ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 4, pp: (1-13), Month: October - December 2018, Available at: www.paperpublications.org

INVESTIGATION STUDY OF EFFECTIVENESS SOLAR RENEWABLE ENERGY INSTALLATION AT ON SITE INSTALLATION

Zeckrey Jikurun[1], Ahmad Mukifza Harun[2], Shahril Yusof[3]

[123]Faculty of Engineering

Abstract: **This paper presents the installation study of solar renewable energy at UMS peak. The single line diagram for the renewable energy study will be design and explain thoroughly in this paper, the design will be based on off grid system photovoltaic. The expected solar power generation will be calculated and the efficiency of the system will be discussed. The efficiency of energy storage capacity also will be discussed in this paper.**

Keywords: **Renewable Energy; Electric; Solar; MPPT; Off-grid.**

I. INTRODUCTION

Renewable energy becomes very important alternative source for generating electricity and more important it provides us the greenest way to generate electricity. Renewable energy come in different resource such as solar power [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11], hydro [11] [12], thermal [11], wind [3] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] and Biomass [11] that could be utilized to generate electricity. Malaysia geographic location which located near the Equator line enables people located at this location to receive abundant and constant solar irradiance throughout the year which is about 4-5 peak sun hour average of 1,000Wm^{-2}/hr [21] [22]. Hence photovoltaic system is the most suitable system to be proposed at this project location which is located at University Malaysia Sabah reported to produce annual power generation 287,241.58 (MWh) of solar photovoltaic in the year of 2017 [21] [22]. To harvest solar irradiance and turn it into electricity we must have a PV array and Balance of System “BOS” which is depend on the type of installation to make a complete working system to function [21] [22] [23]. In this paper, a standalone photovoltaic system will be installed at UMS peak to test the efficiency of the solar renewable energy installation at the site.

II. BACKGROUND THEORY

Solar energy can be used in two ways to generate usable electricity. The first way is to use electronic device called Photovoltaic [4] [8] [22] [24] [25] [26] [27] [28] [29] [30] and the second way is to use a thermal concentrator [24] to collect thermal energy from the sun ray. In this paper, generating usable electricity using photovoltaic device will be discuss and elaborate more because of the effectiveness and the easiness of installation of the solar technology.

A. *Photovoltaic effect*

Photovoltaic effect is a physical phenomenon that can convert solar radiation into electricity [4] [8] [22] [25] [31]. The words ‘photovoltaic’ itself is made from two term photo which mean ‘light’ and ‘voltaic’ which mean voltage [24]. The phenomenon occurs is explained as the valance electron of an atom receive enough energy, the electron will jump into conduction band. Photon in the sun ray contain energy that enough to bring electron into the conduction band. Electron in the conduction band is free to move. This electron will flow through a complete circuit and create a current.

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 4, pp: (1-13), Month: October - December 2018, Available at: www.paperpublications.org

