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Photovoltaic Power System Simulation in Maximizing Return of Investment for Feed in Tariff for Residential Area

M.A. Abu[1, 3],M.Z. Mohamad[2,3] & M.H. Rosli[1, 3]
[1]Electronics Technology Section
[2]Electrical Technology Section
[3]Universiti Kuala Lumpur British Malaysian Institute, Gombak, Selangor

Corresponding email: mohdazlan@bmi.unikl.edu.my

Abstract: Due to the increasing tariff of electricity by Tenaga Nasional Berhad (TNB), the alternative for electricity currently is investigated through the development of solar based power sources for home uses. This paper presents the application of solar photovoltaic system to reduce the burden from paying high electricity bill. The project is designed with suggested photovoltaic system that can maximize return of investment (ROI) for residential area. The simulation software HOMER is applied to and verify the outcome of the system. As a result, the cheaper electricity bill was proposed and explained using the suggested system.

Keywords: Photovoltaics system, return of investment, software HOMER, feed in tariff

1.0 INTRODUCTION

One of the major problems faced by Malaysians recently is the increase of electricity rate and tariff. Sometimes, the electricity bill can increase to hundreds of Malaysian Ringgits (RM). The use of power consumed by electrical appliances such as air conditioner caused the bill to be higher than usual. This definitely affects certain group of people especially those who earn lesser monthly income [3]. This project aims to suggest on how electricity usage and bills could be reduced using the solar photovoltaic systems. Photovoltaic's (PV) system is a method of generating electrical power by converting solar radiation into directcurrent(DC) electricity using semicon ductors that exhibit the photovoltaic effect. Materials used for photovoltaic's cell include Monocrystalline Silicon, polycrystalline silicon and amorphous silicon for the fabrication of solar cell [4]. Solar photovoltaic's systems are classified into three types; Stand Alone Systems, Hybrid Photovoltaic's Systems and Grid-connected Photovoltaic's Systems [5]. Feed-in tariff is a new recommendation for Malaysians to use the renewable energy under the Renewable Policy and Action Plan which is up to 30MW in size. This mechanism allows electricity to be produced from indigenous renewable energy resources to be sold to power utilities at a fixed premium price for a specific duration [6].

Return of Investment (ROI) is the minimum time used to recover the investment that had been made [7]. HOMER software performs three principal tasks; simulation, optimization, and sensitivity analysis. In this case, HOMER used to model the performance of a particular micro-power system configuration each hour of the year to determine its technical feasibility and life-cycle cost [8]. Anwari et al (2011), reported to modeling and simulation of 1MW grid connected PV system using National Renewable Energy Laboratory's (NREL) HOMER software, and the optimum system is analyzed to see the economic feasibility of the system in a small industry area in Malacca, Malaysia. The study shows that a grid connected PV system generate electricity from the sun light and then converted into grid compliant AC by inverter. HOMER will simulate the system and perform optimization of the system according to the available usage data and the available renewable energy (sun radiation) data. The obtained result with two inverters 250kW x 4 and 500kW x 2 to analysis the result using three photovoltaic panels is 165W, 225W and 315W. The result is similar to 250kW x 4 and 500kW x 2 but the operating costing is different when HOMER is applied. Firdaus Muhammad-Sukki reported a general concept of

the FIT Malaysia is explained and financial analysis is carried out, comparing the return on investment of installing solar PV in different locations in Malaysia, as well as in other countries. This paper concluded that solar PV industry showed significant results in terms of installation, the study suggested that Malaysians are not willing to invest in this sector. With a low level of awareness of government policies available in Malaysia, it is not surprising and appears to be one of the barriers for the Feed in Tariff (FIT) scheme - especially solar PV [2]. This paper will show on how HOMER simulation software is used to create simulation of photovoltaic which maximizes the return of investment for consumers.

2.0 METHOD

Solar photovoltaic's systems are broadly classified into three types as explained before. This project proposed a technique using Stand-alone System as shown in Fig. 1. This project does not require other resources from grid connection under Tenaga Nasional Berhad (TNB).

