Ecofriendly Elevator Solar Power System Design And Evaluation Using PVSYST

Nwaibe obiora Chukwuma[1]
Advanced Space Technology Applications Laboratory Uyo,
National Space Research and Development Agency,
Federal Capital Territory, Abuja, Nigeria

Sunday Victor Etop[2]
Department of Electrical /Electronic Engineering
University of Uyo, Akwa Ibom State
victor.etop@yahoo.com

Iniobong E. Abasi-obot[3]
Department of Electrical and Electronic Engineering
Akwa Ibom State University, Ikot Akpaden, Nigeria
iniobongabasiobot@aksu.edu.ng

***Abstract*— In this paper, ecofriendly elevator solar power system design and evaluation using PVSyst. A case study traction lift (elevator) with 41675.7 Wh analytically determined daily energy demand is used. The meteorological data of installation site in Akwa Ibom State was downloaded from NASA portal using PVSyst software and the system was configured for 4 days power autonomy and 1 % loss of load probability along with a backup generator which has a nominal power of 3 kW and effective power of 2.7 kW. The simulation was also conducted using PVSyst and the results showed that the annual energy yield was 21637 kWh per year, the annual unused energy was 5683.1 kWh per year, the annual battery self-discharge was 732.5 Ah and the batter energy charge/discharge efficiency was 92.8 %. Also, the annual performance ratio of the system was 0.562 or 56.2 %. In essence, about 56.2 % of the energy yield were utilized whereas the remaining 43.8% of the energy were losses of which 25.12 % was loss due to unused energy. In all, the solar power system designed for the ecofriendly elevator can adequately power the elevator without any loss of load and without requiring any backup power system. Also, the unused energy realized can be used to power additional 25 % of the elevator energy demand.**

Keywords*— *Ecofriendly, solar power, elevator, PVSyst, loss of load, solar radiation, photovoltaic power

1. INTRODUCTION

In the last few decades, there have been growing quest for ecofriendly power systems [1,2,3,4,5]. In this wise, the global community has continued to promote solar power systems, wind energy system, and other energy generation approaches that minimizes carbon emission into the atmosphere [6,7,8]. Among the various energy sources, solar photovoltaic power has been the most adopted option in Nigeria [9,10,11,12]. Accordingly, in this paper, solar power system for ecofriendly elevator is presented.

Specifically, elevators require effective power supply without loss of load as any power failure might have serious effect on the users [13,14,15,16]. Also, in Nigeria with perennial power problem [17,18,19], it is better to design for autonomous power system that can sustain the load without the power from the national grid. As such, in this work, an off grid solar power system with backup generator and battery bank is designed for the ecofriendly elevator. The PVSyst software is used for the solar power system sizing and performance evaluation [20,21,22,23,24]. The energy consumption of the elevator is analytical determined using the approach and case study presented in [25].

2. METHODOLOGY

The focus in this paper is to design a solar power system that can be used to effectively power an elevator. In order to guarantee constant power supply without loss of load, a backup generator is included. The approach used is to first determine the daily energy demand of the elevator using available analytical expressions and datasets. Next, the meteorological data for the installation site of the elevator is downloaded using PVSyst meteorological data import tool. Then, the sizing and evaluation of the performance of the solar power system is conducted using the PVSyst software.

2.1 DETERMINATION OF THE DAILY ENERGY CONSUMPTION OF THE ELEVATOR

For an elevator with daily standby and running energy consumptions denoted as E_{stby} and E_{rndly} respectively, the total daily energy consumption, E_{tdloy} of the elevator is given as [25];

$$E_{tdloy} = E_{rndly} + E_{stby} \quad (1)$$

Where

$$E_{rndly} = \frac{(n_{trp})(Pav_{trp})(K_{Lftrp})(E_{rnISO})}{2} \quad (2)$$

where: n_{trp} indicates the number of trips done by the elevator per day. Pav_{trp} Indicates the % of average distance traveled per trip, K_{Lftrp} indicates the load factor, and E_{rnISO} indicates the ISO reference cycle running energy consumption which is 2 trips and expressed in Wh. The value of E_{rnISO} can be read from ISO table. The load factor, K_{Lftrp} for traction lifts can be estimated from the percentage average elevator car load/weight, $\%Q$ as follows [25];

$$K_{Lftrp} = \begin{cases} 1-(\%Q)(0.0164) & \text{for counter balance of } 50\% \\ 1-(\%Q)(0.0192) & \text{for counter balance of } 50\% \end{cases} \quad (3)$$