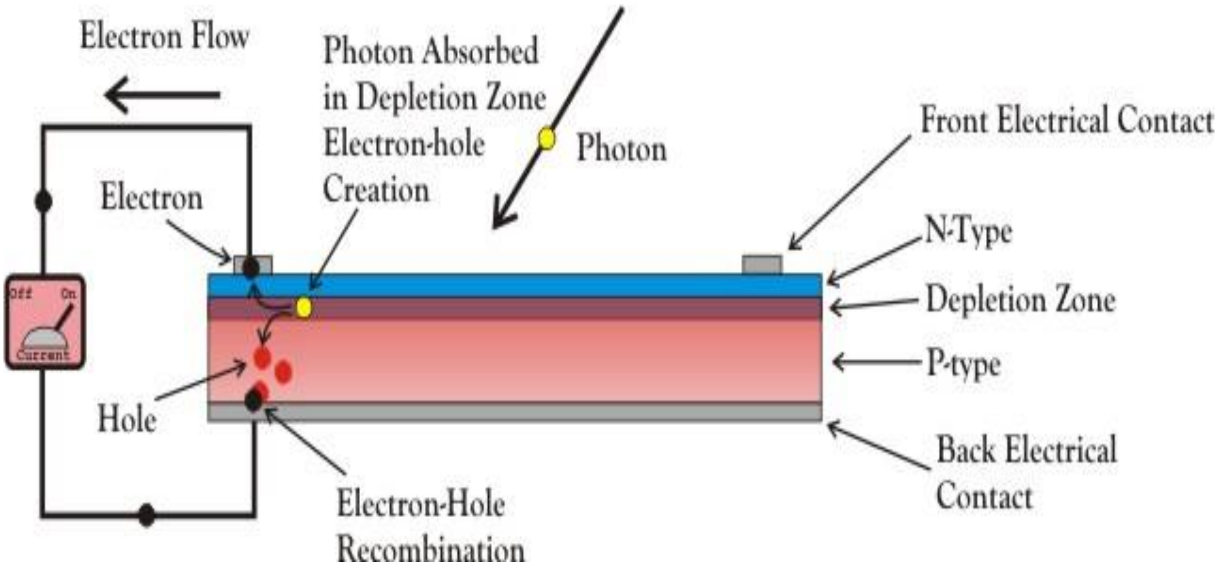

Figure 1: How solar panel generate electric

As show in **Error! Reference source not found.**, for the n-layer the pure substance will be dope with a substance that has an extra electron. Taken example of a silicon atom, the outer valance electron contain 4 electrons, hence doping with phosphorus will result 1 free electron charge. Different with p-layer, the substance will be doping with less electron than the main substance to create hole. The n and p layer then will be put together and then another p-n region will be form between the two layers as a result of the electron and hole moving to opposite layer and leaving negative and positive charge behind, this charge will form an electric field.

B. ***Solar irradiation data from Meteorology Sabah Department (Airport station) year 2016***

These is the solar irradiation data of year 2016 at Kota Kinabalu Airport Meteorology Station that we get from Meteorology Sabah to further support that the proposed site is suitable with solar panel installation to generate electricity.

Daily values of Solar Irradiation in MJm-2

Table 1: Station Metorologi Kota Kinabalu (Air Port) year 2016

D/M	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	24.65	24.76	25.38	25.05	25.41	19.82	23.14	12.18	17.90	19.01	14.03	20.74
2	24.39	23.05	25.13	24.19	24.73	16.02	18.77	10.05	21.38	21.44	12.07	18.81
3	16.41	25.50	DEF	24.89	13.11	17.92	21.62	16.74	26.21	24.57	19.33	19.63
4	20.66	23.70	26.71	23.60	DEF	14.43	23.86	25.78	18.08	DEF	17.19	17.72
5	21.97	24.31	24.11	23.74	DEF	20.80	20.62	15.14	20.50	18.65	10.69	20.20
6	21.70	24.61	22.94	25.96	23.55	18.99	23.85	16.83	19.30	20.28	14.12	23.54
7	22.55	12.36	25.81	25.23	25.96	24.35	22.97	20.39	21.17	14.43	24.16	16.41
8	22.04	26.39	25.62	24.94	25.04	18.06	21.37	25.92	18.79	23.82	24.07	17.77
9	22.46	20.83	25.32	19.33	26.25	24.43	17.29	22.74	5.99	19.94	25.04	23.82
10	24.01	25.77	26.84	23.67	25.22	20.49	22.72	22.78	10.15	18.11	DEF	22.03
11	19.71	25.58	20.24	24.85	25.90	22.60	20.00	22.18	22.87	17.56	DEF	18.50
12	20.94	22.37	26.04	13.33	16.12	20.26	25.29	20.88	18.40	23.55	19.42	21.88
13	23.93	23.69	24.88	21.04	25.28	18.33	25.60	25.29	11.60	21.20	25.55	20.59
14	23.87	25.45	DEF	23.94	26.81	25.34	20.41	26.15	20.64	21.18	DEF	21.86
15	24.07	22.18	DEF	23.28	23.03	23.93	19.76	24.53	19.45	19.29	20.76	15.91

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 4, pp: (1-13), Month: October - December 2018, Available at: www.paperpublications.org

