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Sizing Of An Off-Grid Solar Powered Street Light For Ibom Plaza To Le Meridienibom Hotel And Golf Resort

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Abstract*—In this paper, the sizing of an off-grid solar powered street light for Ibom Plaza to Le Meridien Ibom Hotel and Golf Resort in Akwa Ibom State is presented. The load demand was carried out using the Google map to estimate the distance or path length of the street light and then the total number of street light poles and fittings were determined. The PVSyst software was used to simulate the solar power system. Specifically, energy saving street light of 60 watts was used. A total of 786 poles are required for the 14.14 Km road and the total daily energy demand was 565.92 Kwh per day. The street light was divided into two equal sections. One section of the street light at the outskirts of the Uyo metropolis will be power by the centralized PV array, battery bank and battery charger controllers installed close to the Le Meridien Ibom Hotel and Golf Resort while the second section of the street lights will use the all-in-one unit installed per pole. Essentially, in this paper, the sizing was done for one section n of the street light with 282.96 Kwh daily energy demand. The results show that the solar photovoltaic system has a performance ratio of 0.66 or 66 % with specific energy yield of 1432 kWh/kW//year. Also, the normalized energy output of the system is 3.14kWh/kW/day with normalized array loss of 1.28 kWh/kW/day and normalized system loss of 0.28 kWh/kW/day. Also, the yearly average loss of load probability is 0.07 % which amounts to a total loss of load duration of 6 hours per year. The month of February had the worst loss of load probability is 0.3 %and of load duration of 2 hours. In all, the results showed that the off-grid solar power system will meet the daily load demand of the street light

Keywords— Solar Power, Photovoltaic, Street Light, Loss Of Load Probability, Solar Fraction, Off-Grid Power System

I. INTRODUCTION

Nowadays, advancement in energy saving light bulbs and solar photovoltaic technologies has led to the increasing adoption of solar powered street light across Nigeria [1,2,3,4,5]. Particularly, the off-grid solar powered street light with complete units per pole has become popular; in this case, the storage battery, the solar panels, the battery charging unit and the energy saving light unit are all installed on each street light pole. In recent times, it has been observed that such street lights located at the outskirts of the city are usually vandalized. In most cases, the solar panels, the battery and the battery charging units are stolen by the vandals. In view of the setback, government agencies that are responsible for street lights are considering the centralized PV power system as the alternative installation framework whereby, the street lights in the inner city retain the one pole one complete street light units, whereas the street lights at the outskirts of the city will utilize a centralized PV array, battery bank and battery charging units and the generated energy will be distributed to the street lights using electric power cables [6,7,8,9]. In this way, the incidence of vandalisation of the solar powered street lights will be minimized.

Accordingly, in this paper, the sizing of the off-grid solar photovoltaic power system [10,11,12,13,14,15] for the street lights along the Nwaniba road, in Uyo metropolis is presented. The daily load demand of the section of the street lights that are at the outskirts of the city are identified and the centralized PV, battery and battery charging solar power system is designed for it. The PVsyst software [16] is used to determine the number of PV modules, the battery bank and the charger controller that will be suitable for the street light off-grid solar power system.

II. METHODOLOGY

Google map is used to determine the path length of the street light, as shown in Figure 1. The latitude and the longitude of the Ibom Plaza are given as 5.052022 and 7.792527 while latitude and the longitude of the Le Meridien Ibom Hotel & Golf Resort are given as 6.060143 and 8.038836. The Google maps plot of the street light path and the distance between the two end points are given in Figure 1. The street light spans a distance of 14.14 Km. A 60 W LED street light pack is used with 18 meters distance between adjacent street light poles. In all, a total of 786 street light poles with total daily energy demand of 565.92 Kwh are required, as shown in Table 1.However, the solar power system is split into two, one installed near the Le Meridien Ibom Hotel & Golf Resort while the other one is installed near the Uyo Plaza. Consequently, the sizing is done for one solar power plant with 282.96Kwh daily energy demand. In order to ensure that adequate energy is generated from the PV modules in all the months, the least monthly average Peak Sun Hours (PHS) is used in the sizing of the solar power system. Available data from

NASA website shows that the minimum monthly average Peak Sun Hours (PHS) in Uyo is 3.77 hours/day and it occurred in August. PVSyst software is then used to select the PV array and the battery bank that will accommodate 5 days of autonomy. The maximum loss of load probability (LOLP) is set to 5 %. The details of the selected PV array and the battery bank are shown in Figure 2 while the schematic diagram of the off-grid solar powered LED street light is shown in Figure 3.