Similarly, the load factor, K_{Lftrp} for r hydraulic lifts can be estimated from the percentage average elevator car load, $\%Q$ as follows [25];

$$K_{Lftrp} = \begin{cases} 1-(\%Q)(0.01071) & \text{for no counter balance} \\ 1-(\%Q)(0.01) & \text{for counter balance of } 35\% \\ 1-(\%Q)(0.0187) & \text{for counter balance of } 70\% \end{cases} \quad (4)$$

The idle / standby energy consumption of the elevator per day is denoted as E_{stby} and it is given as [25];

$$E_{stby} = \left(24 - \left(\frac{n_{trp}}{3600}\right) t_{avtrp}\right) [(P_{id})(R_{id}) + (P_{st})(R_{st})] \quad (5)$$

Where P_{id} indicates the idle mode power of the elevator (W); P_{st} indicates the standby mode power of the elevator (W); R_{id} indicates the idle time ratio when the elevator is consuming P_{id} (its value is less than 1) , R_{st} indicates the standby time ratio when the elevator is consuming P_{st} (its value is less than 1) and t_{avtrp} indicates the time taken to travel the average distance per trip (s). The value used for R_{id} and R_{st} are given in ISO Table. If S_{avtrp} is the average distance, then the t_{avtrp} is given as [25];

$$t_{avtrp} = \frac{S_{avtrp}}{V} + \frac{V}{a} + \frac{a}{j} + t_d \quad (6)$$

where V is the elevator velocity in m/s, a is acceleration m/s^2, j is the rated jerk in m/s^2, t_d is the time for elevation door opening and closing at the landing.

2.2 THE CASE STUDY ELEVATOR DAILY ENERGY CONSUMPTION AND SOLAR RADIATION DATA

The case study traction lift (elevator) parameters are given in Table 1. Now, for Counter balancing of 50% [25]; $K_{Lftrp} = 1-(\%Q)(0.0164)$, hence, $K_{Lftrp} = 1-(7)(0.0164) = 1 - 0.1148 = 0.8852 \approx 0.89$

Table 1 The case study elevator parameters

S/N	Parameter	Traction lift
1	Rated load, Q (kg)	600
2	Speed, V (m/s)	2.5
3	Travel distance, d (m)	75
4	No. of stops	20
5	Counter balancing, (%)	50
6	Acceleration ,a (m/s^2)	1
7	Jerk , j (m/s^2)	1.25
8	Door times , t_d (s)	8
9	Idle mode power, P_{id} (W)	500
10	Standby mode power, P_{st} (W)	120
11	ISO reference cycle energy, (E_{rnISO}) (Wh)	170
12	Average no. of trips per day, n_{trp}	1500
13	Percentage of average distance traveled, (Pav_{trp}) (%)	33
14	Average car load, $\%Q$ (%)	7
15	R_{id}	0.42
16	R_{st}	0.58

$$E_{rndly} = \frac{(n_{trp})(Pav_{trp})(K_{Lftrp})(E_{rnISO})}{2} = \frac{(1500)(0.33)(0.89)(170)}{2} = 37446.75 \text{ Wh}$$

$$S_{avtrp} = (Pav_{trp})(d) = 0.33(75) = 24.75 \text{ m}$$

$$t_{avtrp} = \frac{S_{avtrp}}{V} + \frac{V}{a} + \frac{a}{j} + t_d = \frac{24.75}{2.5} + \frac{2.5}{a1} + \frac{1}{1.25} + 8 = 21.3$$

$$E_{stby} = \left(24 - \left(\frac{n_{trp}}{3600}\right) t_{avtrp}\right) [(P_{id})(R_{id}) + (P_{st})(R_{st})]$$

$$E_{stby} = \left(24 - \left(\frac{15000}{3600}\right)(21.)\right) [(500)(0.42) + (120)(0.58)] = 4228.95 \text{ Wh}$$

$$E_{tdloy} = E_{rndly} + E_{stby} = 37446.75 + 4228.95 = 41675.7 \text{ Wh}$$

The analytical computations based on the parameter values in Table 1 show that the daily energy case study elevator has a daily energy demand of 41675.7 Wh per day. The energy demand is modeled in PVSyst software as a constant load of 1737 watts that runs for 24 hours in a day (as shown in Figure 1) and that amounts to 41688 Wh per day which is 41.688 kWh per day. The PVSyst sofwtaere approximated to 41.7 kWh per day (as shown in Figure 1). Also, the screenshot of PVSyst software plot of the daily global solar radiation on the horizontal plain at the installation site of the PV power system is shown in Figure 2.

