Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 12 Issue 1, January - 2025

Sizing and performance analysis of grid-connected solar power for electronic and communication laboratories using PVSYST Software

Aniekan James Ekpo
Department of Electrical /Electronic Engineering,
University of Uyo, Akwa Ibom State, Nigeria
aniboy2016@gmail.com

***Abstract*— In this paper, the sizing and performance analysis of grid-connected solar power for electronic and communication laboratories using PVSYST Software is presented. The work is focused on presenting the steps used in PVsyst software to size the solar power system for powering a set of laboratories used for electronics and communication in the faculty of Engineering located at the main campus of University of Uyo with geo-coordinate of 5.041294, 7.974573, annual mean solar radiation of 1717.2 kW/m^2 and mean temperature which has annual mean value of 24.9 °C. The results showed that with the 12 V 200 Wp PV panel, total of 213 PV module are required for the PV array while 147 battery units are required in the system. The result shows zero loss of load probability and zero duration of loss of load duration. As such, the system is sized to avoid any power outage which resulted in excess energy yield that led to as much unused energy loss of 16427 kWh per year. Also, the PV array operated with efficiency of 7.01 % annual average and thermal loss of about 12,57 % of the total energy yield.**

***Keywords*— Grid-Connected, PVSYST Software, Solar Power, Loss of Load, Alternative Power**

1. Introduction

Over the years, the power sector in Nigeria has witnessed chronic power challenges including grossly inadequate generation and losses on the system, as well as epileptic power supply due to load shading and scheduling [1,2,3]. This has affected the university community which rely on electric energy for most of their research works. Particularly, the department of electrical and communication engineering requires energy supply for a given number of hours every working day to attend to the laboratory works as required in the curriculum. Such practical works cannot be adequate conducted without the availability of electric power in the laboratories.

In view of the energy challenges, the university community has resulted in using diesel generators as the alternative energy source [4,5,6]. Such approach, though highly welcomed has suffered enormous setback due to recent increase in the prices of fossil fuel and their associated energy system [7,8]. The central diesel generator can no longer be powered as regular as required to meet up with the demands in the school. As such, alternative energy solutions are need. Accordingly, in this work, the solar power system for the laboratory is recommended and a simulated sizing and performance analysis of the standalone solar power for the electronic and communication laboratories are presented. The simulation is conducted using the PVSyst simulation software [9,10].

2. Methodology

The work is focused on presenting the steps used in PVsyst software to size the solar power system for powering a set of laboratories used for electronics and communication in the faculty of Engineering located at the main campus of University of Uyo. The first step in the study is the determination of the site geo-coordinates using Google Map. The case study laboratory is in the faculty of engineering located in university of Uyo main campus with geo-coordinate of 5.041294, 7.974573 and shown in Google map visualization of Figure 1.

The second step is that the geo-coordinate of 5.041294, 7.974573 was used in PVSyst to acquire the daily mean global solar radiation and temperature of the site [11]. The plot of the daily mean global solar radiation on the horizontal plane for the site is shown in Figure 2 with annual mean of 1717.2 kW/m^2 while Figure 3 shows the plot for the daily mean temperature which has annual mean value of 24.9 °C.

The third step is that the optimal tilt angle for the solar panel is determined using the PVSyst. The optimal tilt for the PV panel as captured using PVSyst software is shown in Figure 4. It shows that for annually fixed tilt, the site required tilt angle of about 13° to gain transposition factor of 1.02. This means that 2 % of solar radiation is captured by the optimally tilted PV panel when compared with that of the PV on a horizontal plane.

The fourth step is the determination of the daily energy demand of the case study laboratory which is shown in the load profile in Table 1. The schematic layout of the standalone solar power in PVSyst is captured and presented in Figure 5. The system configuration for the battery bank is presented in Figure 6 while the configuration for the PV array is shown in Figure 7.