Figure 1 Google maps plot of the street light path and the distance between the two end points

Table 1 The daily load demand of the LED street light from Ibom Plaza to Le Meridien Ibom Hotel & Golf Resort

S/N	Parameter title and unit	Parameter Value
1	Project tile	
2	Street light path length (Km)	14.14
3	Distance between adjacent street light poles (m/P)	18
4	Watts/pole	60
5	Total no. of poles	786
5	Total watts (Kw)	47.16
6	No. of hours in operation	12
7	Daily Energy Demand (Kwh)	565.92

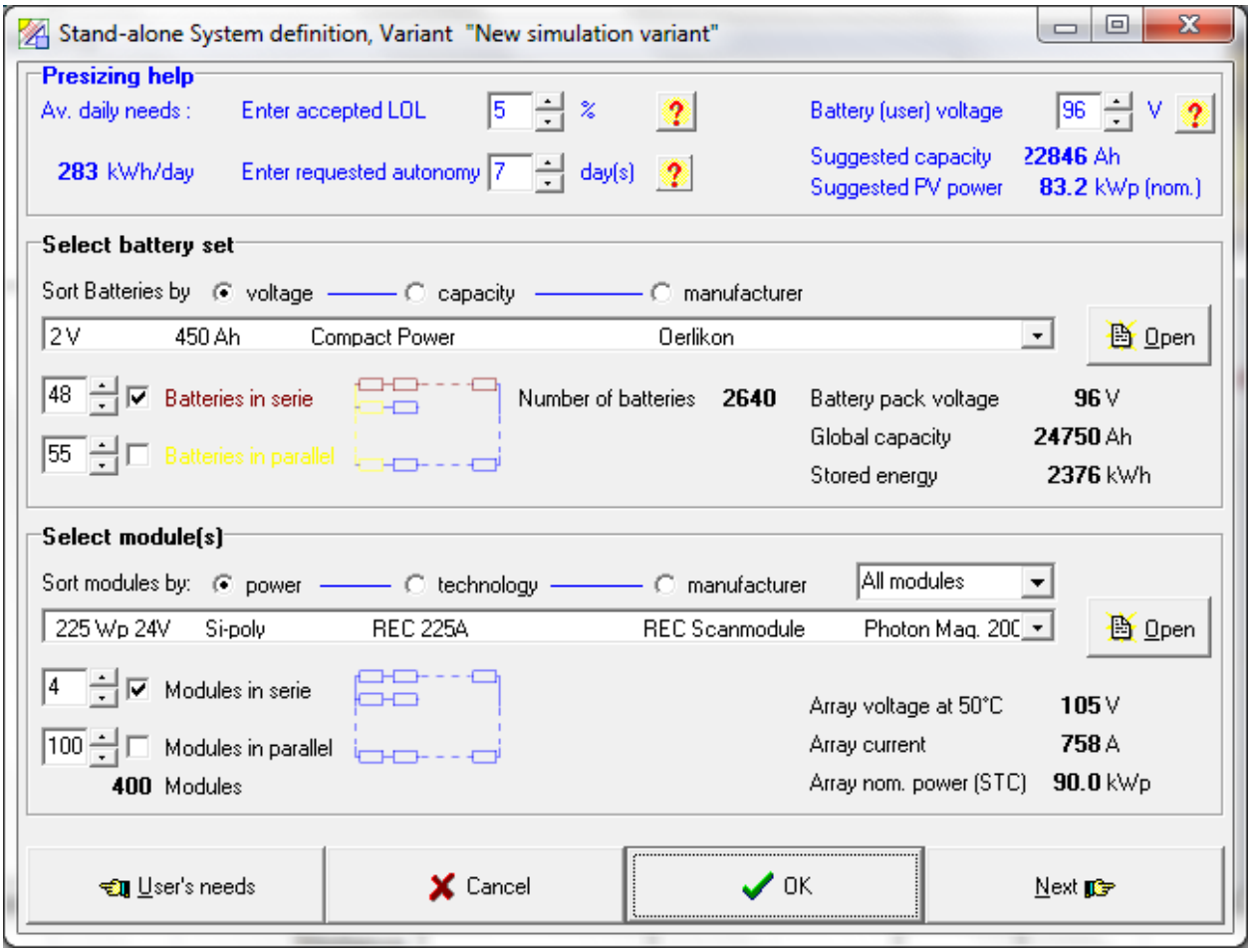