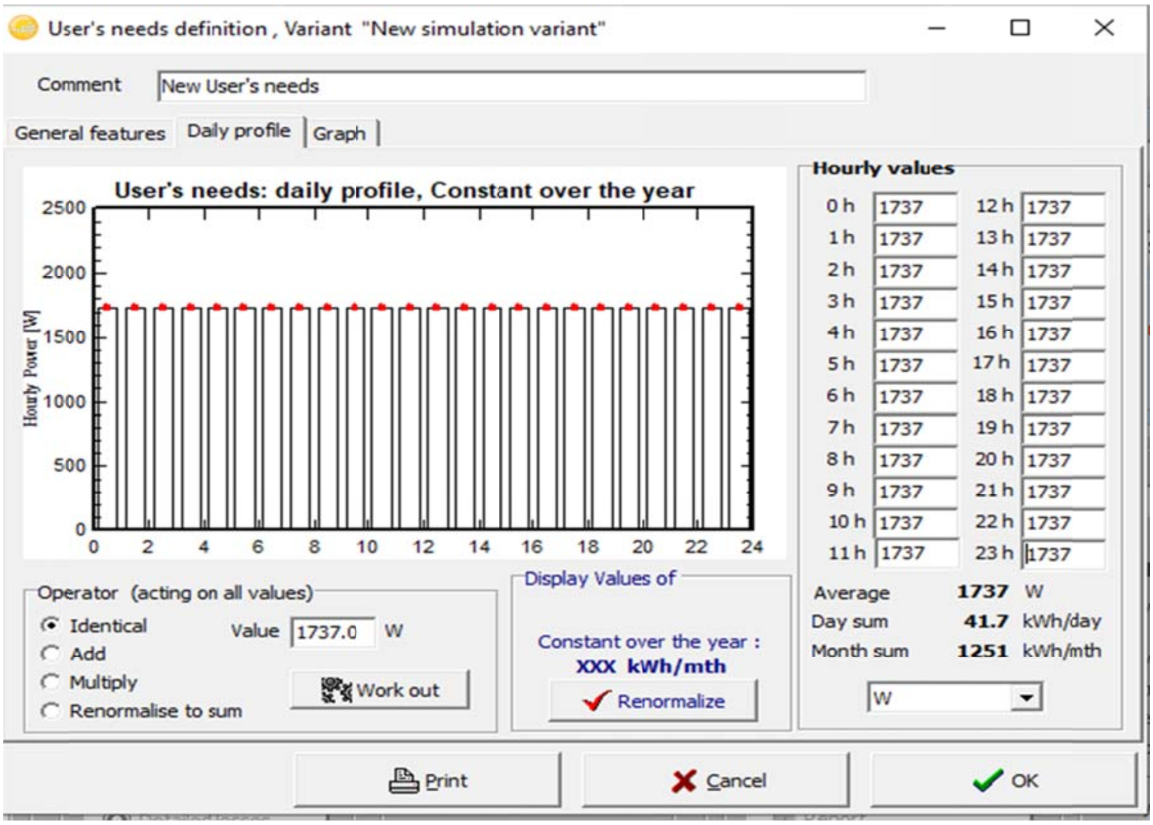

Figure 1 The screenshot of PVSyst software modelling of the daily energy demand of the case study elevator.