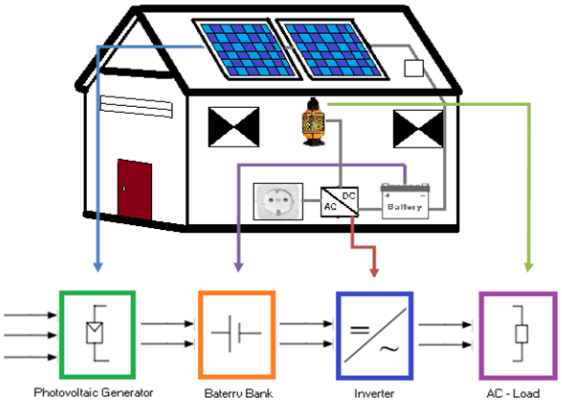

Fig. 1 Block diagram for the stand-alone PV system

The type of material was selected from the suggested material that proved to be durable and lasted for a long time. The material used is Polycrystalline solar cells because this material can get a consistent input for supply voltage to the load. With the researched information, HOMER is believed to be the appropriate software to design the system and calculate the price [8].

Besides that, Feed-in Tariff (FIT) will be able to work alone without any other backups which made this project possible. Calculation for the sizing of photovoltaic has 5 steps to verify whether the solar system will perform as specified or vice versa. A correct choice should be made so that user will have a reliable and durable solar photovoltaic system. [9]. Steps 1 to 5 below show the equation and calculation of load, the number of solar module, battery capacity, solar regulator size and inverter sizing that used in HOMER simulation.

Step 1: Determine the load (Wattage)

Load = Power x Hour
Allowing for 5% loss

Step 2: Determine Solar Module Required (Solar Panel)

Power Solar Capacity = Load ÷ Peak Hour

Step 3: Determine Battery Capacity

Battery Ah = Load ÷ Voltage of battery

Step 4: Solar Regulator Sizing

Minimum regulator sizing = Short circuit current of solar panel x 125%

Step 5: Inverter Sizing (Only applicable if load is AC type)

Maximum peak of 80%/90%
1kWh x 0.80 = 1250Watts
1kWh x 0.90 = 1111.111111Watts

To calculate ROI, the benefit (return) of an investment is divided with the cost of the investment; the result is expressed as percentage or ratio [7]. The ROI formula is:

Total Personal Loan Amount × Years of Loan × Interest from Bank
= Total Amount for Interest

↓

Total Amount for Interest + Total Personal Loan Amount
= Total Amount to Pay

↓

Total Amount to Pay ÷ Monthly Payment
= Amount for Payment per Month

Fig. 2 The calculation of HOMER value

3.0 SOFTWARE DEVELOPMENT

Fig. 3 focuses on evaluating standalone photovoltaic designs with renewable energy sources and has a sensitivity analysis built in. This gives opportunities to investigate change in demand which has a large impact on sizing a standalone photovoltaic system. HOMER has an hour to hour simulation and this feature gives possibilities to investigate how the battery bank status is and determine the sizing of the batteries. HOMER is built with an optimization focus and this means that the model tries to reduce cost of electricity.