16	23.20	25.89	24.85	24.54	18.69	22.28	24.05	20.98	19.25	17.37	16.05	22.31
17	19.31	23.67	26.42	27.33	12.16	19.69	17.89	DEF	19.88	20.73	24.13	22.83
18	21.77	23.02	22.47	27.69	25.59	17.87	22.02	25.49	25.59	21.02	21.90	21.33
19	24.42	26.59	22.15	26.18	DEF'	14.02	24.43	24.68	18.74	25.02	19.17	16.73
20	15.33	26.63	23.50	27.21	25.67	DEF	22.59	23.08	21.78	14.65	21.49	19.48
21	23.94	25.43	25.76	26.48	25.70	12.97	19.41	18.27	21.01	16.99	21.41	19.60
22	25.30	26.89	24.18	24.32	18.36	12.58	16.03	9.55	16.50	15.57	21.43	23.53
23	23.95	25.10	24.76	21.75	15.23	16.47	20.26	25.14	15.01	22.83	21.53	19.61
24	21.38	26.94	23.94	25.70	22.30	23.13	18.03	25.42	21.14	14.63	15.76	19.50
25	24.78	26.71	20.82	26.47	12.67	16.00	19.51	19.65	21.28	22.97	21.99	12.36
26	24.65	26.64	24.02	22.86	19.71	24.86	17.48	21.88	22.11	15.58	19.14	21.31
27	25.45	27.11	27.43	21.69	21.96	13.24	16.97	24.00	23.54	16.65	23.67	15.45
28	25.28	21.83	26.33	22.64	20.14	19.17	15.12	23.16	15.59	20.01	23.09	13.65
29	22.06	25.72	26.31	14.29	24.85	21.52	23.11	19.92	18.66	17.66	19.34	15.86
30	18.32		26.19	24.76	19.83	20.45	5.55	18.57	22.13	23.30	17.52	22.67
31	25.63		24.96		13.17		18.17	25.04		11.75		15.29
M	22.52	24.44	24.75	23.70	21.52	19.31	20.25	21.08	19.15	19.33	19.78	19.29

Given the conversion of unit from 1 Kwh/m^2 = 3.6 MJ/m^2 [22] [23].

Hence from the data we gain that;

Table 1.2: Conversion monthly data from Kwh/m2 to MJ/m

Month	**Average mean/ day MJ/m^2**	**Average mean/ day KWh/m^2**
January	22.52	6.26
February	24.44	6.79
March	24.75	6.88
April	23.70	6.58
May	21.52	5.98
June	19.31	5.36
July	20.25	5.63
August	21.08	5.86
September	19.15	5.32
October	19.33	5.37
November	19.78	5.49
December	19.38	5.38
Average Day	21.27	5.91

From the data above we can further analysis to get Peak Sun Hour, PSH which is the number of hour that the solar irradiance (G) of 1,000 w/m^2 give the equivalent amount of solar irradiation (H) for the day;

According to [22];

$$PSH = \frac{H}{G}$$

Where,

H= Solar irradiation Wh/m^2

G= Solar irradiance 1000 W/m^2

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 4, pp: (1-13), Month: October - December 2018, Available at: www.paperpublications.org

Hence,

$$PSH = \frac{5{,}910}{1{,}000} = 5.9$$

From the analysis data above, we can conclude that at Kota Kinabalu area, average 5.9 Peak sun hours will be available at the site. This data show that, there are adequate of resource to generate electricity using solar panel.

III. METHOD

A. Site Investigation Equipment

Figure 2: Seaward solar irradiation meter

Site investigation has been done using seaward meter, the solar irradiation at site is 876w/m^2 and we even get a record of the highest instantaneous irradiant about 1000 w/m^2 which we cannot capture in this picture.

Figure 3: Solar path finder

Solar path finder is a tool to analysis shading to the solar panel at the site [21] [22] [23] [32].

