Performance Evaluation Of Standalone PV Solar Power System Computer And Internet Service Centre

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***Abstract*— In this paper, the performance evaluation of standalone PV solar power system computer and internet service centre is presented. The center has load demand of 324740kWh per day and the installation site is located in Idu Akwa Ibom State with 5.027595 as its latitude and 8.016309 as its longitude. The PVSyst software was used for the simulation. The PVSyst simulation result show that the annual energy yeild from the system is 155085 kWh/year,the used energy delivered to the load is 118546 kWh/year and the unused energy is 33886 kWh/year. Also the system performance ratio is 58.83 %. Also, the results showed that the energy demand could not be satisfied with the use of solar power alone in the months of July, August and September. The worst case energy deficit occurred in the month of July with about 813.8 kWh energy required from the back-up generator. In that July also, the generator is required to run for 70 hours which is about days. The loss diagram show that the two major losses are due to unused energy (20.79%) and loss due to cell temperature (11.09%). In all, due to the cumulative loses the system performance is 58.83 %. This means that about 41.17 % of the energy produced is lost.**

Keywords*— *Solar Fraction, Performance Evaluation, PVSyst, Standalone PV , Solar Power System

1. INTRODUCTION

Today, computer and Internet have revolutionised our society. Numerous changes have occurred in the way we live and relate [1,,3,4]. As such, any one without some basic knowledge of computer and internet in this present day finds it difficult to take advantage of the numerous benefits these technologies can afford[5,6,7,8,9] In any case, there are still locations in the remote part of some developing countries where the computer and internet penetration is still low [10,11,1,13]. One of the major challenges in some of these remote locations is lack of access to electricity and wireless network service from the major service providers [14,15,16]. As such, in such locations, computer centres and internet service based on VSAT technology are used to provide computer and internet services to the inhabitants. Accordingly, the issue of power can be addressed by using standalone sola power system [17,18,19]. As such, in this paper, the performance evaluation of a standalone solar power system for a computer and internet service centre in a remote location in Akwa Ibom State is presented. The evaluation is done using the PVSyst software.

2. METHODOLOGY

The work considered the solar power for a computer and internet service centre located in Idu Akwa Ibom State with 5.027595 as its latitude and 8.016309 as its longitude. The center has load demand profile, as shown in Table 1, with about 324740kWh per day. The meteorological data for the installation site at Idu Akwa Ibom State is shown in Table 1.

The optimal tilt angle selection for the PV module was done using the PVSyst tilt angle dialogue box shown in Figure 1. The tilt angle is relative to the site latitude and the optimal tilt angle for the site, as shown in Figure 1 is 14°. The schematic diagram of the standalone PV power system with back up is shown in Figure 2. PVSyst software was used to simulate the system with 3 days of power autonomy. The results as captured from the PVSyst simulation outputs are shown in Figure 3 to Figure 8.

The PVSyst software is used to examine some key features of the selected PV module. Notably, the graph of PV cell efficiency versus solar radiation for different temperatures is shown in Figure 3 while the graph of PV cell efficiency versus temperatures is shown in Figure 4. The commercially quoted PV cell efficiency for the selected

module is 10.64% at temperature of 25°. However, the graphs in Figure 3 and Figure 4 show that the efficiency decreases below the quoted efficiency value as the cell temperature increases above 25°. On the other hand, the efficiency increases above the quoted efficiency value as the cell temperature decreases below 25°.
The PVSyst software is used to examine some key features of the selected storage battery. Notably, the graph of The graph of battery voltage versus charging time in hours is shown in Figure 5. The graph shows that at 24 A it will take about 4.9 hours to fully charge the battery, at 6 A it will take about 20 hours to fully charge the battery and at 1.2 A it will take about 104 hours to fully charge the battery.

