Performance Analysis of Different Type PV Module for 3kW Residential Roof Top PV System using PVSyst Simulation tool

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Abstract. The purpose of this article is to discuss a performance comparison of solar panel between mono crystalline, poly crystalline and HIT photovoltaic for roof top solar photovoltaic (PV) system. Residential PV power generation is a growing fast nowadays due to technology transfer success to everyone while also serving as a renewable energy source. Correct selection of PV modules possible to get a fast return of investment while wrong selection is vice versa. Three type of PV panel was applying in 3.12kW rooftop PV design in Selangor, Malaysia residential this work for comparison analysis. To make a fair comparison, the PV module analyse with same location, weather, orientation and losses. Simulation was performed fully under PVSyst software and looking at performance ratio system, a yearly balanced, effective output energy, daily output generation, system output generation, and yearly system losses. In this article the performance of three different types of PV panels is demonstrated. The HIT PV module shows the highest yearly performance ratio up to 81 % compare to mono and poly type. The normalized production with standardized variable to evaluate the PV output including collection losses, device losses and energy generated show the HIT type produces lowest losses while highest output. The performance of HIT PV module was good compared to PV module mono and poly type; this is due to the lower losses and high output produce significantly. The PV system's payback period can be shortened, and the PV system can perform better, if the PV panels are more efficient.

1. Introduction

To promote clean and sustainable energy and satisfy international climate change obligations, Malaysia's government has set a goal of 31 percent renewable energy in the national energy mix by 2025.[1]. Solar energy must contribute up to 18 000MW of installed capacity by 2035 to meet the aim. As a result, the Malaysian government is developing policies and regulations to promote renewable energy, particularly solar energy[2]. Malaysia has been working on renewable energy development since 2001, using the premise of leveraging market forces to achieve the desired results in terms of electricity output[3].

Malaysia renewable energy resources is well known especially solar, making it a desirable location for solar photovoltaic power installations [4]. Solar energy has gained popularity in Malaysia in recent years as a result of a rapid price drop in PV technology and a growing awareness of sustainable energy among these world's cities. Due to the increase of market demand installation of solar PV, there are also growth the company of solar equipment provider and the market price is versus the efficiency of the output product. Thus, in order to archive high return investment and good PV installation system, an analysis is require especially for PV module, since it was the main component of the PV system.

The electrical energy generated by such a solar system can be fed into the electrical network with predetermined quality and reliability parameters, with no disturbance to the network's usual operation. By converting the DC output of the array PV panels to an AC output waveform that matches the voltage and frequency of the local network, an inverter connects the PV array to the network [5][6].

A performance assessment for PV systems is used to determine the potential for solar energy generation in a specific site. Various research on the performance of solar modules deployed outside have been undertaken all around the world [7]. [8]found that the PVsyst simulation results were almost identical to or almost identical to the measured power generation data for an 830 kWp grid-connected solar power plant installed in India, hence PVsyst was chosen for the simulation. In Eastern India the similar idea was investigated for a rooftop photovoltaic grid-tied system [9]. For analysing the performance of grid-connected solar systems, the International Energy Agency (IEA) developed performance metrics based on parameter such as array capture losses, performance ratio, reference yield, final yield, and system efficiency [5], [10]. In this article, a few of the above-mentioned metrics were also used to evaluate the performance of a grid-connected PV system.

2. Methodology

This study created performance criteria to evaluate the performance of a grid-connected rooftop solar PV system. Energy generation, overall system losses, performance ratio, capacity factor, PV array efficiency, and PV system efficiency all contribute to overall system performance. The PVSyst programme was used to simulate numerous derived parameters related to energy and efficiency for this study. The PVSyst simulation was predicated on achieving hourly energy balances over the course of a year. Figure 1 shows the schematic design under PVSyst software for the rooftop PV system analysis, where the panel type is replaced by three type respectively according to model stated in Table 1. Number of panel is different due to availability in market of the actual size to make sure overall system is equal to 3.12kW. While the inverter used is model 3kW Huawei.