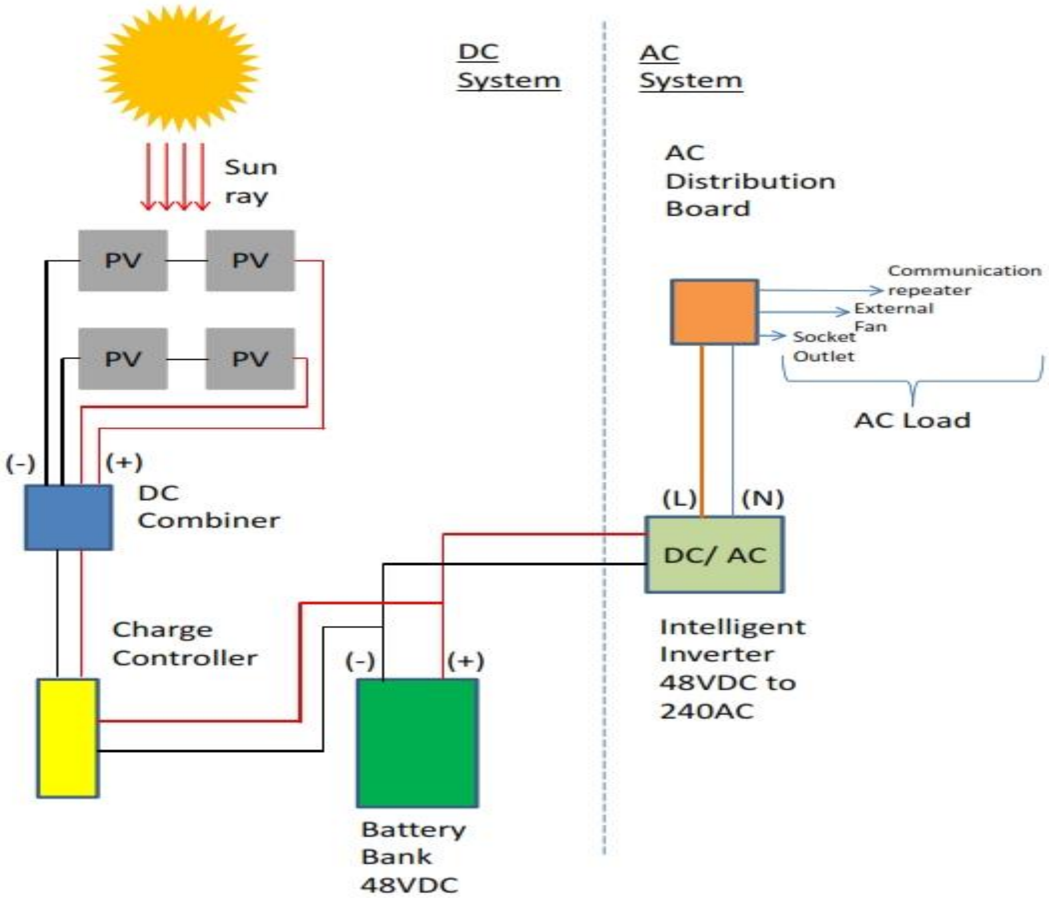

Figure 4: 48Vdc solar system circuit.

Above diagram is our proposed circuit arrangement for 48Vdc system solar renewable energy generation that will be used in this study which contain four modules photovoltaic which in 2 string x 2 module connection arrangement, dc combiner, charge controller and four 12Vdc batteries connected in series forming 48vdc voltage system. Site investigation has been done earlier to determine site condition, lightning hazard protection level and the availability of renewable resource for electrical generation. SEDA is the authority appointed by Malaysia government to supervise and conduct safe installation of renewable energy installed within Malaysia. Hence in this study, standard for solar installation by SEDA will be used to make sure the solar installation is according to the law and standard as specify in Malaysia also for complying safety standard for electrical power generation. On the Alternate current system, electrical building standard from Suruhanjaya Tenaga will be used as a standard of design and method of installation. For solar irradiance investigation, special equipment such as seaward solar is needed to determine the solar irradiance at the targeted solar noon (12.00-1.00pm) will be collected at least for 1 sunny day. Other than that solar irradiance data for 1 year from nearest meteorology station will be collect and study before installation of the solar system. After installation, the generated power solar will be recorded manually at least 1 times a week. The collected data will be compare with the investigate data to determine the performance of the installed system.

Since the Peak Sun Hour we calculated earlier is 5.9hr, our off grid solar generation system will need to withstand the energy consumption for another 18.1hr. Hence we going to make our energy calculation in to two parts for designing the PV generation system;

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 4, pp: (1-13), Month: October - December 2018, Available at: www.paperpublications.org

Calculation

The 18.1hr consumption for connected load is calculated using formula as follow;

Energy required,

$$CL\ x\ hr = KWh$$

Where,

CL= Connected Load

hr= Hour

Maximum Demand,

$$KWh\ x\ k_s = MD$$

KWh= Connected Load

Ks= Simultaneity factor

Table 2: 18.1 hr connected load consumption

Appliance	Power Load (w)	quantity	Connected load, CL (kW)	Usage (Hrs/ day)	Energy E_1 Required, Erq (kWh/ day) CL x usage (hr)= kwh	Simultaneity factor (ks)	Maximum Demand (kW) Kwh x ks = MD
Communication Repeater	60	1	0.060	18.1	1.086	1	0.06
External Fan	50	1	0.050	18.1	0.905	1	0.05
Total					1.991		0.11

Table 3: 5.9 hr connected load consumption

The 5.9 hr consumption for connected load during peak sun hour is calculated as follow;

Appliance	Power Load (w)	quantity	Connected load, CL (kW)	Usage (Hrs/ day)	Energy E_2 Required, Erq (kWh/ day) CL x usage (hr)= kwh	Simultaneity factor (ks)	Maximum Demand (kW) Kwh x ks = MD
Communication Repeater	60	1	0.060	5.9	0.354	1	0.06
External Fan	50	1	0.050	5.9	0.295	1	0.05
Total					0.649		0.11

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 4, pp: (1-13), Month: October - December 2018, Available at: www.paperpublications.org

B. Sizing PV

To replenish the total usage $\overline{E_1}$ used in 18.1hr with the time limit of PSH 5.9hr;

$$KW_{p1} = \frac{E_1}{PSH}$$

$$KW_{p1} = \frac{1.991}{5.9} = 0.337\ KW_p$$

PV Size $KW_p = KW_{p1} + MD$

$$KW_p = 0.337\ KW_p + 0.11\ KW_p = 0.447KW_p$$

In this study, we will use $330W_p$ solar panel, hence atleast 2 nos of solar panel should be installed on this system to cope the energy replenishment for the given PSH.