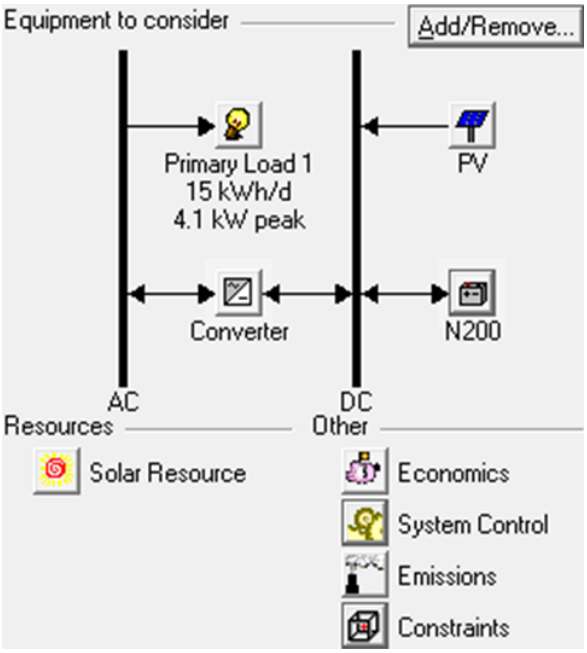

Fig. 3 Equipment overview

3.1 Use stand alone photovoltaic component

Based on a total research about HOMER software, stand alone photovoltaic system is chosen. Components that are used in standalone photovoltaic system are photovoltaic cell (Monocrystalline Silicon), inverter, battery and load at house in the residential area. The entire components will be set in the software to find the result using HOMER.

3.2 Include information

The component has a price and types to put at the software. The prices has been researched at the company that provides the component. After obtaining the components, it is compared to each other to obtain a good price at the end. The location (longitudes and latitude) has to be searched as well as daily radiation every month and time zone at Malaysia to put in software.

3.3 Power electric provide

This is the baseline and the scaled annual average is where the different loads are used as inputs. It can be seen in the system. HOMER has a random variability function with a day to day and step to step change. In the simulations for this report, those values has been zero because a refine hour to hour curve has been made.

3.4 Calculation

All the data has to be filled in the HOMER software. After all the data is given to the software, the software can simulate the data and obtain the result.

3.5 Result for photovoltaic price

After getting the result from calculation, the price of photovoltaic technology will be described in Homer's software. That price is purchased by consumers. Fig. 4 shows the flow chart to define the price using HOMER.

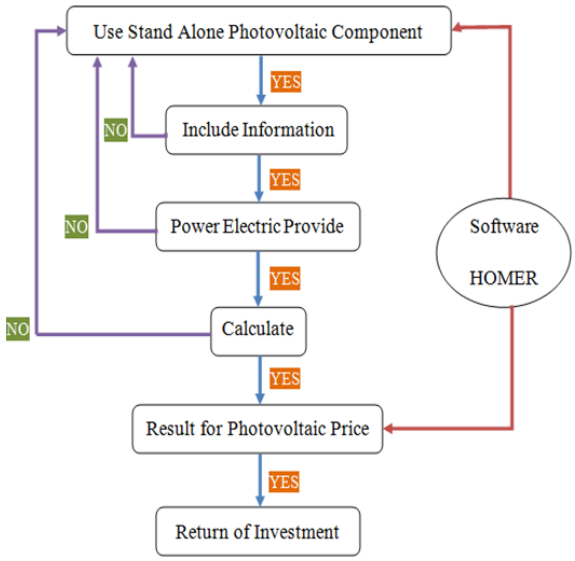

Fig. 4 Flow chart

4.0 RESULT AND DISCUSSION

The surveying for this project consists of the Photovoltaic, battery, inverter and load. Every part has to be keyed in HOMER and formulate the result. The result will be displayed at the end of the software and has difference in terms of price between Monocrystalline and Polycrystalline solar panel.

4.1 Simulation Parameters

The photovoltaic data considered in this simulation is based on the availability of solar radiations at Malaysia's latitude and longitude is 2º 30' North and 112º 30' East. The annual solar resource profile obtained through HOMER is given in Fig. 5.

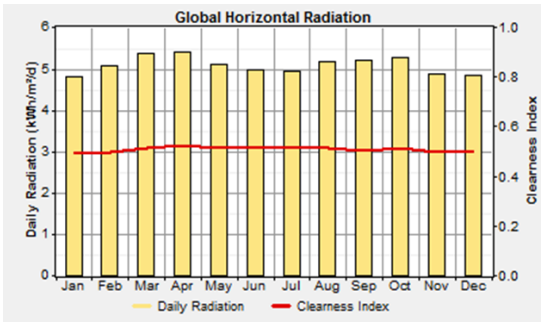

Fig. 5 Solar radiation profile

An average demand of the general load center with the 15kWh/day is considered. In the analysis, the load is modeled with a few peak demands of almost 4.12 kW and a load factor of 0.156. The electric load profile of a similar load for a 24- hour is obtained through HOMER electric load database is shown in Fig. 6.