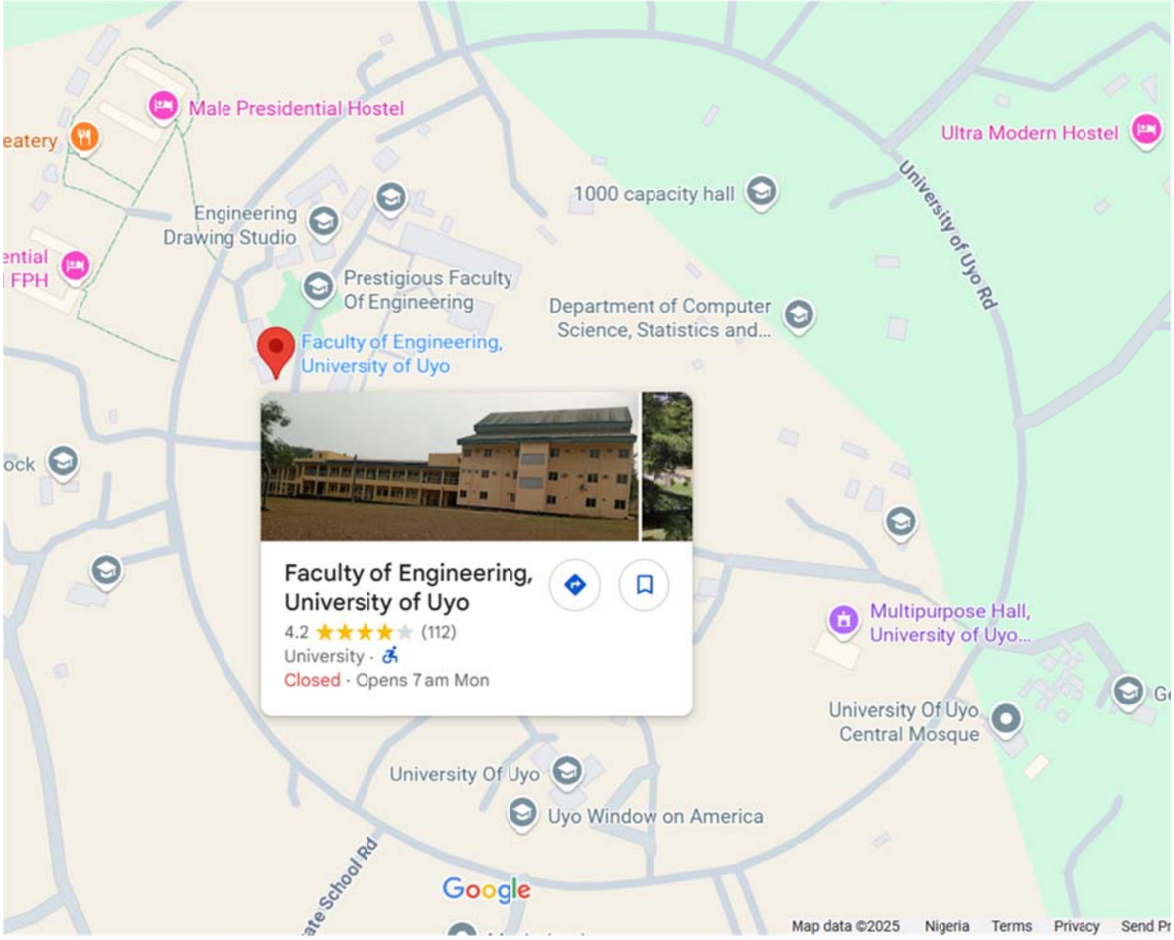

Figure 1 The visualization of faculty of engineering which is the location of the case study laboratory

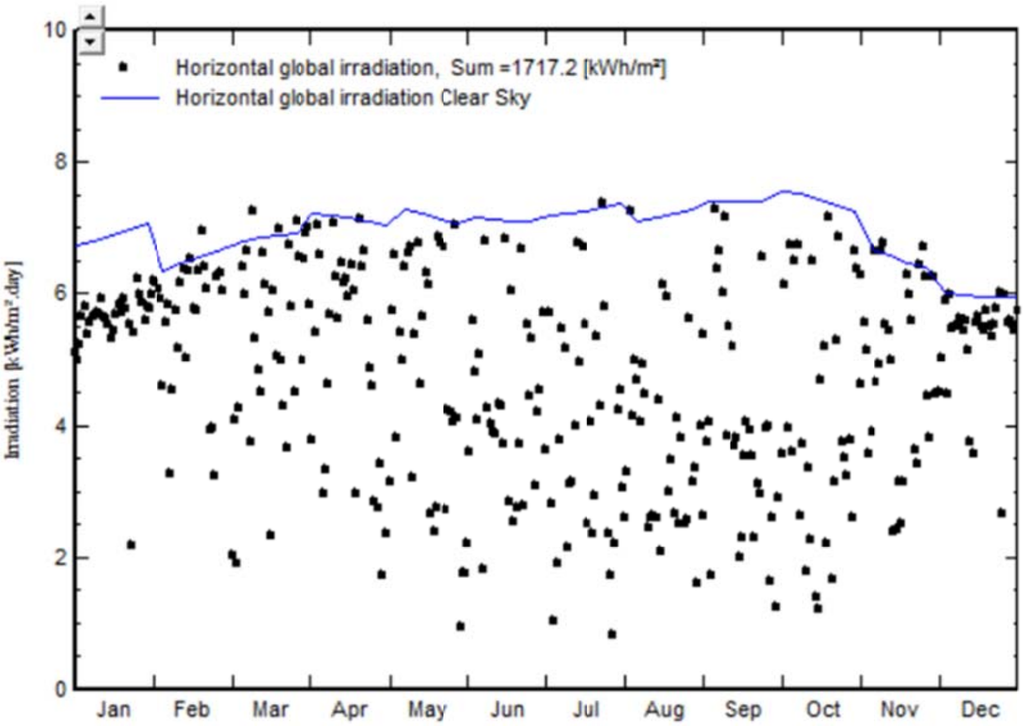

Figure 2 The plot for the daily mean global solar radiation on the horizontal plane for the site