Table 1: Load demand profile of the case study remote computer and internet service centre

ICT Center Description	Quantity	Rated Power (W)	Total Power Rated (W)	Hours/day	Wh/day
Lighting	40	35	1400	10	14000
Security light	20	80	1600	12	19200
Fan	18	60	1080	10	10800
Laptops	120	65	7800	10	78000
Network Servers	3	210	630	24	15120
Air conditioner for server	3	1100	3300	24	79200
Air conditioner	8	1100	8800	10	88000
Printer	1	50	50	10	500
Routers	1	35	35	24	840
Switches	1	30	30	24	720
VSAT Modem	1	15	15	24	360
Other items	15	120	1800	10	18000
TOTAL			**26540**		**324740**

Table 2 Meteorological data for Idu in Akwa Ibom State Nigeria

Interval beginning	GlobHor kWh/m².mth	T_Amb °C
January	173.9	24.7
February	158.5	25.1
March	165.9	24.8
April	152.7	24.9
May	148.2	24.8
June	130.8	23.9
July	120.6	23.1
August	114.4	23.0
September	120.3	23.2
October	133.9	23.6
November	145.2	23.8
December	165.2	24.0
Year	1729.6	24.1

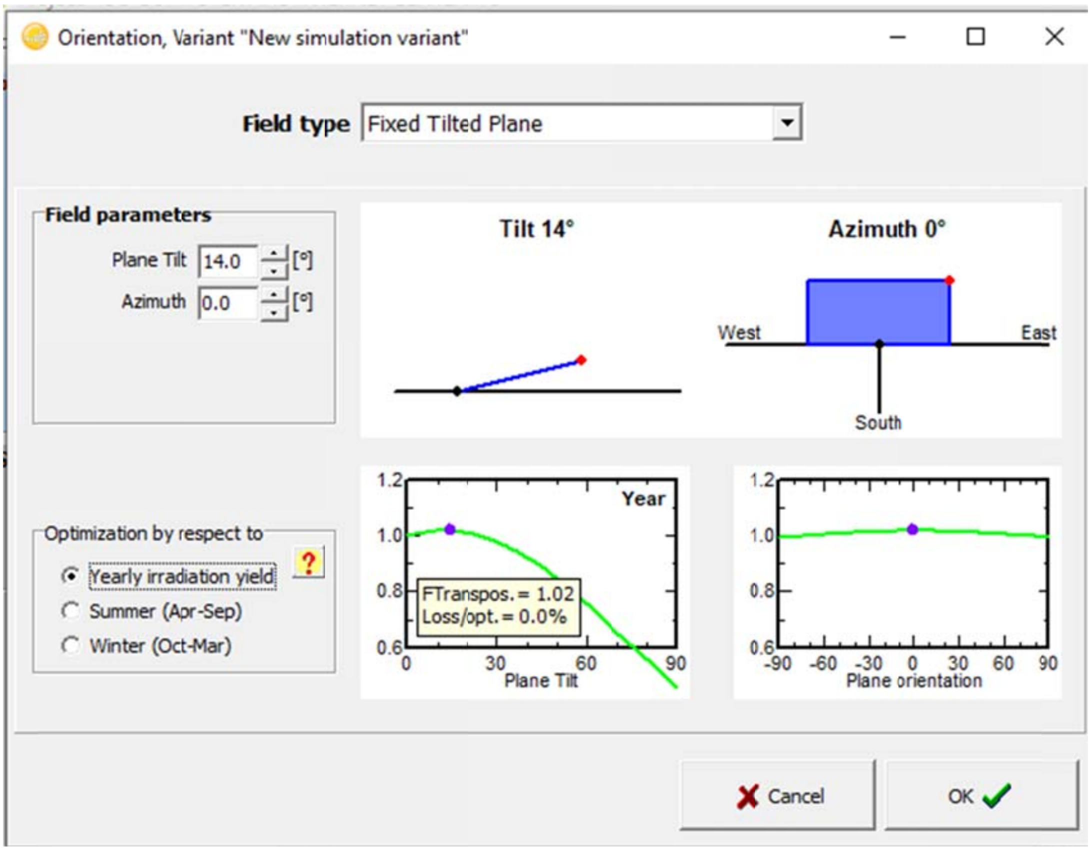

Figure 1 The optimal tilt angle selection for the PV module

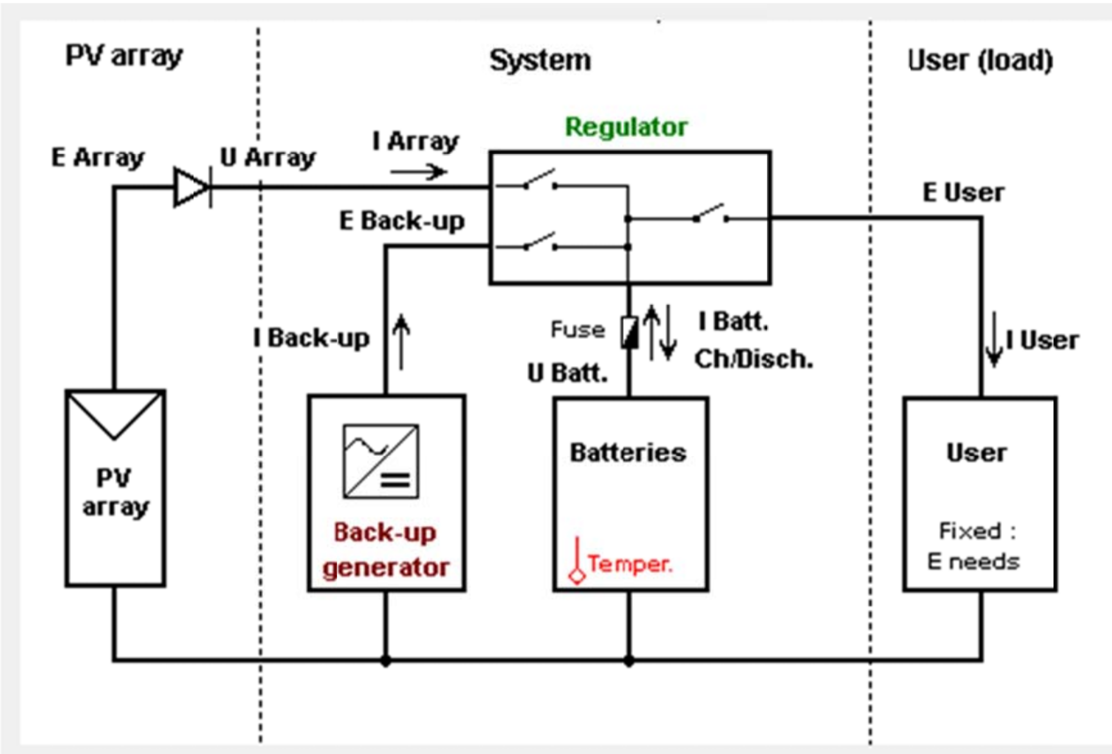

Figure 2 The schematic diagram of the standalone PV power system with back up

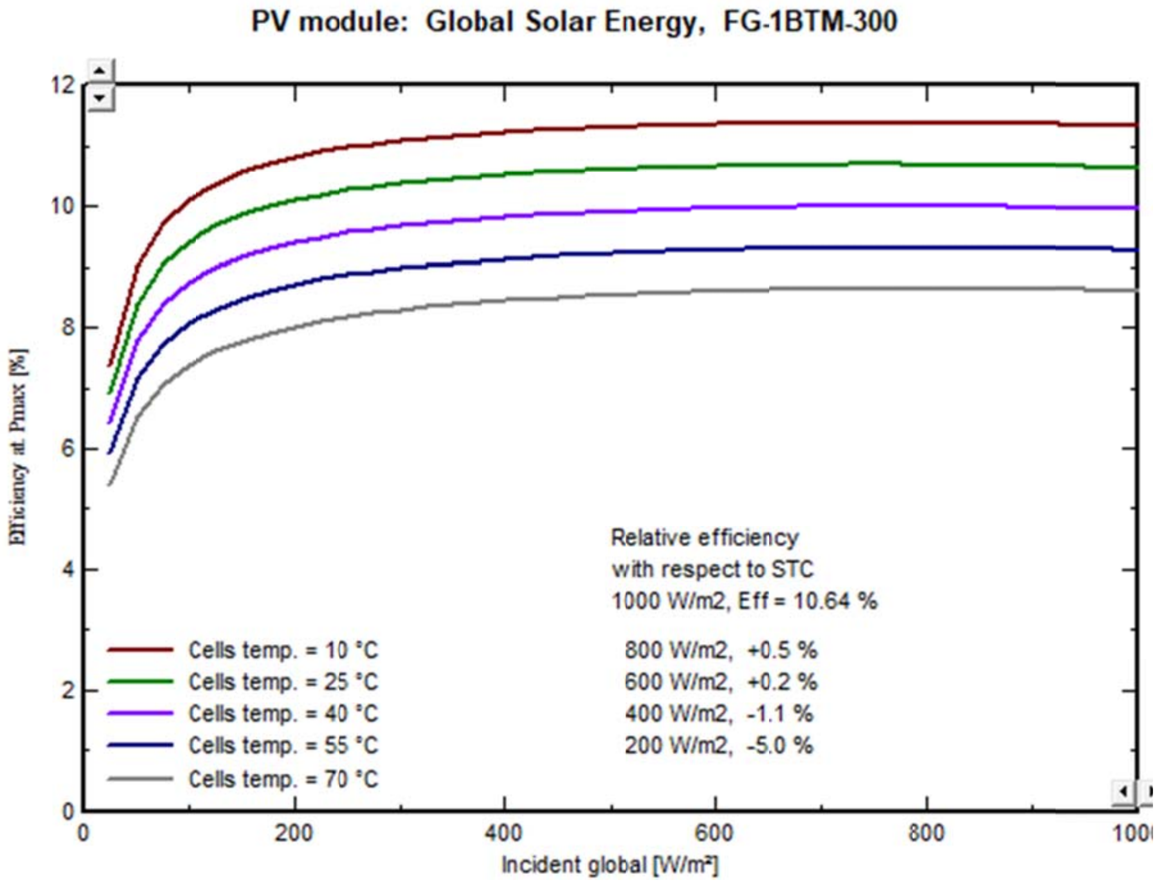

Figure 3 The graph of PV cell efficiency versus solar radiation for different temperatures