Hence using 330w panel we would get;

$$No_{pv\ panel} = \frac{KW_p}{KW_{p\_pv}} = \frac{447W}{330W} = 1.35\ \approx 2\ nos\ pv\ panel$$

However at site we install 4 nos of PV panel which is greatly reduce our charging recovery time to;

$$t_{Charging\ recovery} = \frac{E_1 + E_2}{No_{pv\_panel}\ x\ KW_{p\_pv}}$$

$$t_{Charging\ recovery} = \frac{1{,}991Wh + 649Wh}{4\ x\ 330W} = 2hr$$

This is also as a preparation for future expansion load which we can add into the system about;

$$E_{generated} = PSH\ x\ No_{pv\_panel}\ xKW_{p\_pv}$$

$$E_{generated} = 5.9\ x\ 4\ x\ 330W = 7.79KWh$$

$$E_{extra} = E_{generated} - (E_1 + E_2)$$

$$E_{extra} = 7.79KWh - (1.991KWH + 0.649KWH) = 5.15KWH$$

The pv panel module brand that will be used in this study is, Hareon 330W, checking on the array parameter of the design circuit of PV module is;

Voc = 46.15 V x 2 = 92.3 V

Vmp = 37.21 V x 2 = 74.42 V

Isc = 9.43 A x 2 =18.86 A

C. Battery Sizing

Battery sizing is calculated as follow

$$C_{Ah\_req} = \frac{E_{req}}{V_{sys}}\ x\ \frac{K_{storage}}{DOD} xT_{out}$$

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 4, pp: (1-13), Month: October - December 2018, Available at: www.paperpublications.org

Where,

C_{Ah_req} = charge storage capacity required (Ah).

E_{req} = daily energy requirement (wh).

V_{sys} = Voltage system. (48V)

$K_{storage}$ = Correction factor of storage unit. (0.85)

DOD = Depth of discharge battery. (70%)

T_{out} = Number of backup day. (3 hari)

$$C_{Ah\_req} = \frac{2640}{48}\ x\ \frac{0.85}{0.7} x\ 3$$

Number of battery in series

Declare

$$N_{s\_bat} = \frac{V_{sys}}{V_{nom\_bat}} = \frac{48V}{12V} = 4$$

Hence, the most suitable battery configuration is 4 nos of 12V (200Ah) connected in series because the number of nos is the sum of total 4 x12v=48V. The proposed model of battery used in this study is Oliter 6-GFMH-200 Gel free maintenance battery. Referring to the battery data sheet, the manufacturer guarantee at 70% DOD the battery have at least 800 of cycle service life at 35 ^{o}C temperature [33]. Generally the calculation of the maximum charging current for battery is based on C10 charging rate:

$$I_{a\_bc\_max} = \frac{C_{10}}{10}$$

Which,

C_{10}= battery capacity at 10hr.

$I_{a\_bc\_max}$= maximum charging current.

However, referring to the data given by manufacturer, they product have a maximum charging current as show in the max charge current section at Technology data table below;

Table 4: Oliter battery data sheet

Rated Voltage	Capacity (10hr, 1.80V/Cell)	Weight	Max Discharge Current	Max Charge Current	Self-Discharge (25 ^{o}C)	Recommended Using Temperature	Cover Material
12V	200Ah	58Kg	$30I_{10}$A (3 min)	≤0.25C10	<3%/ Month	15^{o}C - +75 ^{o}C	ABS

Table 5: Oliter battery data sheet

Using Temp	Charge Voltage	Charge Mode	Cycle life	Capacity Affected by Temp
Discharge: -45^{o}C~50 ^{o}C Charge: -20 ^{o}C~45 ^{o}C Storage: -30 ^{o}C~40 ^{o}C	Float Charge: 13.5V-13.8V Average Charge: 14.1V-14.4V	Float Charge: 13.65±0.15V/Cell Temp compensation Coefficient: ± mV/Cell ^{o}CCycle Charge: 14.7±0.3V/Cell Temperature Compesation Coefficient: ±5mV/Cell ^{o}C	100% DOD 493 times 50% DOD 1385 times 30% DOD 2048 times	105%@ 40 ^{o}C 85%@0 ^{o}C 60%@-20 ^{o}C