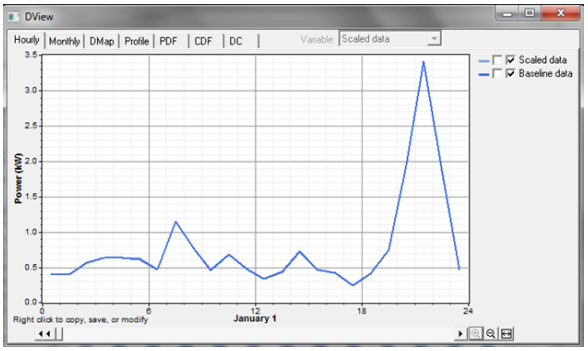

Fig. 6 Profile of the twenty four hour

Fig. 7 shows the period for 24- hour per day in January. The result shows that the radiation of the sun started at 0600 hours until 1800 hours. The peak radiation is between 1000 hours and 1300 hours and the maximum load demand was at 2200 hours for the residential area. The amount of the electricity generated by the solar panel could not support the demand of electricity for the particular day. Thus, the tilt angle of the solar panel needs to be adjusted so that the solar panel could receive a large amount of sun radiation.

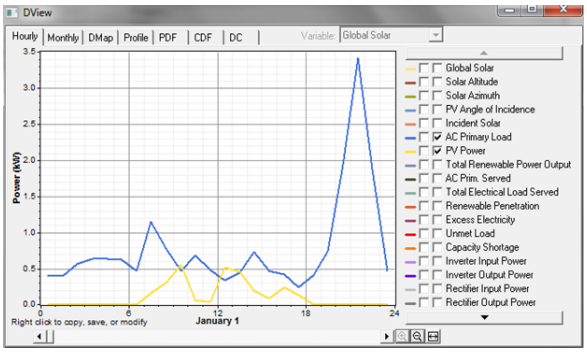

Fig. 7 PV power versus AC primary Load for 24-hours

4.2 Simulation Results

Two stand-alone photovoltaic system configurations were used different photovoltaic panels namely Polycrystalline silicon (ET-P672). Monocrystalline silicon (ET-M672) was simulated using the system in Fig. 1. The result between Monocrystalline and Polycrystalline can be seen in Fig. 8 and Fig. 9. There is a different price between the two types because Monocrystalline more expensive compared with Polycrystalline silicon. The price initial capital for Polycrystalline to install the solar panel was obtained which is RM 57479 and Total NPC (net present cost) is RM 84215. The price initial capital for Polycrystalline to install the solar panel was obtained which is RM 59520 and Total NPC (net present cost) is RM 86256.