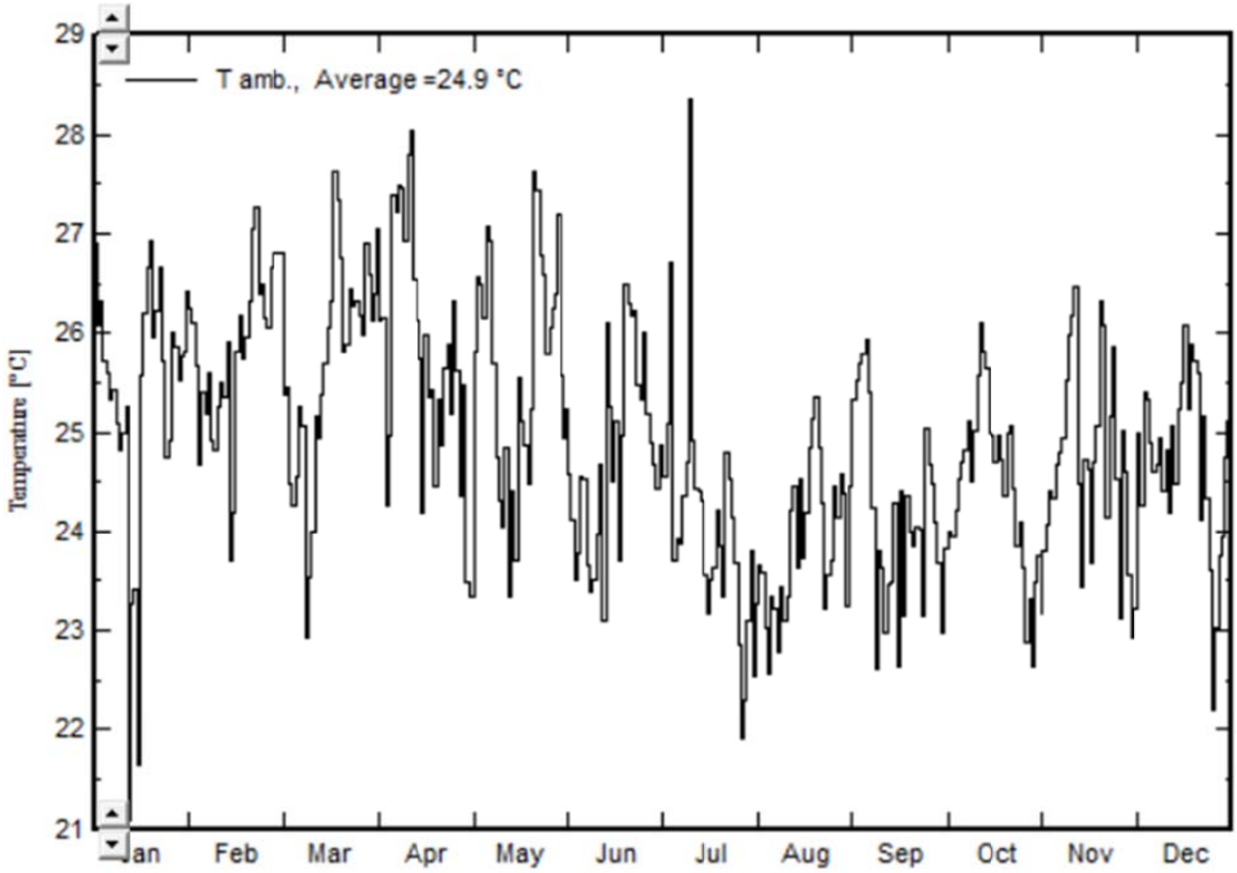

Figure 3 The plot for the daily mean temperature which has annual mean value of 24.9 °C.

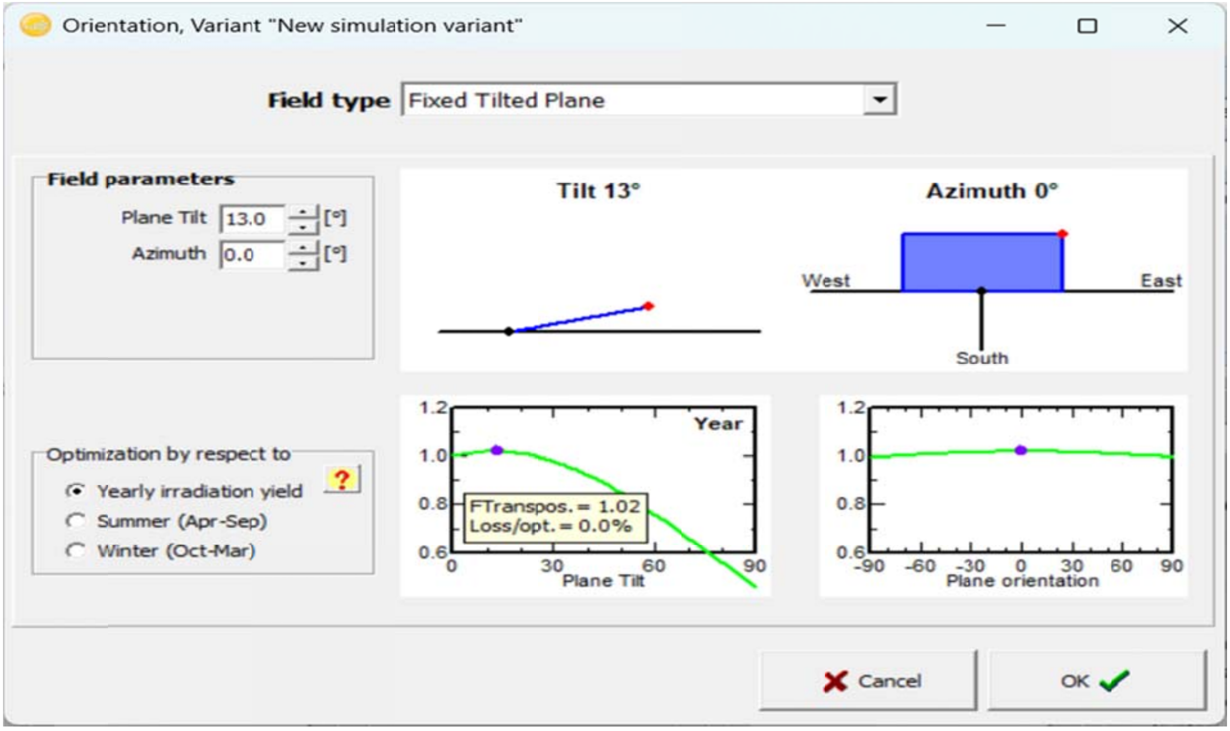

Figure 4 The optimal tilt for the PV panel as captured using PVSyst software

Table 1 The load profile for the three laboratories that make up the electronic and communication laboratory [12]