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 4, pp: (1-13), Month: October - December 2018, Available at: www.paperpublications.org

Referring to the max charge current by the manufacturer data sheet, charging current must be lower and equivalent to 0.25C10 these mean the calculation of limiting max charge current is as follow;

$$I_{a\_bc\_max} = 0.25\, x \frac{C_{10}}{10} = 0.25\, x\, 200 = 50A$$

D. Charge Controller

Pv module selection is depend on the charge controller characteristic, since our installation is include with wind generation, we only have a few selection for the model and maker that available for wind and solar hybrid generation that fit in our budget.

The characteristic model of charge controller that we choose is;

Table 6: Hefei hybrid wind solar charge controller

MAX-T4-WS-10-NNHN-1	
Battery Parameters	
Applied battery voltage	48V
Battery protection method	Reverse connection protection (do not burn any components, with voice prompt): over voltage protection (for street light and such kind of load)
Voltage at the over voltage protection point	58.0V ±0.3V
Voltage at the over voltage recovery point	55.0V ±0.3V
Voltage at the under voltage protection point	42.0V ±0.3V
Voltage at the under voltage recovery point	46.0V ±0.3V
Battery temperature compesation	5mV/^{o}C/2V (setteable) (Optional component)
Wind Turbine input parameters	
Rated power of applied wind turbines	1000W/ 48V
Rated power of the terminal	25A dc (after rectification)
Max. input current of the therminal	30A dc (after rectification)
The default current of the wind turbines generation with limited current	25A (settable)
Wind turbine protection method	Over rev protection, over current protection, induction lightening protection
Unloading method	Outer unloading device
MPPT function	Boost MPPT model (automatic tracking or 5 segments curve tracking)
Input current of MPPT channel	12A
PV input parameter	
Rated input current of applied PV	1000V/ 48V (standard) 2000W/48V (optional)
Rated input current of terminal	15A (standard) 30A(optional)
Charging voltage drop	<0.2V
PV protection method	Reverse connection protection (voice prompt)
Unloading method	Open circuit unloading
Other	
Auxiliary function	Monitor of the air temperature inside controller, temperature of unloading parts and wind turbines MPPT components, and also the monitor of control terminal installed on the inversion (Voice prompt)
Display mode	Liquid crystal (LCD) display
Communication mode	RS232 (5V electrical level) (standard) RS485/short range wireless (optional)

Display parameters	Wind turbine input voltages/ current /power generated energy/ rev/ unloading current/ PV input voltage/ current/ power/ generated energy/ Battery voltage/ charging current/ power/ total charging capacity/ battery status information.
Power comsumption in standby mode (screen backlight closed)	About 20ma/ 24V system
Operating mode	3M foil key operation (4 keys)
Working temperature / humidity range (environtment)	-40~+80^{o}C/20~85%RH (non-condensing)
Protection grade	IP41
Controller size (L*W*H)	235mm*148mm*84mm
Net weight	2.5KG

After doing research on multiple products, we make a decision to buy this product since the charge controller is hybrid, and have multiple system voltage modes to choose for the study.

IV. RESULT AND DISCUSSION

A. Result

Table 7: Generated energy data

				Cumulated Energy Reading (kWh)			Instantaneous			Temperature (T ˚C)
Date	Time	Weather	Day (d)	Last Reading	New Reading	Energy Accumulated from Last Reading	P (W)	I (A)	V (V)	
28.10.17	9.00am-11.00am	Sunny	0	No record	36.4	36.4	83	1	83.8	Not recorded
29.10.17	5.00pm-6.00pm	Sunny	1	36.4	36.8	0.4	79	1.5	52.8	Not recorded
04.11.17	2.00pm-4.00pm	Sunny	6	36.8	43.8	7	90	1.1	82.3	49
10.11.17	3.00pm-4.00pm	Cloudy	12	43.8	46.9	3.1	73	1.3	81.8	36
14.11.17	2.00pm-3.00pm	Cloudy	16	46.9	49.4	2.5	83	1.1	83.1	41
21.11.17	10.00am-11.00am	Cloudy	23	49.4	51.9	2.5	100	1.3	83.9	36
23.11.17	4.00pm-4.30pm	Sunny	25	51.9	53.9	2	81	1	81.3	41
27.11.17	11.00am-12.30pm	Cloudy	29	53.9	55.8	1.9	82	1.1	82.8	35
3.12.17	4.00pm-5.00pm	Rainy	35	55.8	58.3	2.5	78	1.5	52.6	31
16.12.17	10.00am-10.30am	Cloudy	48	58.3	63.4	5.1	101	1.1	83.9	35

Total generated for 48 day = 27kwh

The latest Energy generated data is taken which is almost 10 month the total generated power for solar to charge the battery and for the system consume is (154.5kwh).