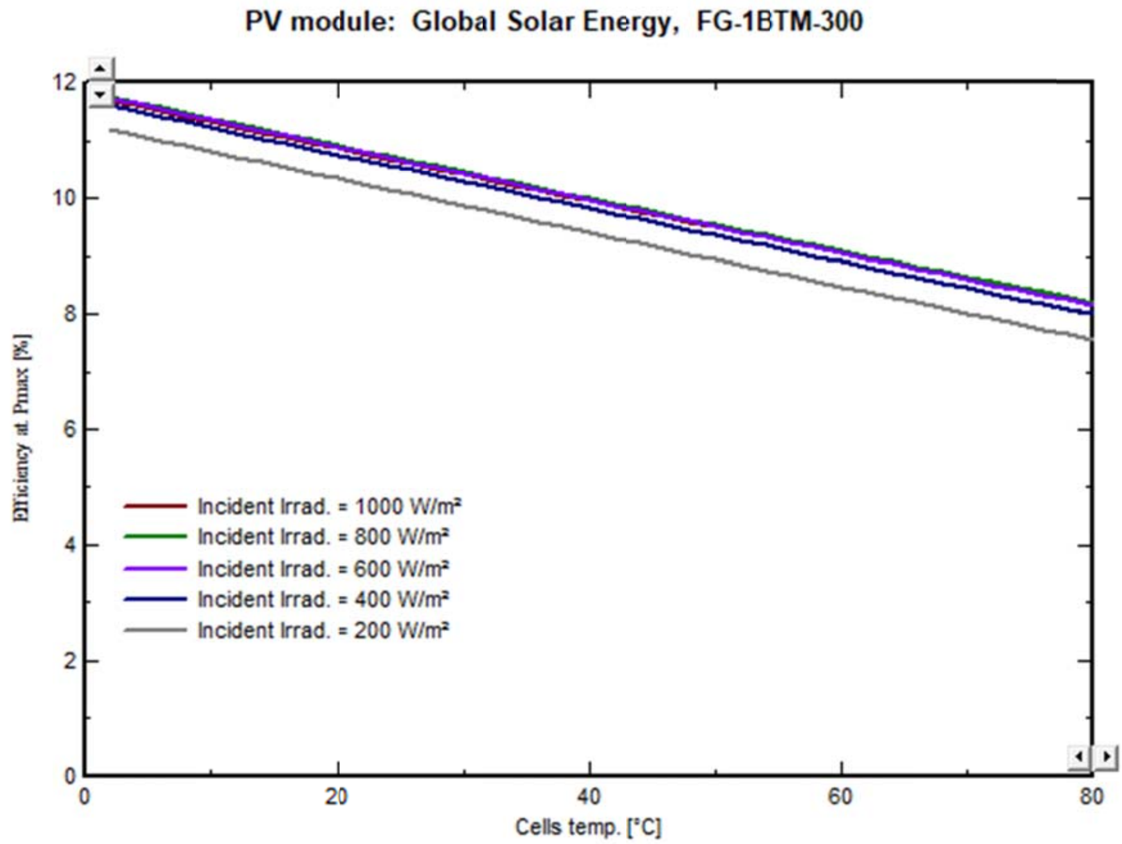

Figure 4 The graph of PV cell efficiency versus temperatures

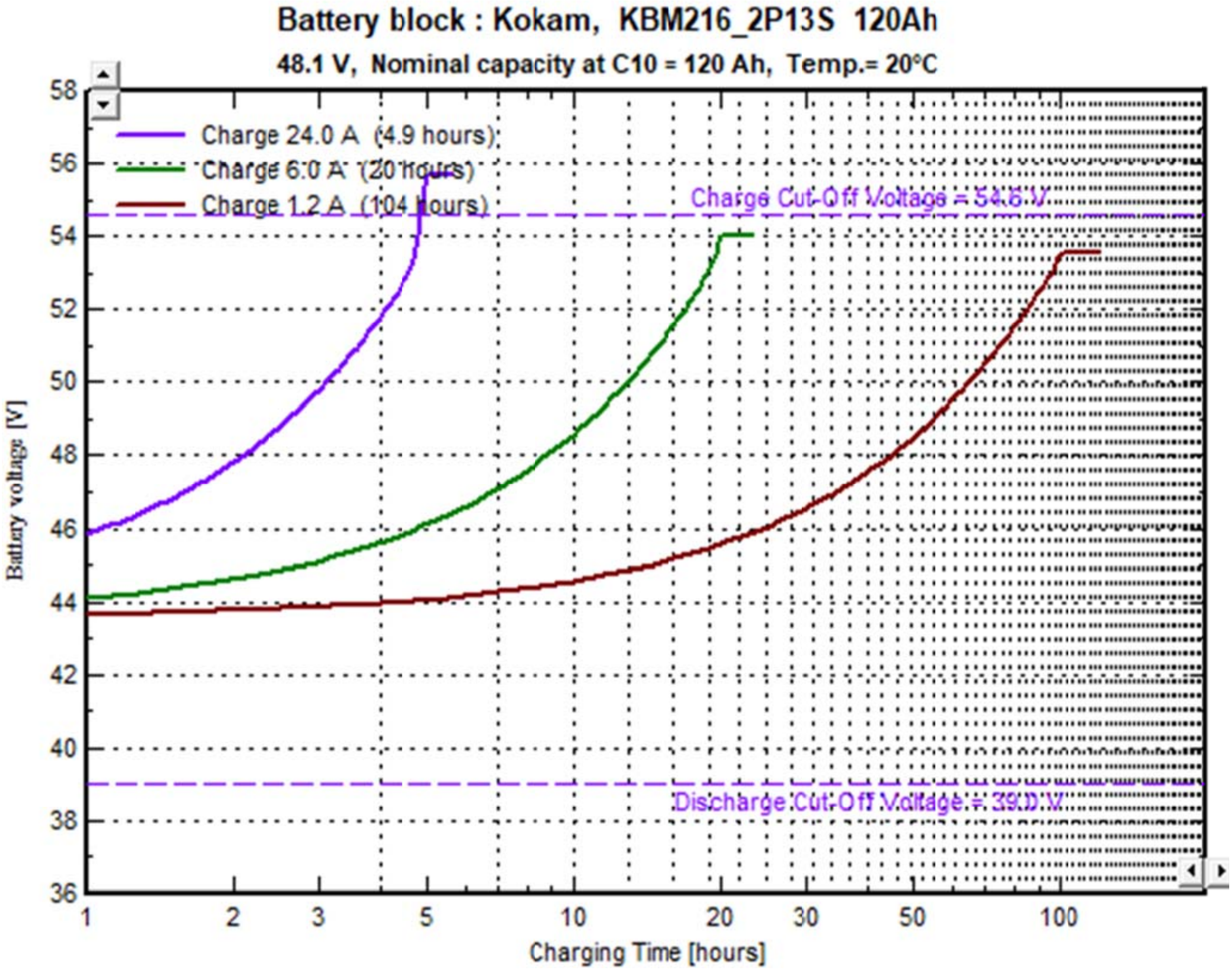

Figure 5 The graph of battery voltage versus charging time in hours

3. RESULTS AND DISCUSSIONS

The PVSyst simulation result showing the simulation parameters and the system components settings is shown in Figure 6. It shows the selected PV module, the battery , the charger controller and the back-up generator. The PVSyst simulation result showing the simulation parameters and the energy yield f the system is shown in Figure 7. It shows that the annual energy yeild from the system is 155085 kWh/year,the used energy delivered to the load is 118546 kWh/year and the unused energy is 33886 kWh/year. Also the system performance ratio is 58.83 %.

The PVSyst simulation result showing the simulation parameters and the different components of energy yield and energy consumption in the system is shown in Figure 8. It shows also the solar fraction is less than 1 which indicates that the energy demand could not be satisfied with the use of solar power alone in the months of July, August and September. These 3 months have solar fraction less than 1. Accordingly, the results in Figure 9 shows that the back-up generator was used only in the listed 3 months. The worst case energy deficit occurred in the month of July with about 813.8 kWh energy required from the back-up generator. In that July also, the generator is required to run for 70 hours which is about days.