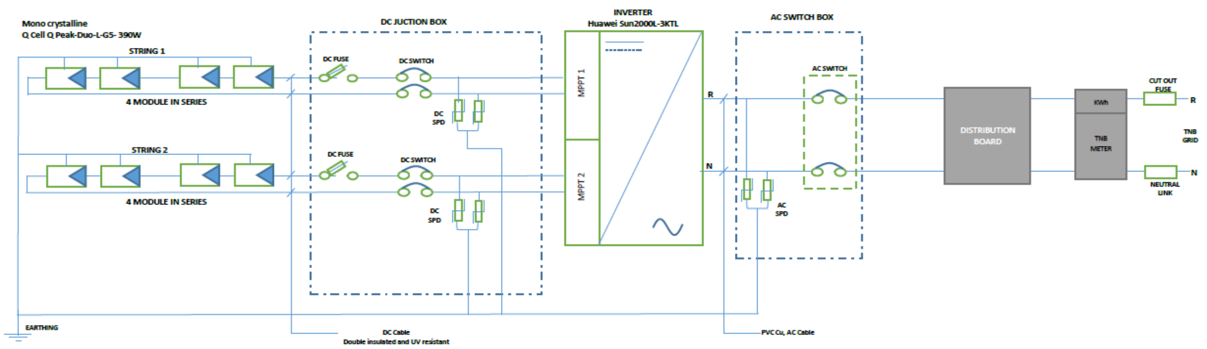


Figure 1. Schematic diagram for 3.12kW PV System

Table 1. Parameter PV Panel used for comparison in 3.12kW PV system

PV Type	Model	Quantity
Monocrystalline	Q Cell Q Peak-Duo-L-G5- 390W	8 pieces
Polycrystalline	Eagle JKM 340PP-72-DV	10 pieces
HIT	240WP 37V HIT VBHN240SJ25	13 pieces

Equations 1, 2, 3, 4, and 5 were used to calculate the reference yield Y_R, final yield Y_F, performance ratio P_R, capacity factor C_F, and energy loss L in this work. The reference yield Y_R is expressed as the average of the ratio of total incident irradiation in panel H_t (kWh/m^2) to reference irradiation (G_o = 1 kW/m^2). The performance and losses parameters were theoretically compared with simulation. The simulations used both measured and Meteonorm-derived climate datasets.

$$Y_R = \frac{H_t}{G_0} \quad (1)$$

$$Y_F = \frac{E_{AC}}{P_{max}G,STC} \quad (2)$$

$$P_R = \frac{Y_R}{Y_F} \quad (3)$$

$$C_f = \frac{E_{AC}}{P_o \; X \; 24h \; X \; 365hr} \quad (4)$$

$$L = L_c + L_s = Y_R - Y_F \quad (5)$$

Where;
EAC is the amount of energy produced by a solar PV system in AC (kWh)
Pmax G,STC is the PV array rated power at Standard Test Condition (kW)
Po is the rated power output of the installed PV array (kW)

The balances and main effects section of the performance analysis looks at factors such global irradiance on the horizontal plane, ambient temperature, global irradiance on the collector plane without any optical corrections, and efficient global irradiance after soiling and shading losses. Aside from these variables, the DC energy produced by the PV module array, the energy injected into the grid after accounting for electrical component losses, the photovoltaic array, and the device efficiency were computed. The computed values of each variable listed in the balances and key results were derived in terms of monthly and yearly values. Annual values as averages can be used to calculate temperature, performance, irradiance, and energy.

3. Results and Discussion

Result of comparison for three type PV panel have been success performed under PVsyst for 3.12kW roof top residential PV system at Selangor, Malaysia with consider 4 hours of peak sun hours. Figure 2 shows the balances and main results of one year's simulation for HIT PV panel only. Comparison shows that poly crystalline produce the highest energy inject to grid with 4046.9kWh compare to mono 3737.2 kWh, HIT 3810.3kWh respectively. Even though Poly crystalline produce high energy to grid but the performance ratio of yearly shows the HIT panel is greater with 81% compare to polycrystalline 79% and monocrystalline 79.5% respectively as shown in Table 2.

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	129.5	72.82	27.15	123.2	118.1	321.8	311.1	0.810
February	131.4	74.87	27.63	124.6	119.7	325.8	315.7	0.812
March	150.2	93.65	27.97	142.0	136.6	372.3	361.0	0.815
April	140.2	77.50	27.47	131.7	126.6	344.1	332.9	0.810
May	142.3	77.52	28.48	133.7	128.3	348.3	336.7	0.807
June	131.0	71.18	27.71	122.9	117.9	321.6	310.6	0.810
July	133.3	80.01	27.73	125.1	119.9	327.8	316.8	0.812
August	133.8	83.30	27.68	125.7	120.6	329.3	318.3	0.812
September	131.2	76.84	27.10	123.6	118.7	323.8	312.9	0.811
October	135.6	82.62	27.38	128.1	123.1	335.6	324.2	0.811
November	120.1	65.41	26.59	113.6	109.0	297.0	286.4	0.808
December	118.9	70.79	27.08	112.6	107.9	294.2	283.7	0.807
Year	1597.3	926.52	27.50	1506.8	1446.5	3941.4	3810.3	0.810