Laboratory	Appliance	QTY.	Power Rating (W)	Total Power (W)	Hours/Day	Energy per day (Wh)
Electrical and Electronic Circuits Laboratory	Digital storage oscilloscope	10	50	500	6	3000
	Function generator	10	50	500	6	3000
	DC power supply (dual)	10	120	1200	6	7200
	PC desktop	2	500	1000	6	6000
Digital Electronics Laboratory	PC desktop	10	500	5000	6	30000
	Digital storage oscilloscope	10	50	500	6	3000
	Microcontroller training kit	10	50	500	6	3000
	Digital analog training system	10	40	400	6	2400
Communications Laboratory	Digital storage oscilloscope	8	50	400	6	2400
	PC desktop	10	500	5000	6	30000
	Communications training kit EV	8	36	288	6	1728
	Function generator (20GHz)	2	250	500	6	3000
	Function generator (25MHz)	2	120	240	6	1440
	Network analyzer (20GHz)	1	350	350	6	2100
	Spectrum analyzer (20GHz)	1	450	450	6	2700
	Total power rating	104	3116	16828		100968

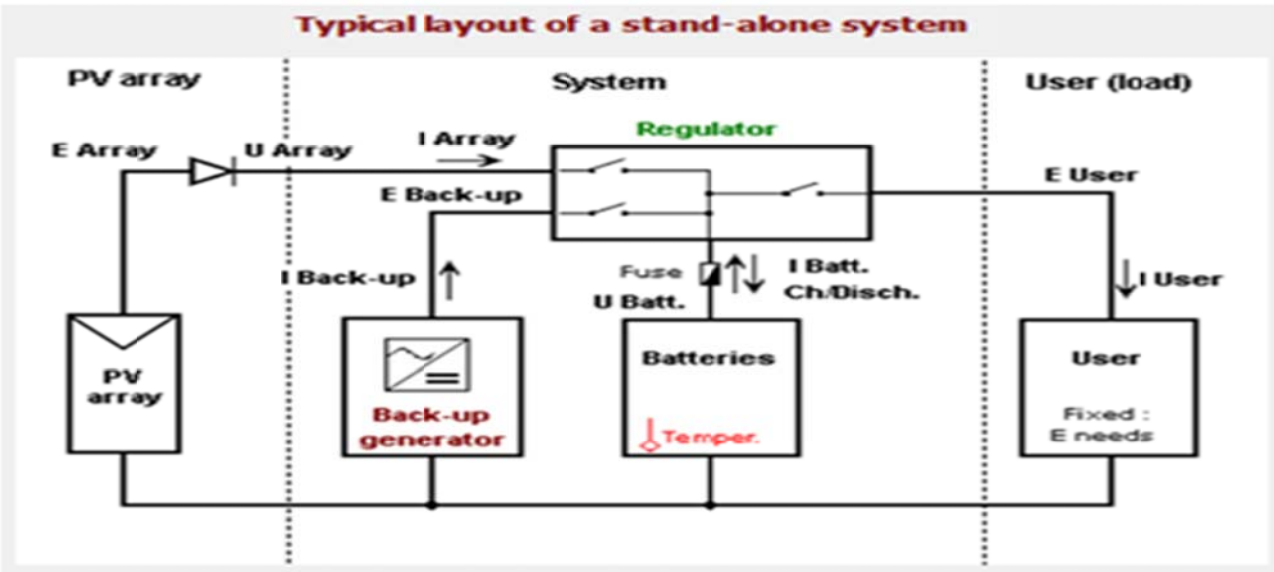

Figure 5 The layout of the standalone solar power in PVSyst

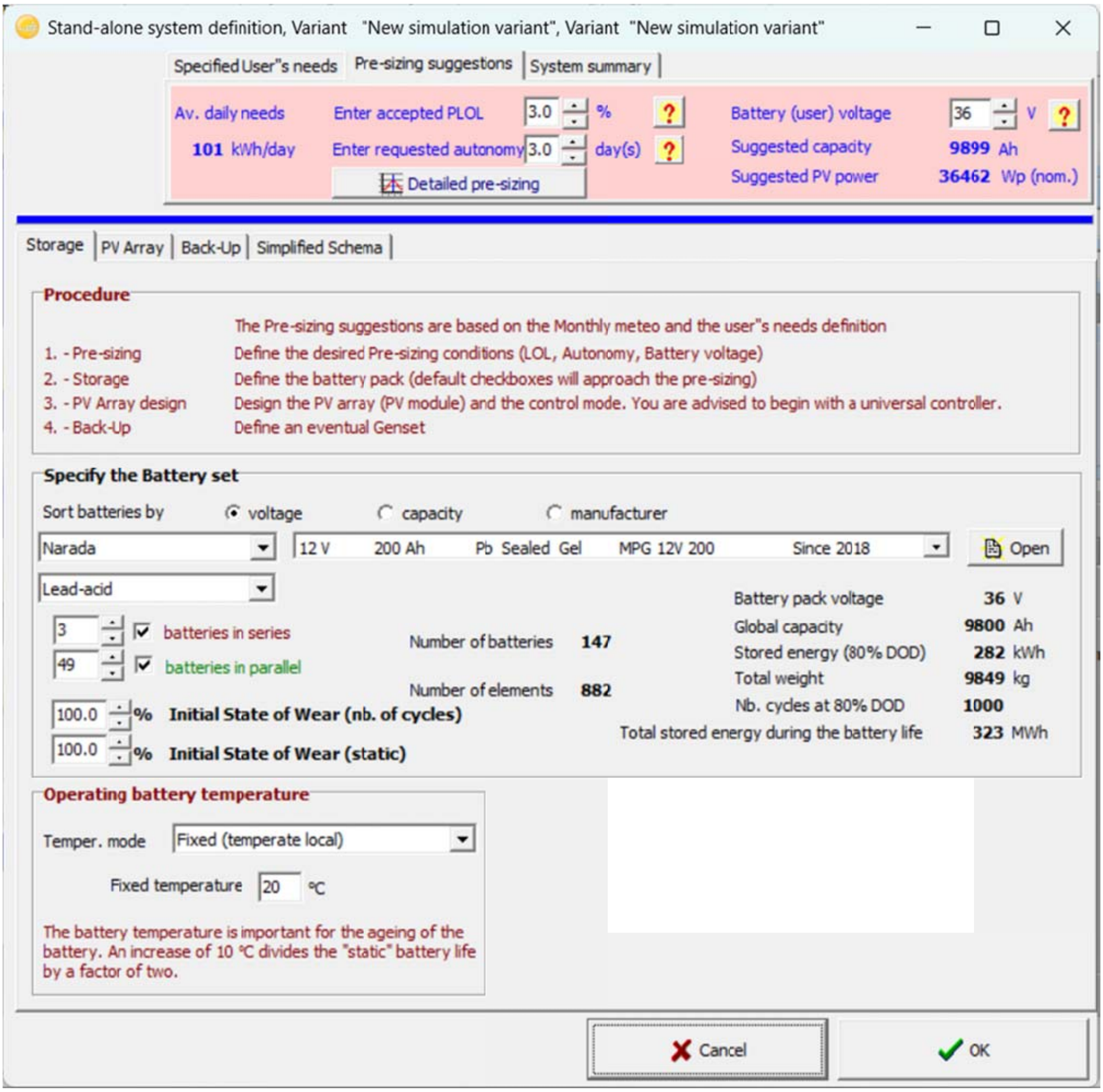

Figure 6 The configuration for the battery bank of the solar power system

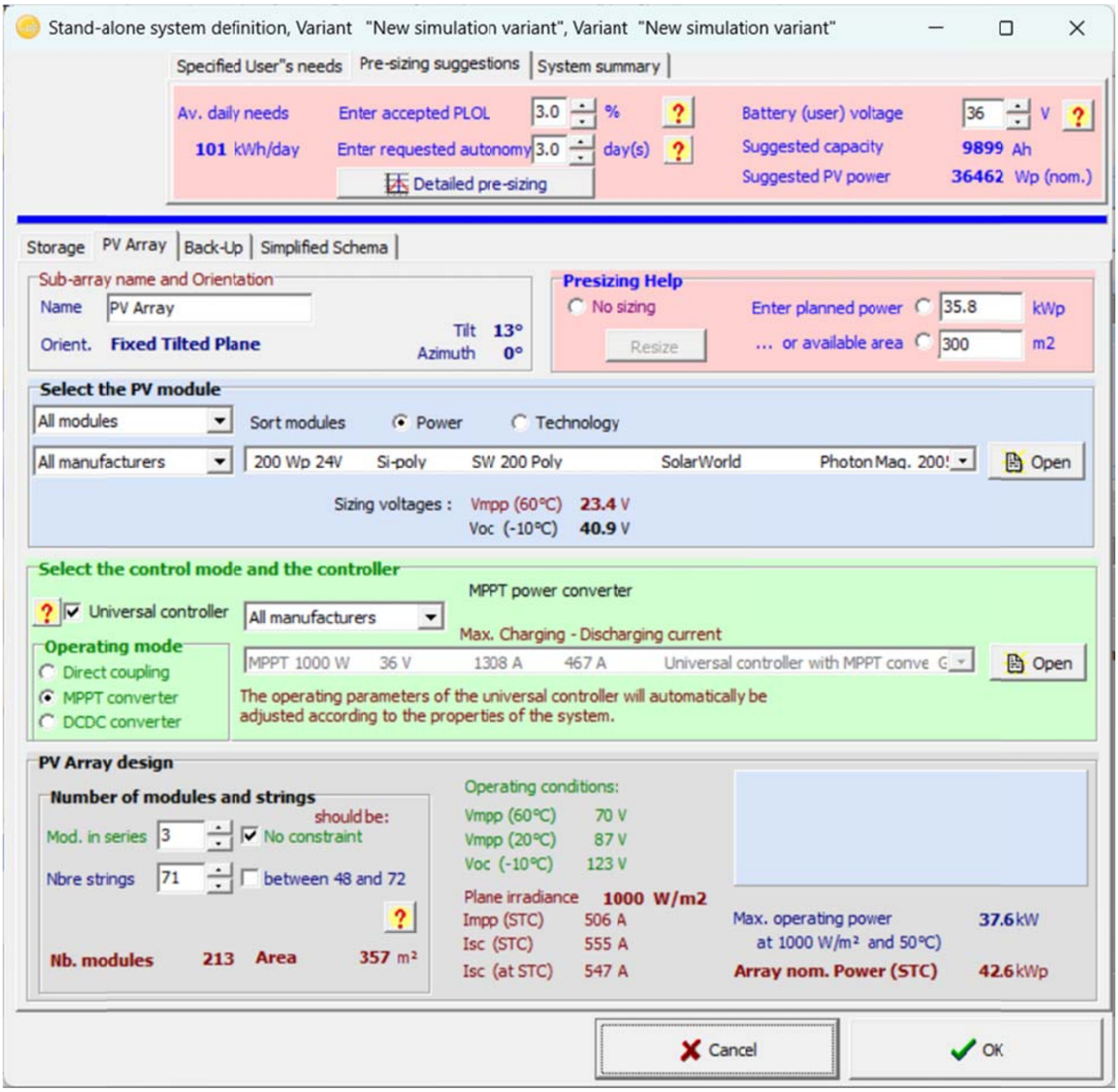

Figure 7 The configuration for the PV array of the solar power system

3. Results and Discussion