Figure 2 The details of the selected PV array and the battery bank

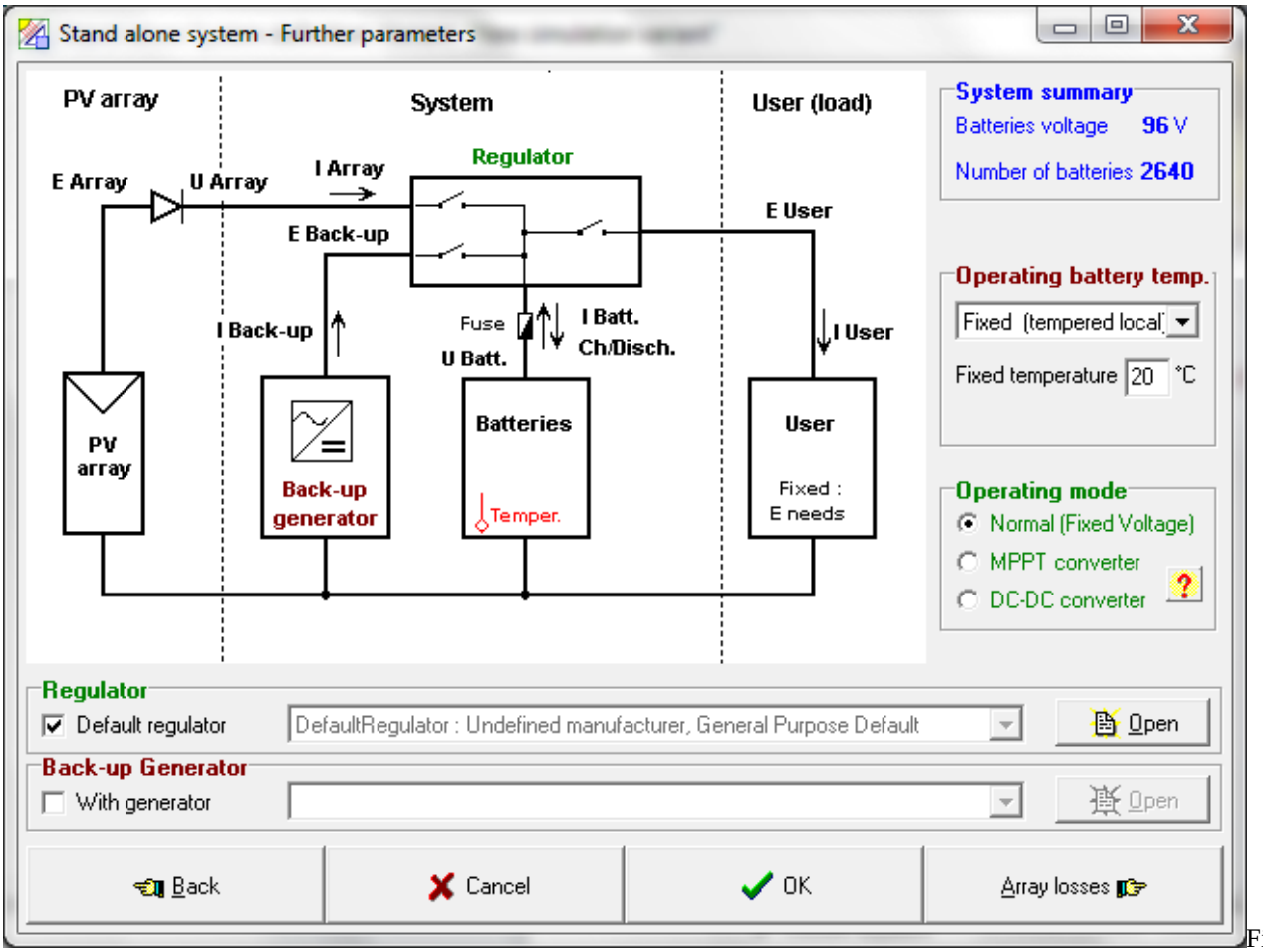


Figure 3 The schematic diagram of the off-grid solar powered LED street light

III. RESULTS AND DISCUSSION

The screenshot of PVSyst main result on normalized energy production is shown in Figure 4. The results show that the system has a performance ratio of 0.66 or 66 % with specific energy yield of 1432 kWh/kW//year. Also, the normalized energy output of the system is 3.14kWh/kW/day with normalized array loss of 1.28 kWh/kW/day and normalized system loss of 0.28 kWh/kW/day.