Finally, the PVSyst simulation result showing the losses in the system is presented in Figure 10. The loss diagram show that the two major losses are due to unused energy (20.79%) and loss due to temperature (11.09%). In all due to the cumulative loses the system performance is 58.83 %. This means that about 41.17 % of the energy is lost.

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Stand alone system: Simulation parameters

Project : **IDU COMPUTER AND INTERNET CENTER**

Geographical Site	**IDU AKWA IBOM STATE**			Country	**Nigeria**
Situation		Latitude	5.03° N	Longitude	8.02° E
Time defined as		Legal Time	Time zone UT	Altitude	56 m
		Albedo	0.20		
Meteo data:	**IDU AKWA IBOM STATE**		NASA-SSE satellite data 1983-2005 - Synthetic		

Simulation variant : **New simulation variant**

Simulation date 25/07/23 13h57

PV Array Characteristics					
PV module	CIS	Model	FG-1BTM-300		
Original PVsyst database		Manufacturer	Global Solar Energy		
Number of PV modules		In series	7 modules	In parallel	54 strings
Total number of PV modules		Nb. modules	378	Unit Nom. Power	300 Wp
Array global power		Nominal (STC)	113 kWp	At operating cond.	102 kWp (50°C)
Array operating characteristics (50°C)		U mpp	335 V	I mpp	304 A
Total area		Module area	1072 m²	Cell area	857 m²
System Parameter		System type	Stand alone system with back-up generator		
Battery		Model	KBM216_2P13S 120Ah		
		Manufacturer	Kokam		
Battery Pack Characteristics		Nb. of units	5 in series x 40 in parallel		
		Voltage	241 V	Nominal Capacity	4800 Ah
		Discharging min. SOC	10.0 %	Stored energy	1028.8 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 = 0.96 / 0.80		
		Discharging	SOC = 0.10 / 0.35		
		Back-Up Genset Command	SOC = 0.15/0.45		
Back-up genset		Model	3 kW		
		Manufacturer	Back-up generator		
		Nominal power	3.0 kW		