The simulation was conducted based on the system (PV array and battery bank) configuration of Figure 6 and Figure 7 and the summary of PVSyst simulation result for the load profile, the PV array configuration and the battery bank of the system is shown in Figure 8 while Figure 9 included the input and output energy diagram of the system generated by the PVSyst software. The results showed that with the 12 V 200 Wp PV panel, total of 213 PV module are required for the PV array while 147 battery units are required in the system.

PVSYST V6.88		14/06/25	Page 1/6

Simulation parameters	System type	**Stand alone system with batteries**		
Collector Plane Orientation	Tilt	13°	Azimuth	0°
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
User's needs :	daily profile	Constant over the year		
	average	101 kWh/Day		

	0 h / 12 h	1 h / 13 h	2 h / 14 h	3 h / 15 h	4 h / 16 h	5 h / 17 h	6 h / 18 h	7 h / 19 h	8 h / 20 h	9 h / 21 h	10 h / 22 h	11 h / 23 h	
Hourly load	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.83	16.83	kW
	16.83	16.83	16.83	16.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	kW

PV Array Characteristics				
PV module Si-poly	Model	**SW 200 Poly**		
Original PVsyst database	Manufacturer	SolarWorld		
Number of PV modules	In series	3 modules	In parallel	71 strings
Total number of PV modules	Nb. modules	213	Unit Nom. Power	200 Wp