The screenshot of PVSyst energy use and loss of load probability is given in Figure 5. It shows that the yearly LOLP is 0.07 % which amounts to a total loss of load (LOL) duration of 6 hour per year. This means that out of the 8760 hours in a year, only 6 hours in a year will the user (street light) energy demand not be met. Specifically, Figure 5 shows that there are 2 hours LOL duration in February, 2 hours LOL duration in April, 1 hour LOL duration in May and 1 hour LOL duration in December.

The results on the normalized production and loss factors are shown in Figure 6. The system has 10.5% unused energy, 16.7% PV array losses, 6 % system losses and 66.8 performance ratio. In all, the solar power system will provide the daily energy demand with maximum LOLP of 0.3 % in February and annual average LOLP of 0.07 % which is very small compared with the specified maximum annual average LOLP of 5%.

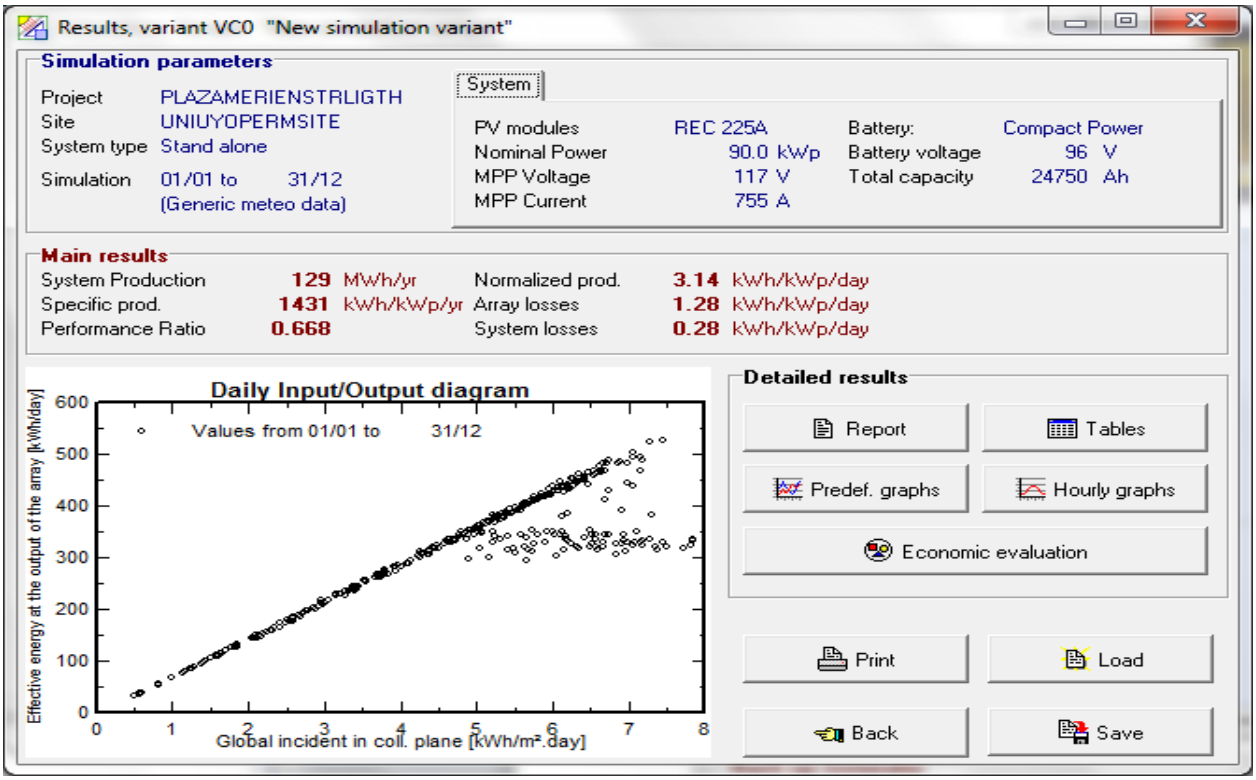
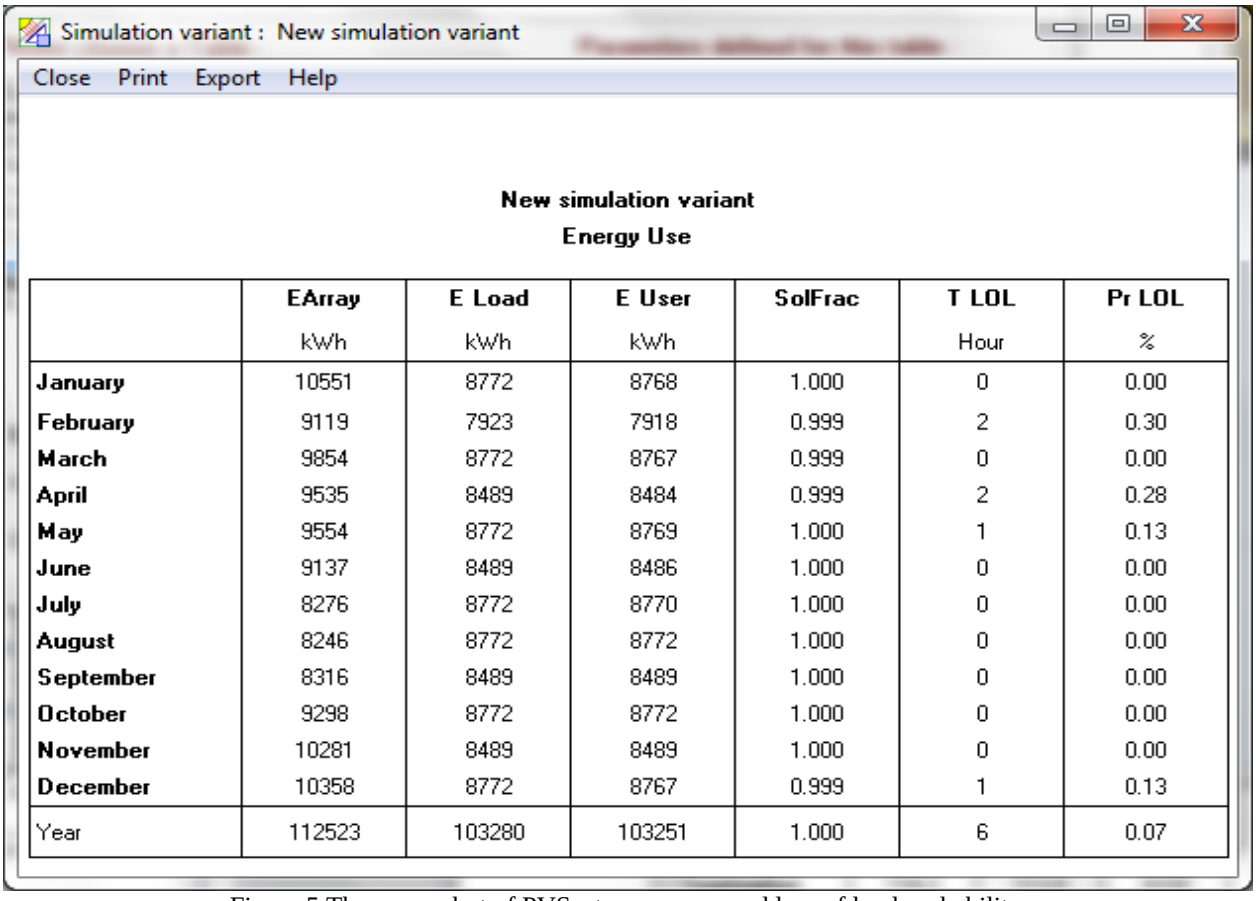