Which convert into our rate of electricity in malaysia which is assume at a flat rate 0.33 sen /kwh unit use is; 0.33 x 154.5 kwh = Rm 51

B. Discussion

Comparing to the installed capacity of pv which is 1.32kwp (4 nos 330w panel), the system is estimated to generate at normal operating cell temperature;

Specific yield Kwh = 0.8 x 15.33% x (1.936m^2 x4 nos)x 5.82 kwh/m^2= 5.53 Kwh

The energy generated for 10 month considering the site have the same irradiation from the Malaysia Meteorology data;

10 month x 30 days x 5.53 Kwh = 1,659 kwh

Average energy generated from the PV that are recorded during this period is;

27kwh/48 day = 0.56kwh.

The different in energy generated and recorded because of the charge controller can only charge the battery as much as the used energy to fill to avoid over charging and damaging the battery. At some point we realise that our inverter is keep tripping because of overheating, we found out that the inverter fan is not working. This has caused us to get inaccurate data for pv generation, since the battery energy is not used. Our solution is to put external fan plus new inverter to avoid this kind of problem is repeated. Since the repair work has been done (1 feb 2018), the energy capture before modification is 95kwh. The inverter has been run 24hr for 2 month without trip, and the generated energy captured from pv is increase.

The latest data taken is at 18 march 2018 is 154.5kwh.

Which is;

Total generation since the repairmen and modification is done = 154.5kwh-95kwh=59.5 kwh

Average generation since the modification is made is = 59.5 kwh/ 46 day = 1.29 kwh/ day

The increase in percent is = 0.56kwh/1.29kwh x 100% = 43.4% increase of total pv generation.

The efficiency of solar installation at ums peak is given by;

Eff=(average kwh generation/day)/ (estimated kwh generation/ day) x 100

= (1.29kwh/day /5.53 kwh/day) x 100 = 23.33%

This low efficiency is as the result of the energy generated and stored is not fully utilise. Hence in future more load will be add in to fully utilise the energy generated by the system.

V. CONCLUSION

Investigation study of effectiveness solar renewable energy installation at ums peak was carried successfully by using the proposed single line diagram based on off grid system. In this paper we found out that the sites have an adequate resource of solar energy to support our renewable energy system based on Malaysia meteorology data (kota kinabalu airport station).

REFERENCES

[1] Kasai, H., T. Sato, and H. Matsumura. *Impurity photovoltaic effect in crystalline silicon solar cells*. in *Photovoltaic Specialists Conference, 1997., Conference Record of the Twenty-Sixth IEEE*. 1997.

[2] Jäger-Waldau, A., *Photovoltaics photovoltaic (PV) , Status of*, in *Solar Energy*, C. Richter, D. Lincot, and C.A. Gueymard, Editors. 2013, Springer New York: New York, NY. p. 174-211.

[3] Al Busaidi, A.S., et al., *A review of optimum sizing of hybrid PV–Wind renewable energy systems in oman.* Renewable and Sustainable Energy Reviews, 2016. **53**: p. 185-193.

[4] Askari, M., V. Mirzaei Mahmoud Abadi, and M. Mirhabibi, *Types of Solar Cells and Application*. Vol. 3. 2015. 2015.

[5] Bostan, I., et al., *Solar Energy*, in *Resilient Energy Systems: Renewables: Wind, Solar, Hydro*. 2013, Springer Netherlands: Dordrecht. p. 47-164.

[6] Chua, S.C. and T.H. Oh, *Solar energy outlook in Malaysia.* Renewable and Sustainable Energy Reviews, 2012. **16**(1): p. 564-574.

[7] Fayaz, H., et al. *Solar energy policy: Malaysia vs developed countries*. in *Clean Energy and Technology (CET), 2011 IEEE First Conference on*. 2011.

[8] Compaan, A.D., *Photovoltaics: Clean power for the 21st century.* Solar Energy Materials and Solar Cells, 2006. **90**(15): p. 2170-2180.

[9] Guney, M.S., *Solar power and application methods.* Renewable and Sustainable Energy Reviews, 2016. **57**: p. 776-785.