Array global power	Nominal (STC)	**42.6 kWp**	At operating cond.	37.6 kWp (50°C)
Array operating characteristics (50°C)	U mpp	74 V	I mpp	506 A
Total area	Module area	**357 m²**		

System Parameter	System type	**Stand alone system**		
Battery	Model	**MPG 12V 200**		
	Manufacturer	Narada		
Battery Pack Characteristics	Nb. of units	3 in series x 49 in parallel		
	Voltage	36 V	Nominal Capacity	9800 Ah
	Discharging min. SOC	20.0 %	Stored energy	290.9 kWh
	Temperature	Fixed (20°C)		
Controller	Model	Universal controller with MPPT converter		
	Technology	MPPT converter	Temp coeff.	-5.0 mV/°C/elem.
Converter	Maxi and EURO efficiencies	97.0 / 95.0 %		
Battery Management control	Threshold commands as	SOC calculation		
	Charging	SOC = 0.90 / 0.75	i.e. approx.	40.3 / 38.0 V
	Discharging	SOC = 0.20 / 0.45	i.e. approx.	35.4 / 36.8 V

PV Array loss factors				
Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	2.5 mOhm	Loss Fraction	1.5 % at STC
Serie Diode Loss	Voltage Drop	0.7 V	Loss Fraction	0.8 % at STC
Module Quality Loss			Loss Fraction	1.5 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP
Strings Mismatch loss			Loss Fraction	0.10 %

Figure 8 The summary of PVSyst simulation result for the load profile, the PV array configuration and the battery bank of the system