Figure 6 The PVSyst simulation result showing the simulation parameters and the system components settings

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Stand alone system: Main results

Project : **IDU COMPUTER AND INTERNET CENTER**

Simulation variant : **New simulation variant**

Main system parameters	System type	**Stand alone with back-up generator**		
PV Field Orientation	tilt	14°	azimuth	0°
PV modules	Model	FG-1BTM-300	Pnom	300 Wp
PV Array	Nb. of modules	378	Pnom total	**113 kWp**
Battery	Model	KBM216_2P13S 120Ah		Lithium-ion, NMC
Battery Pack	Nb. of units	200	Voltage / Capacity	**241 V / 4800 Ah**
User's needs	daily profile	Constant over the year	Global	119 MWh/year

Main simulation results				
System Production	**Available Energy**	**155085 kWh/year**	Specific prod.	1368 kWh/kWp/year
	Used Energy	118546 kWh/year	Excess (unused)	33886 kWh/year
	Performance Ratio PR	58.83 %	Solar Fraction SF	98.61 %
Back-Up energy from generator	Back-Up energy	1660 kWh/year	Fuel Consumption	996/year
Battery ageing (State of Wear)	Cycles SOW	92.0%	Static SOW	80.0%
	Battery lifetime	5.0 years		

Figure 7 The PVSyst simulation result showing the simulation parameters and the energy yield f the system

	GlobHor kWh/m²	GlobEff kWh/m²	E_Avail kWh	EUnused kWh	E_User kWh	E_Load kWh	SolFrac
January	173.9	190.0	17160	6380	10067	10067	1.000
February	158.5	165.7	14979	5520	9093	9093	1.000
March	165.9	163.4	14803	4322	10067	10067	1.000
April	152.7	141.8	12883	2809	9742	9742	1.000
May	148.2	131.3	11946	1714	10067	10067	1.000
June	130.8	114.0	10468	758	9743	9742	1.000
July	120.6	106.5	9800	617	10079	10067	0.920
August	114.4	105.0	9747	1	10071	10067	0.928
September	120.3	114.9	10489	15	9743	9742	0.988
October	133.9	134.6	12208	1873	10067	10067	1.000
November	145.2	154.4	13973	3736	9742	9742	1.000
December	165.2	182.6	16629	6143	10067	10067	1.000
Year	1729.6	1704.1	155085	33886	118546	118532	0.986

Legends:				
	GlobHor	Horizontal global irradiation	E_User	Energy supplied to the user
	GlobEff	Effective Global, corr. for IAM and shadings	E_Load	Energy need of the user (Load)
	E_Avail	Available Solar Energy	SolFrac	Solar fraction (EUsed / ELoad)
	EUnused	Unused energy (battery full)		

Figure 8 The PVSyst simulation result showing the different components of energy yield and energy consumption in the system

	BkUp_ON Hour	FuelBU liter	E_BkUp kWh
January	0	0	0.0
February	0	0	0.0
March	0	0	0.0
April	0	0	0.0
May	0	0	0.0
June	0	0	0.0
July	270	488	813.8
August	239	435	725.2
September	9	17	29.0
October	0	0	0.0
November	0	0	0.0
December	0	0	0.0
Year	518	941	1567.9

Legend:
BKUp_ON- Back-up generator running duration
FuelUp - Fuel consumption of Back-up generator
E_BKUp - Back-up generator Energy

Figure 9 The PVSyst simulation result showing the operation of the back-up generator set