[10] Zghal, W., G. Kantchev, and H. Kchaou. *Determination of the exploitable solar energy for electricity generation using the photovoltaic systems*. in *2012 First International Conference on Renewable Energies and Vehicular Technology*. 2012.

[11] Muhammad-Sukki, F., et al., *Solar photovoltaic in Malaysia: The way forward.* Renewable and Sustainable Energy Reviews, 2012. **16**(7): p. 5232-5244.

[12] Bekele, G. and G. Tadesse, *Feasibility study of small Hydro/PV/Wind hybrid system for off-grid rural electrification in Ethiopia.* Applied Energy, 2012. **97**: p. 5-15.

[13] Acosta, J.L., et al., *Performance Assessment of Micro and Small-Scale Wind Turbines in Urban Areas.* IEEE Systems Journal, 2012. **6**(1): p. 152-163.

[14] Akorede, M.F., et al., *Appraising the viability of wind energy conversion system in the Peninsular Malaysia.* Energy Conversion and Management, 2013. **76**: p. 801-810.

[15] Albani, A., M.Z. Ibrahim, and M.H.M. Hamzah, *Assessment of wind energy potential based on METAR data in Malaysia.* International Journal of Renewable Energy Research, 2013. **3**(4): p. 959-968.

[16] Ani, S.O., H. Polinder, and J.A. Ferreira, *Comparison of Energy Yield of Small Wind Turbines in Low Wind Speed Areas.* IEEE Transactions on Sustainable Energy, 2013. **4**(1): p. 42-49.

[17] Azad, A.K., et al., *Analysis of Wind Energy Conversion System Using Weibull Distribution.* Procedia Engineering, 2014. **90**(Supplement C): p. 725-732.

[18] Delgado-Bonal, A., et al., *Solar and wind exergy potentials for Mars.* Energy, 2016. **102**: p. 550-558.

[19] Gevaert, L.F.M., et al. *Evaluation of the MPPT performance in small wind turbines by estimating the tip-speed ratio*. in *Power Engineering Conference (UPEC), 2013 48th International Universities'*. 2013.

[20] Goh, H.H., et al., *Wind energy assessment considering wind speed correlation in Malaysia.* Renewable and Sustainable Energy Reviews, 2016. **54**: p. 1389-1400.

[21] Sulaiman bin shaari, a.m.b.o., shahril irwan bin sulaiman, nor zaini ikrom binti zakaria, *SEDA Grid-Connected Photovoltaic Systems Design Course*. 2016.

[22] SEDA, *OFF-GRID PHOTOVOLTAIC SYSTEMS DESIGN COURSE*. 2014, SEDA MALAYSA: MALAYSIA.

[23] SEDA. *Vision, Mission & Core Values*. 2014 [cited 2016 5 march]; Available from: http://seda.gov.my/?omaneg=00010100000001010101000100001000000000000000000000&s=2222.

[24] Ramasesha, S.K., *Challenges in the Quest for Clean Energies.* Resonance, 2013. **18**(5): p. 440-457.

[25] *PV Basics*, in *Building Integrated Photovoltaics: A Handbook*. 2009, Birkhäuser Basel: Basel. p. 13-30.

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 4, pp: (1-13), Month: October - December 2018, Available at: www.paperpublications.org

[26] BERHAD, T.N., *TNB Technical Guidebook on Grid-interconnection of Photovoltaic Power Generation System to LV and MV Networks*. 2010: TENAGA NASIONAL BERHAD.

[27] Goetzberger, A., C. Hebling, and H.-W. Schock, *Photovoltaic materials, history, status and outlook.* Materials Science and Engineering: R: Reports, 2003. **40**(1): p. 1-46.

[28] FLOOD, D.J., *SPACE PHOTOVOLTAICS – History, PROGRESS AND PROMISE.* Modern Physics Letters B, 2001. **15**(17n19): p. 561-570.

[29] Konagai, M. *National program: thin film solar cells program in Japan - achievements and challenges*. in *Photovoltaic Specialists Conference, 2002. Conference Record of the Twenty-Ninth IEEE*. 2002.

[30] El-Sayed, M.A. and O.A. Al-Naseem. *Efficient Utilization of Photovoltaic Energy for Supplying of Remote Electric Loads*. in *Universities' Power Engineering Conference (UPEC), Proceedings of 2011 46th International*. 2011.

[31] Krauter, P.D.S.C.W., *Solar Electric Power Generation-Photovoltaic Energy System*. 2006: springer. 289.

[32] Pathfinder, S., *Solar Pathfinder.* 2018.

[33] Technology, J.O.E., *Data sheet 6-GFMZ-200.* 2018.