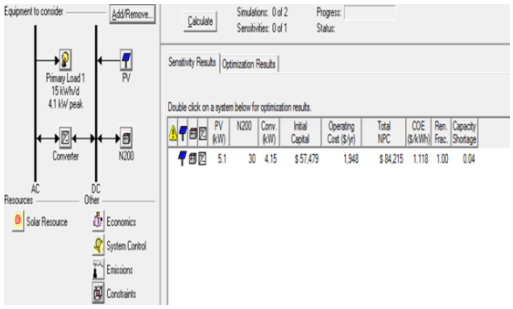

Fig. 8 Homer Price for Polycrystalline silicon

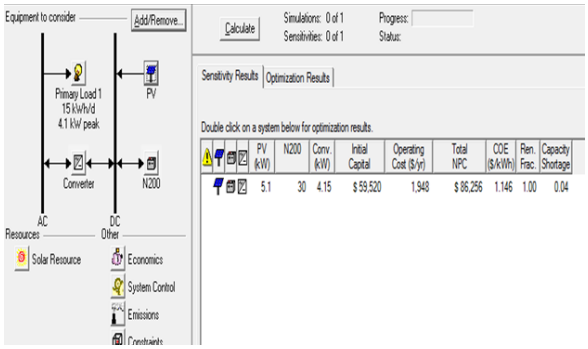

Fig. 9 Homer price for monocrystalline silicon

4.3 Return of Investment for Monthly Payment

The total cost of installation for initial capital is RM 59520 for Monocrystalline silicon. As for the Net Present Cost (NPC), the cost is RM 86256. In order to bear the cost of installation, it is wise to apply for personal loan from banks. Several information regarding personal loan were observed and identified especially in terms of interest. Fig. 10 shows the calculation for Monocrystalline silicon using CIMB bank with interest of 3.98%. Fig. 11 shows the calculation for Polycrystalline silicon using CIMB bank with interest of 3.98%.

Total Amount Initial Capital for Personal Loan using CIMB Bank is RM 59600

RM 59600 x 20 x 3.99% = RM 47560.8

RM 47560.8 + RM 59600 = RM 107160.8

RM 107160.8 ÷ 240 = RM 446.5033

Monthly payment for Initial Capital is RM 446.50333

Total Amount NPC (net present cost) for Personal Loan using CIMB Bank is RM 86300

RM 86300 x 20 x 3.99% = RM 68867.4

RM 68867.4 + RM 86300 = RM 155167.4

RM 155167.4 ÷ 240 = RM 646.5308

Monthly payment for Total NPC (net present cost) is RM 646.5308333

Fig. 10 Calculation for monthly payment for monocrystalline silicon

Total Amount Initial Capital for Personal Loan using CIMB Bank is RM 57500

RM 59600 x 20 x 3.99% = RM 45885

RM 45885 + RM 57500 = RM 103385

RM 103385 ÷ 240 = RM 430.7708

Monthly payment for Initial Capital is RM 430.77083

Total Amount NPC (net present cost) for Personal Loan using CIMB Bank is RM 84300

RM 86300 x 20 x 3.99% = RM 67271.4

RM 67271.4 + RM 84300 = RM 151571.4

RM 151571.4 ÷ 240 = RM 631.5475

Monthly payment for Total NPC (net present cost) is RM 631.5475

Fig. 11 Calculation for monthly payment for polycrystalline silicon

4.4 Analysis

This analysis was conducted according to the results of the system testing. It will give a comparison between the Monocrystalline and Polycrystalline silicon developed at residential area. The Table 1 shows the same external product and the quantity have to be used in standalone system. After that, the different amounts for each silicon with the same equipment and monthly payment for consumer can be made.

Table 1 Price between monocrystalline and polycrystalline silicon

	Monocrstalline		Polycrstalline	
Price/ Month in 20 years	Initial Capital	Total NPC	Initial Capital	Total NPC
	RM446.51	RM646.54	RM430.77	RM631.55
No of Solar Panel	17		17	
Power Output (watt)	5100 Watts		5100 Watts	
Size panel	1956×992×50mm		1956×992×50mm	
Weight	24.07 kg		24.07 kg	

5.0 CONCLUSION

From the research, The Best Photovoltaic System That Maximizes Return of Investment for Feed in Tariff Using HOMER in Residential Area is Polycrystalline silicon. This is because, although the fourth factor is the same for both Monocrystalline and Polycrystalline solar cell, in terms of cost, Polycrystalline has a lower amount of pay which is RM 431.52 compared to Monocrystalline which is RM 446.51 per month in 20 years. The design for the standalone system of the photovoltaic is done through HOMER software. As a result, the price for

initial capital to install the solar panel was obtained which is RM 57512.03 and Total NPC (net present cost) is RM 89821.536.

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