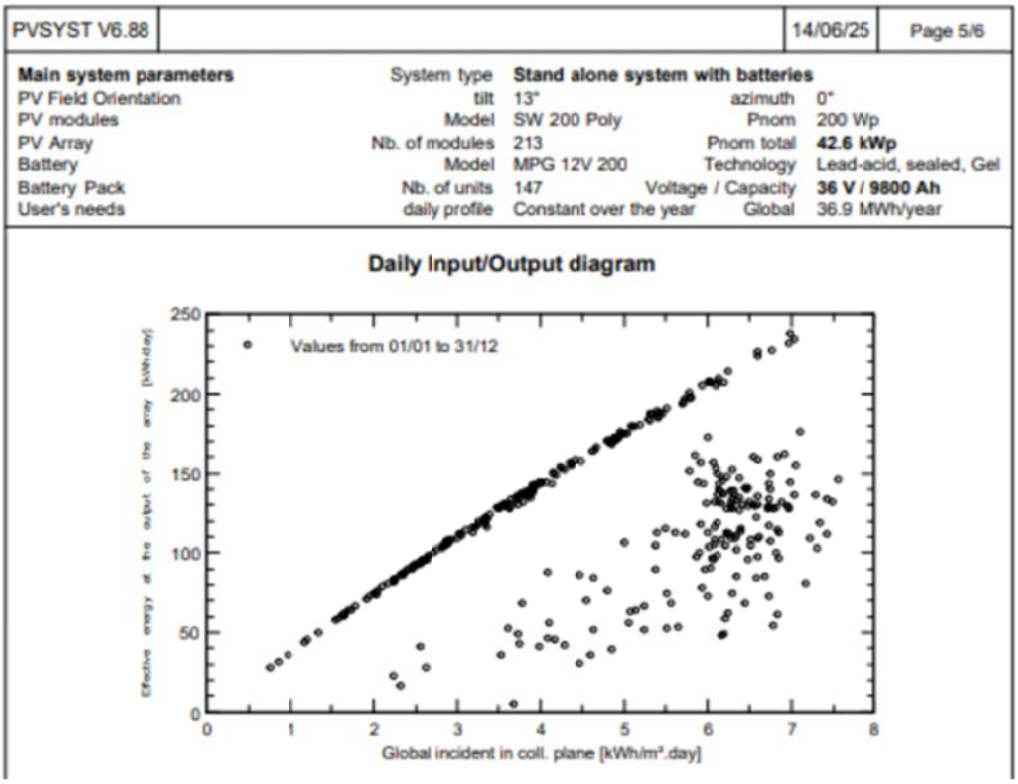

Figure 9 The summary of the system configuration with the input /output energy diagram generated from the PVSyst simulation

The summery of the energy balance results from the PVSyst is shown in Table 2. It shows that the solar fraction (SolFrac in Table 2) is 1 in all the months meaning there is no power outage in all the months. However, there are used energy (EUnused in Table 2) in each of the months with annual total of 16427 kWh per annum. That is the toal of energy produced but not used and hence lost.

The result on the loss of load is shown in Table 3. It shows zero loss of load probability (Pr_LOL in Figure 3) and zero duration of loss of load duration (T_LOL in Figure 3). As such, the system is sized to avoid any power outage which resulted in excess energy yield that led to as much unused energy loss of 16427 kWh per year, as witnessed in Table 2.

The summary of the PV array operating efficiency is shown in Table 4 while the loss diagram of the system is shown in Figure 10. The results show that the PV array operated with efficiency of 7.01 % annual average. The loss diagram showed thermal loss of about 12,57 % of the total energy yield.

Table 2 The summery of the energy balance results

	GlobHor	GlobEff	E_Avail	EUnused	E_Miss	E_User	E_Load	SolFrac
	kWh/m²	kWh/m²	kWh	kWh	kWh	kWh	kWh	
January	171.4	185.3	6230	2610	0.000	3130	3130	1.000
February	156.5	162.4	5436	2218	0.000	2827	2827	1.000
March	164.9	161.6	5445	1915	0.000	3130	3130	1.000
April	152.7	142.6	4833	1557	0.000	3029	3029	1.000
May	146.3	130.7	4458	1052	0.000	3130	3130	1.000
June	129.3	113.4	3917	444	0.000	3029	3029	1.000
July	119.4	106.0	3695	487	0.000	3130	3130	1.000
August	116.9	107.3	3748	198	0.000	3130	3130	1.000
September	118.2	112.4	3889	782	0.000	3029	3029	1.000
October	132.4	132.6	4495	930	0.000	3130	3130	1.000
November	145.2	153.3	5166	1722	0.000	3029	3029	1.000
December	164.0	179.3	6089	2513	0.000	3130	3130	1.000
Year	1717.2	1686.9	57401	16427	0.000	36853	36853	1.000

Table 3 The summary of the loss of load

	EArray kWh	E_Load kWh	E_User kWh	SolFrac	T_LOL Hour	Pr_LOL %
January	3852	3130	3130	1.000	0	0.00
February	3427	2827	2827	1.000	0	0.00
March	3757	3130	3130	1.000	0	0.00
April	3485	3029	3029	1.000	0	0.00
May	3625	3130	3130	1.000	0	0.00
June	3698	3029	3029	1.000	0	0.00
July	3413	3130	3130	1.000	0	0.00
August	3777	3130	3130	1.000	0	0.00
September	3304	3029	3029	1.000	0	0.00
October	3797	3130	3130	1.000	0	0.00
November	3669	3029	3029	1.000	0	0.00
December	3806	3130	3130	1.000	0	0.00
Year	43610	36853	36853	1.000	0	0.00

Table 4 The summary of the PV array operating efficiency

	EffArrR %
January	5.67
February	5.76
March	6.32
April	6.62
May	7.48
June	8.78
July	8.67
August	9.50
September	7.95
October	7.76
November	6.51
December	5.78
Year	7.01