Legends

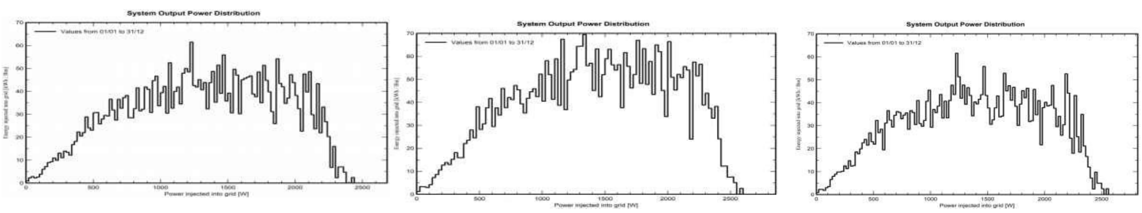
GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse irradiation
T_Amb	Ambient Temperature
GlobInc	Global incident in coll. plane
GlobEff	Effective Global, corr. for IAM and shadings
EArray	Effective energy at the output of the array
E_Grid	Energy injected into grid
PR	Performance Ratio

Figure 2. Balances and main results of HIT Photovoltaic module system

Table 2. Performance Ratio Percentage

PV Type	Performance Ratio (PR) %
Monocrystalline	79.5
Polycrystalline	79
HIT	81

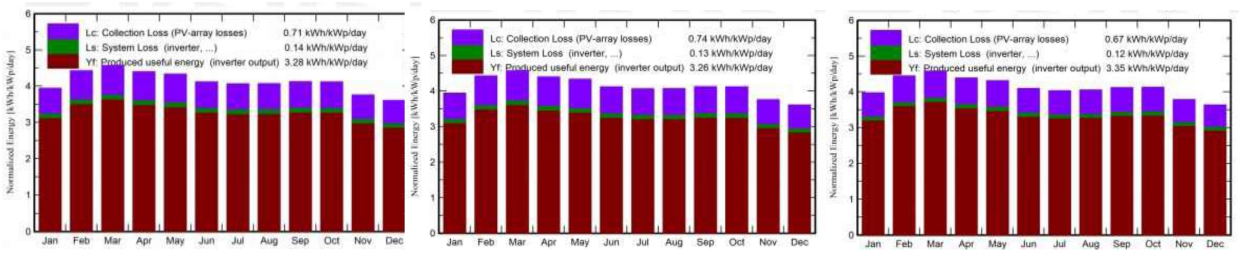
Figure 3 show the power distribution for monocrystalline, polycrystalline and HIT panel from January to December. The power injects to grid versus energy inject to grid clearly shows that the panel PV polycrystalline (b) provide more than other types even though all type panel get the same irradiance.



(a) (b) (c)

Figure 3. System Output Power Distribution diagram for (a)Mono crystalline, (b) Poly crystalline (c) HIT

The normalised monthly production of the installed capacity of the three types of PV panels is shown in Figure 4. The loss of energy at solar panels accounts for a significant portion of output losses. In addition that, seen the daily amount of energy sent to the grid was higher in (c) HIT with 3.35 kWh than in (a) monocrystalline 3.28kWh and (b)polycrystalline 3.26 kWh per day. While Table 3 indicate the individual data collection loss, device loss and energy generate based on normalized production support the type HIT module is provide high energy generated kWh/day.



(a) (b) (c)

Figure 4. Normalized productions per installed kWp for (a) Mono crystalline (b)Poly crystalline, (c) HIT

Table 3. Normalized productions per installed kWh/kWp/day

PV Type	Collection losses (Lc) kWh/kWp/day	Device loss (Ls) kWh/kWp/day	Energy Generated (Yf) kWh/kWp/day
Monocrystalline	0.71	0.14	3.28
Polycrystalline	0.74	0.13	3.26
HIT	0.67	0.12	3.35

Table 4 shows the summary for photovoltaic module photovoltaic system including of monocrystalline, polycrystalline and HIT type. Then an arrow loss diagram representing the various losses in the HIT Photovoltaic module system is illustrated in Figure 5. The global irradiance is 1597 kWh/m^2 on a horizontal axis with 1446 kWh/m^2 to 1453 kWh/m^2 the effective irradiation on collectors where monocrystalline indicate the highest. While the efficiency at standard test conditions also shows monocrystalline highest with 19.36% but PV losses due to temperature shows HIT type is lowest than others type with s a 7.76 percent energy loss as a result of the irradiance stage. The effective irradiance falls on a surface produce electricity or electrical energy, based on that it was conclude that HIT module type is selected for this system.