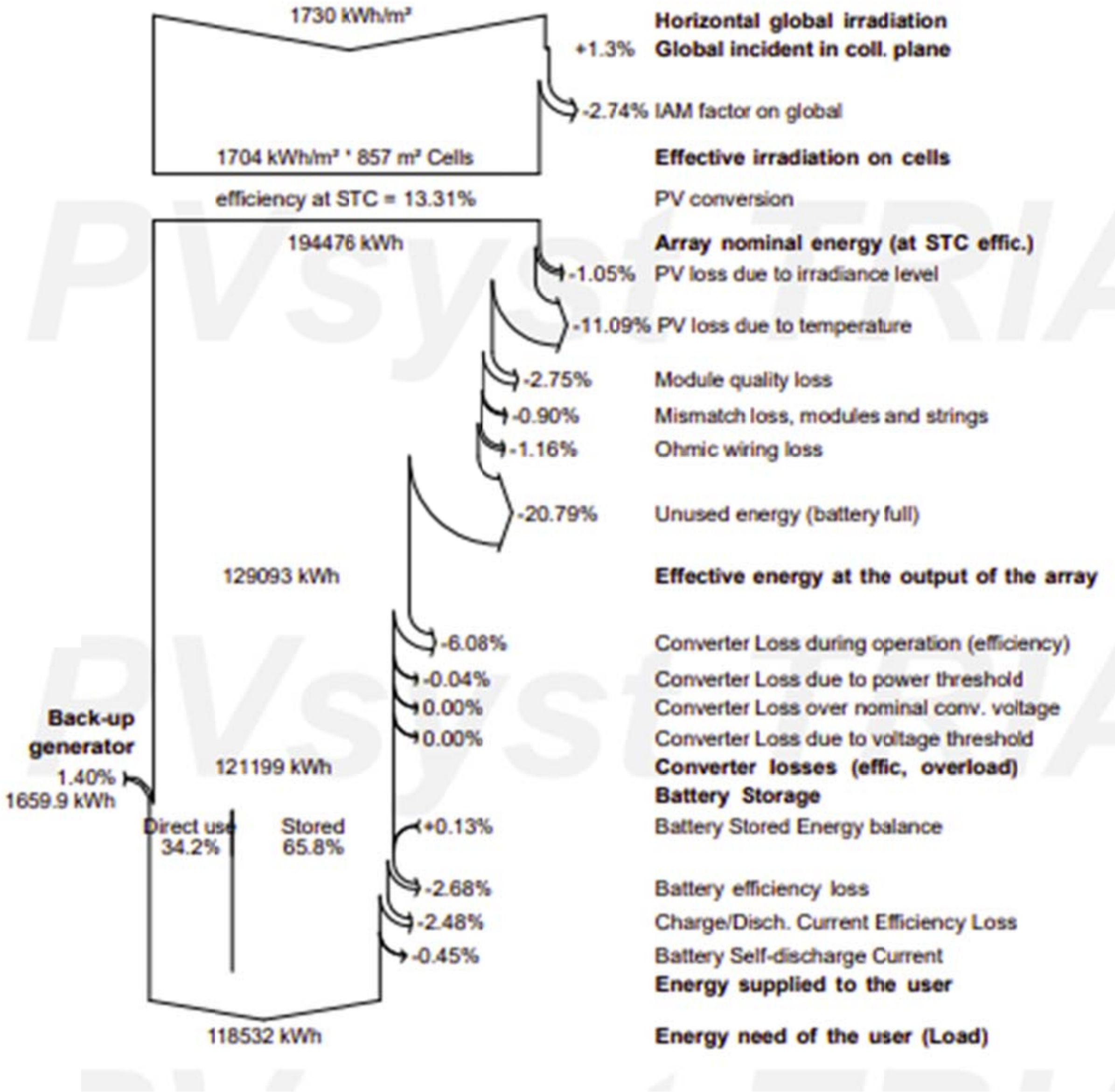

Figure 10 The PVSyst simulation result showing the losses in the system

4 CONCLUSION

The analysis of standalone solar power forcomputer and internet center located a remote site in Idu Akwa ibom State is presneted. The study focused on the sizing of thesolar power system components using PVSysts software and also on the everluation of the losses in the system. Also, the system was designed with back-up generator and the operations of the generator in situations of power supply shortage from the solar power was considered. In all, the systsem only needed the back-up generator in the months of July, August and Septemeber.

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