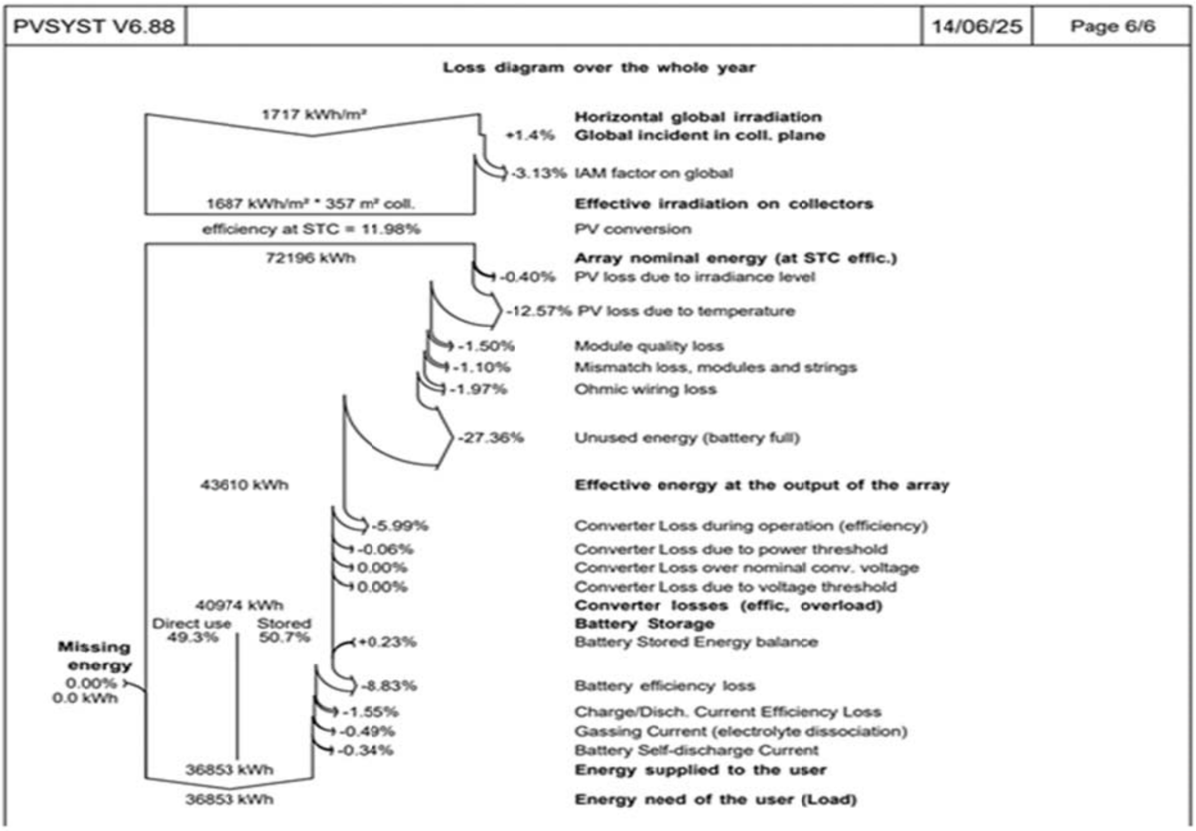

Figure 10 The system loss diagram

4. Conclusion

A standalone solar power system was simulated using PVSysts software. The solar power was modeled for powering a set of laboratories used in the electronic and communication courses in the faculty of engineering located at the main campus of University of Uyo. The simulation steps are presented along with the set of input parameters and the results. The results showed that the sizing configuration of the PV array and battery banks gave solar fraction of 100 % without loss of load but with excess energy loss in the system. In all, the power need of the laboratory is fully met without any power outage.

References

1. Aremu, J. O. (2019). Epileptic electric power generation and supply in Nigeria: Causes, impact and solution. *Journal of Contemporary Research in Social Sciences*, *1*(3), 73-81.
2. Olówósejéjé, S. (2020). Quantifying the challenges associated with poor electricity supply in Nigeria and the role of a hybrid PV system in addressing them.
3. Adewole, A. (2018). Meeting energy demand for critical health care in developing economies: a case study modelling renewable energy systems.
4. Babatunde, O., Denwigwe, I., Oyebode, O., Ighravwe, D., Ohiaeri, A., & Babatunde, D. (2022). Assessing the use of hybrid renewable energy system with battery storage for power generation in a University in Nigeria. *Environmental Science and Pollution Research*, *29*(3), 4291-4310.
5. Mbachu, V. M., Muogbo, A. G., Ezeanaka, O. S., Ejichukwu, E. O., & Ekwunife, T. D. (2022). An economic based analysis of fossil fuel powered generator and solar photovoltaic system as complementary electricity source for a University student's room. *Journal of Solar Energy Research*, *7*(4), 1159-1173.
6. Samson, A. O., Babatunde, O. M., & Denwigwe, I. H. (2019). Powering a space environment research laboratory (SERL): hybrid renewable energy system or diesel system?. *Energy Engineering*, *116*(2), 41-64.
7. Ayodele, M. T., & Alege, P. (2021). Oil price volatility and renewable energy consumption in Nigeria. *International Journal of Energy Economics and Policy*, *11*(4), 470-478.
8. Gençsü, I., Walls, G., Picciariello, A., & Alasia, I. J. (2022). *Nigeria's Energy Transition: Reforming Fossil Fuel Subsidies And) other Financing Opportunities*. ODI.
9. Kumar, R., Rajoria, C. S., Sharma, A., & Suhag, S. (2021). Design and simulation of standalone solar PV system using PVsyst Software: A case study. *Materials Today: Proceedings*, *46*, 5322-5328.
10. Baqir, M., & Channi, H. K. (2022). Analysis and design of solar PV system using Pvsyst

software. *Materials Today: Proceedings*, *48*, 1332-1338.

11. Jagadale, P. R., Choudhari, A. B., & Jadhav, S. S. (2022). Design and simulation of grid connected solar Si-poly photovoltaic plant using PVsyst for Pune, India location. *Renewable Energy Research and Applications*, *3*(1), 41-49.
12. Mahmood, A. L. (2019). Design and simulation of stand-alone pv system for electronic and communications engineering department laboratories in Al-Nahrain University. *EAI endorsed Transactions on Energy web*, *6*(22).