Table 4. Losses summary for Photovoltaic module photovoltaic system

PV Type	Effective irradiance On Collector kWh/m^2	Efficiency At STC %	PV Losses due Temperature %
Monocrystalline	1453	19.36	9.44
Polycrystalline	1446	17.63	10.34
HIT	1446	19.27	7.76

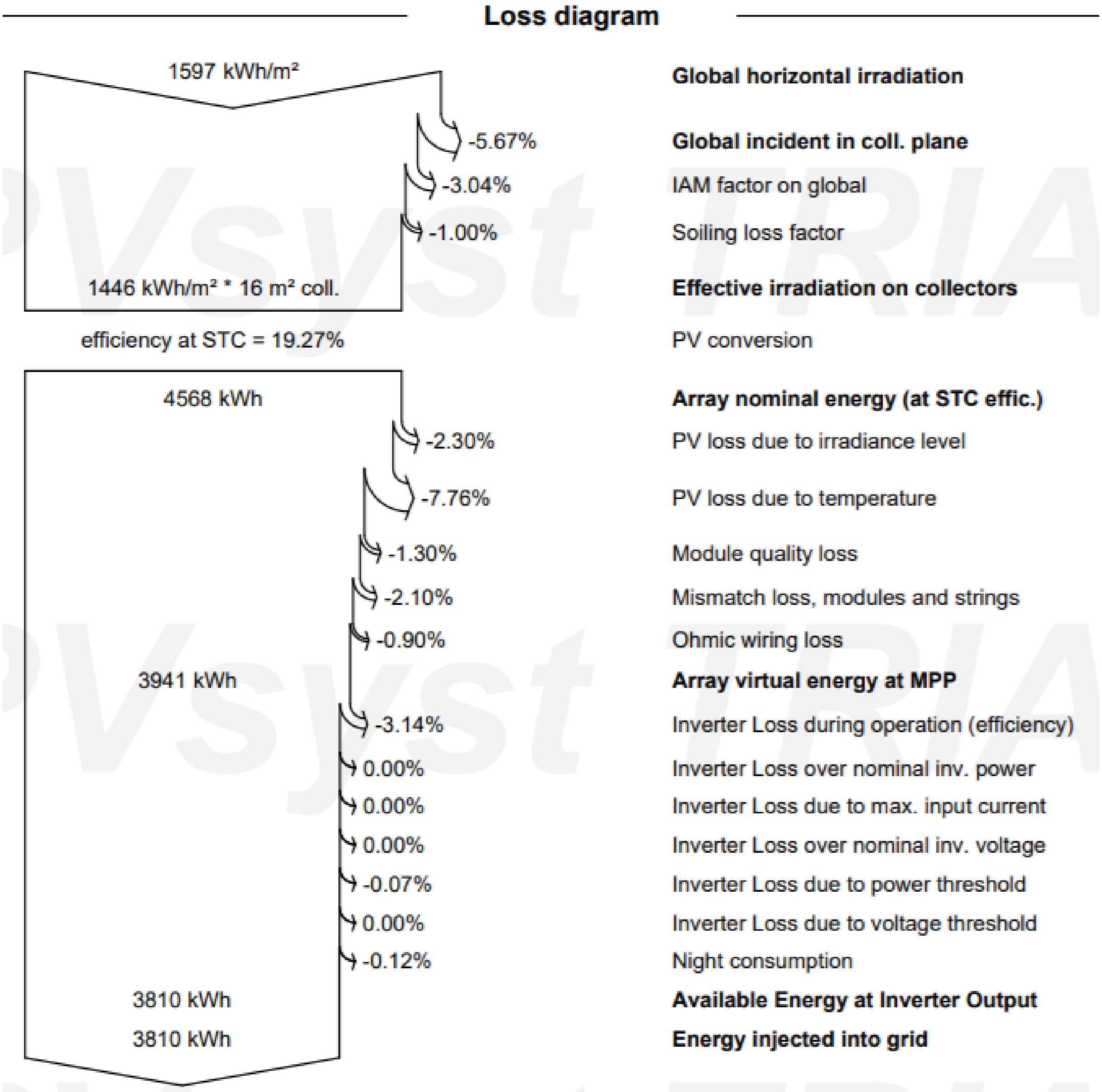


Figure 5. Arrow loss diagram for HIT Photovoltaic module photovoltaic system

4. Conclusion

This paper presents the performance analysis of different type PV module for residential rooftop solar PS system. The objective of looking at performance ratio system, a yearly balanced, effective output energy, daily output generation, system output generation, and yearly system losses has been successfully archived for three type PV module. The comparison of monocrystalline, polycrystalline, and HIT photovoltaic panels in a residential rooftop PV system yields a clear and substantial conclusion. As a result, it was discovered that the HIT photovoltaic type application in the PVSyst rooftop system provides high output generation with little losses. The discovery is important for future PV panel selection on site, as it ensures that the rooftop PV system installation will deliver a good return on investment for both the user and the installer.

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