Figure 4 The screenshot of PVSyst main result on normalized energy production



	EArray kWh	E Load kWh	E User kWh	SolFrac	T LOL Hour	Pr LOL %
January	10551	8772	8768	1.000	0	0.00
February	9119	7923	7918	0.999	2	0.30
March	9854	8772	8767	0.999	0	0.00
April	9535	8489	8484	0.999	2	0.28
May	9554	8772	8769	1.000	1	0.13
June	9137	8489	8486	1.000	0	0.00
July	8276	8772	8770	1.000	0	0.00
August	8246	8772	8772	1.000	0	0.00
September	8316	8489	8489	1.000	0	0.00
October	9298	8772	8772	1.000	0	0.00
November	10281	8489	8489	1.000	0	0.00
December	10358	8772	8767	0.999	1	0.13
Year	112523	103280	103251	1.000	6	0.07

Figure 5 The screenshot of PVSyst energy use and loss of load probability

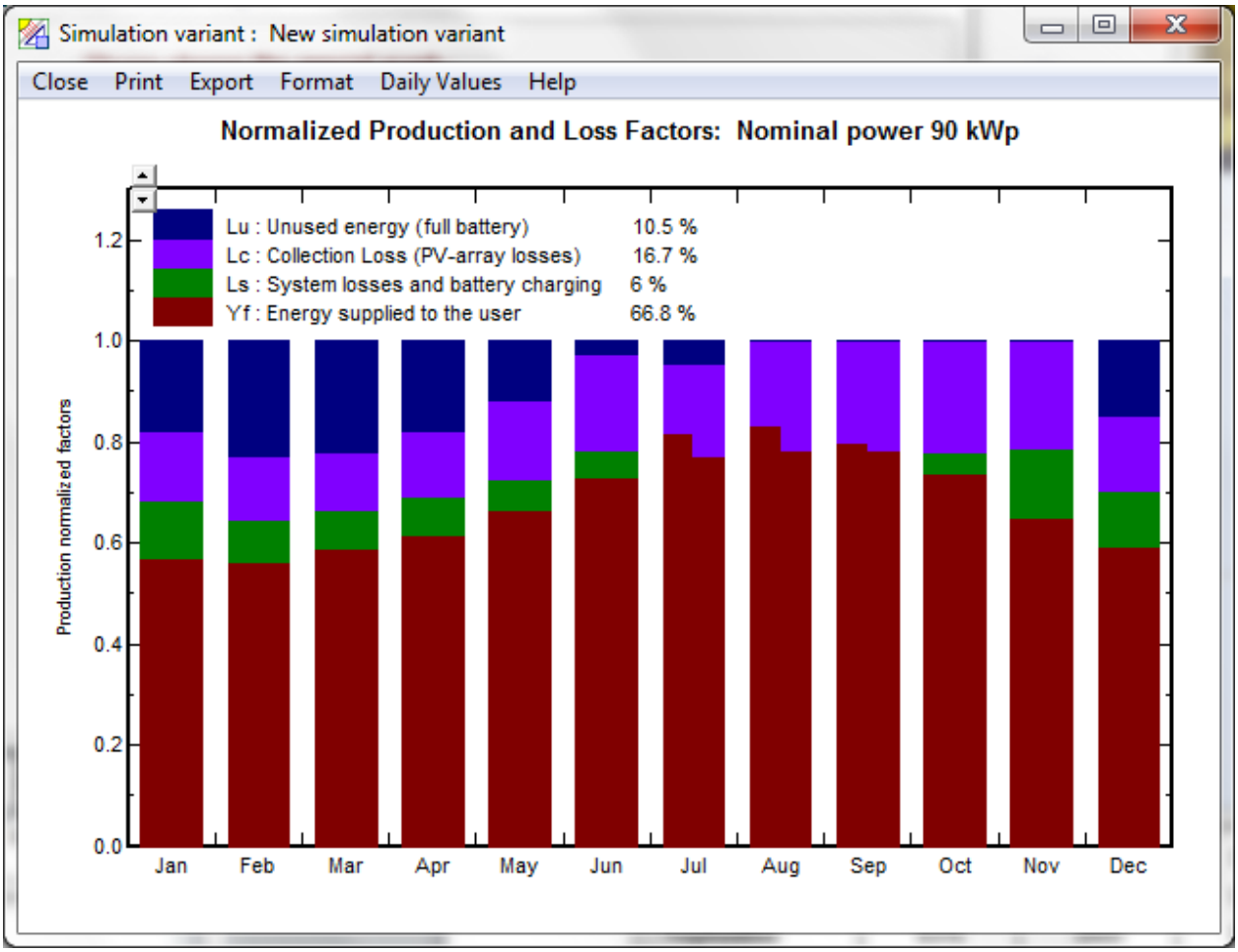


Figure 6 The normalized production and loss factors

IV. CONCLUSION

The sizing of solar power system for street light along the dual carriage way from Uyo Plaza to the Akwa IbomLe Meridien Ibom Hotel & Golf Resort is presented. The 14 Km road is to be powered by aoff-grid solar power system with centralized PV array and battery bank. This approach is meant to avoid the **vandalisation** of the solar power components which is experienced in the split unit installation, where each street light pole is equipped with solar panel, storage battery and LED light bulb. The sizing of the solar power system is conducted using PVSyst software. The sizing specification required a maximum annual average loss of load probability of 5% however, the PVSyst simulation gave a better result with maximum annual average loss of load probability of 0.7 %.

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