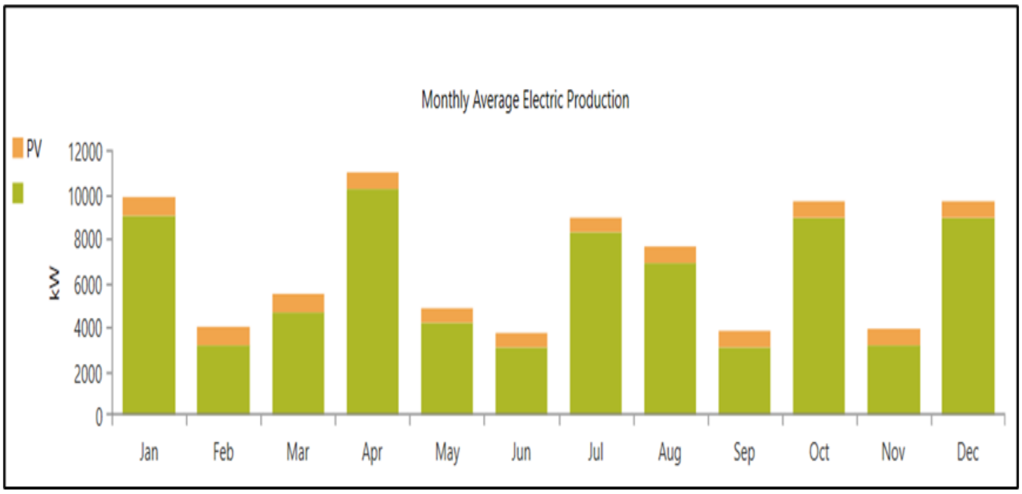

Figure 7: Monthly average electricity production of grid-connected PV system

The total carbon dioxide emission of a grid-connected PV system is shown in Table 1. The total CO_2 emission of a grid-connected PV system is 37,535,471 kg per year. The CO_2 emission produces based on the total energy purchased from the grid system. Gird-connected PV system, the CO_2 emission level is lower because the electric production of the PV system has reduced the total energy purchased from the grid system and thus reduces the CO_2 emission level.

Table 1: Carbon dioxide emission of the grid system and grid-connected PV system

System	Grid System	Grid-Connected PV System	Difference	Percentage %
Carbon Dioxide Emission (kg/year)	41,856,375	37,535,471	4,320,904	10.3

The overall annual grid purchase cost of a grid system and a grid-connected PV system, respectively, is RM 21,921,900 and RM 19,658,249 per year. The grid-connected PV system has a lower annual grid purchase cost compared to the grid system with a difference of RM 2,263,651per year and a percentage difference of 10.3 %. This situation shows that the application of the PV system has successfully reduced the UTHM campus electric usage from the grid system and thus reduce the annual grid purchased cost of the UTHM campus by 10.3%.

The comparison between the grid system and the grid-connected PV system is summarized in Table 2. The comparison summary is focused on the reduction that has been successfully reduced by the grid-connected PV system when compared with the grid system. There are several parameters that have been successfully reduced by a grid-connected photovoltaic (PV) system including net operating cost, annual operating cost, annual grid purchase cost, average grid purchase and carbon dioxide emission.

Table 2: Comparison summary of the grid system and grid-connected PV system

Parameters	Reduction	Reduction Percentage %
Net operating cost (RM)	28,700,879.18	10
Annual operating cost (RM/year)	2,220,140	10
Annual Grid Purchases Cost (RM/year)	2,263,651	10.3
Average Grid Purchase (kWh/year)	6,217,128	11.5
Carbon Dioxide Emission (kg/year)	4,320,904	10.3

4. Conclusion

This project presents the potential of photovoltaic generation potential in UTHM. A grid-connected PV system is proposed on the rooftop of the selected building. Three buildings have been selected for PV system design and evaluation are PTTA building, the FKAAS building and G3 Block building. The size of each building's rooftop area was measured using the Google Map website. Then, the PV system for each building was designed by using a Monocrystalline PV module that has 430W rated power. From the design analysis, it found that the PV system size of the PTTA building, FKAAS building and G3 Block building are 1276.67 kWp, 1667.54 and kWp, 1406.96 kWp respectively. The HOMER simulation, it shows the proposed 4351.17 kWp PV system can significantly reduce up to 11.5% and 10.3 % of electricity purchase from the grid and CO_2 emissions respectively per year. Therefore, the highest number of PV installations in UTHM rooftops have great potential to reduce electricity bills and CO_2 emissions (from conventional power generation).

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References

[1] N. Pawar and P. Nema, "Techno-Economic Performance Analysis of Grid Connected PV Solar Power Generation System Using HOMER Software," 2018 IEEE Int. Conf. Comput. Intell. Comput. Res. ICCIC 2018, pp. 16–20, 2018, doi: 10.1109/ICCIC.2018.8782411.

[2] M. R. Islam, N. A. Rahim, K. H. Solangi, and E. Tower, "Renewable Energy Research in Malaysia," vol. 4, no. 2, pp. 69–72, 2010.

[3] Z. Noranai, U. Tun, and H. Onn, "Study of energy efficiency opportunities in UTHM Study Of Building Energy Index In Universiti Tun," no. May 2011, 2019.

[4] EEA, "EN08 Emissions (CO 2 , SO 2 and NO x) intensity of public conventional thermal power (electricity and heat) production," no. x, pp. 1–8, 2005.

[5] B. Roy, A. K. Basu, and S. Paul, "Connected Solar Photovoltaic Power System for a Residential Load," Autom. Control. Energy Syst. (ACES), 2014 First Int. Conf., pp. 1–5, 2014.

[6] D. A. Quansah, M. S. Adaramola, G. K. Appiah, and I. A. Edwin, "Performance analysis of different grid-connected solar photovoltaic (PV) system technologies with combined capacity of 20 kW located in humid tropical climate," Int. J. Hydrogen Energy, vol. 42, no. 7, pp. 4626–4635, 2017, doi: 10.1016/j.ijhydene.2016.10.119.

[7] M. Nurunnabi and N. K. Roy, “Grid-connected hybrid power system design using HOMER,” Proc. 2015 3rd Int. Conf. Adv. Electr. Eng. ICAEE 2015, pp. 18–21, 2016, doi: 10.1109/ICAEE.2015.7506786.