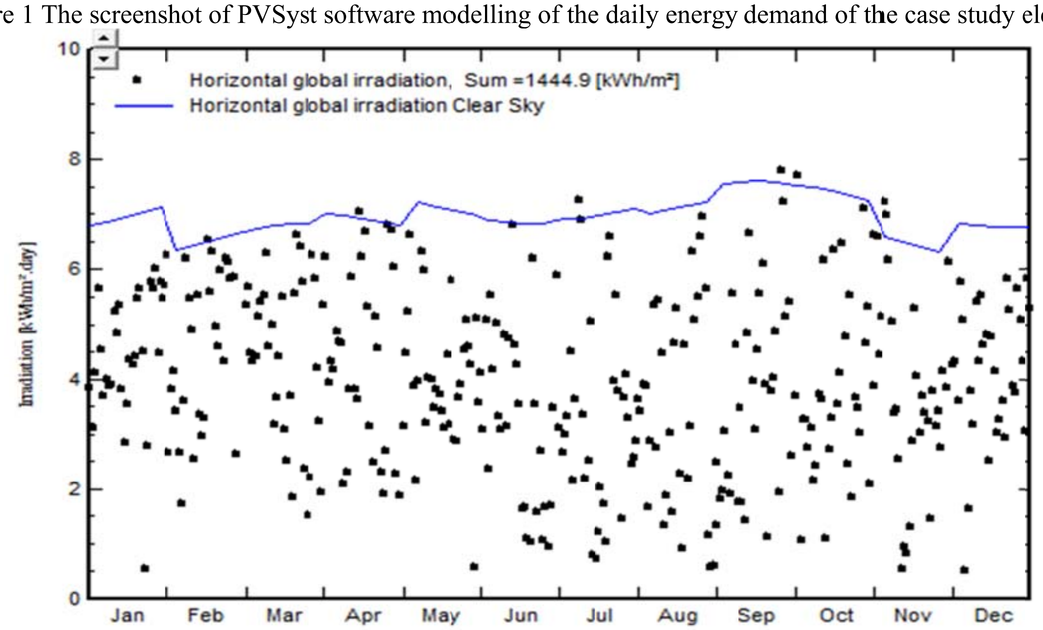

Figure 2 The screenshot of PVSyst software plot of the daily global solar radiation on the horizontal plain at the installation site of the PV power system.

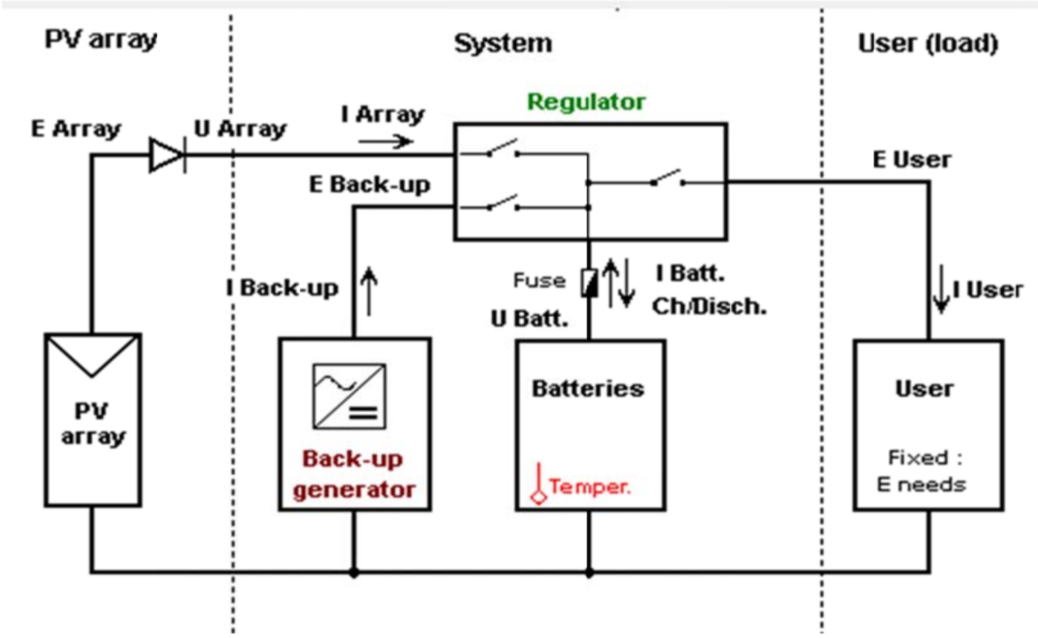

Figure 3 The screenshot of PVSyst software schematic diagram of the PV power system.

Again, the screenshot of PVSyst software system configuration for the solar power system is shown in Figure 3. The information in Figure 3 shows that system is configure for 4 days power autonomy and1 % loss of load probability and based on these settings and the given elevator daily load demand, the PV array and battery bank sizes were determined by the PVSyst software. The system energy yield, energy consumptions, energy losses and performance parameters are then obtained by conducting a simulation using the PVSyst software.

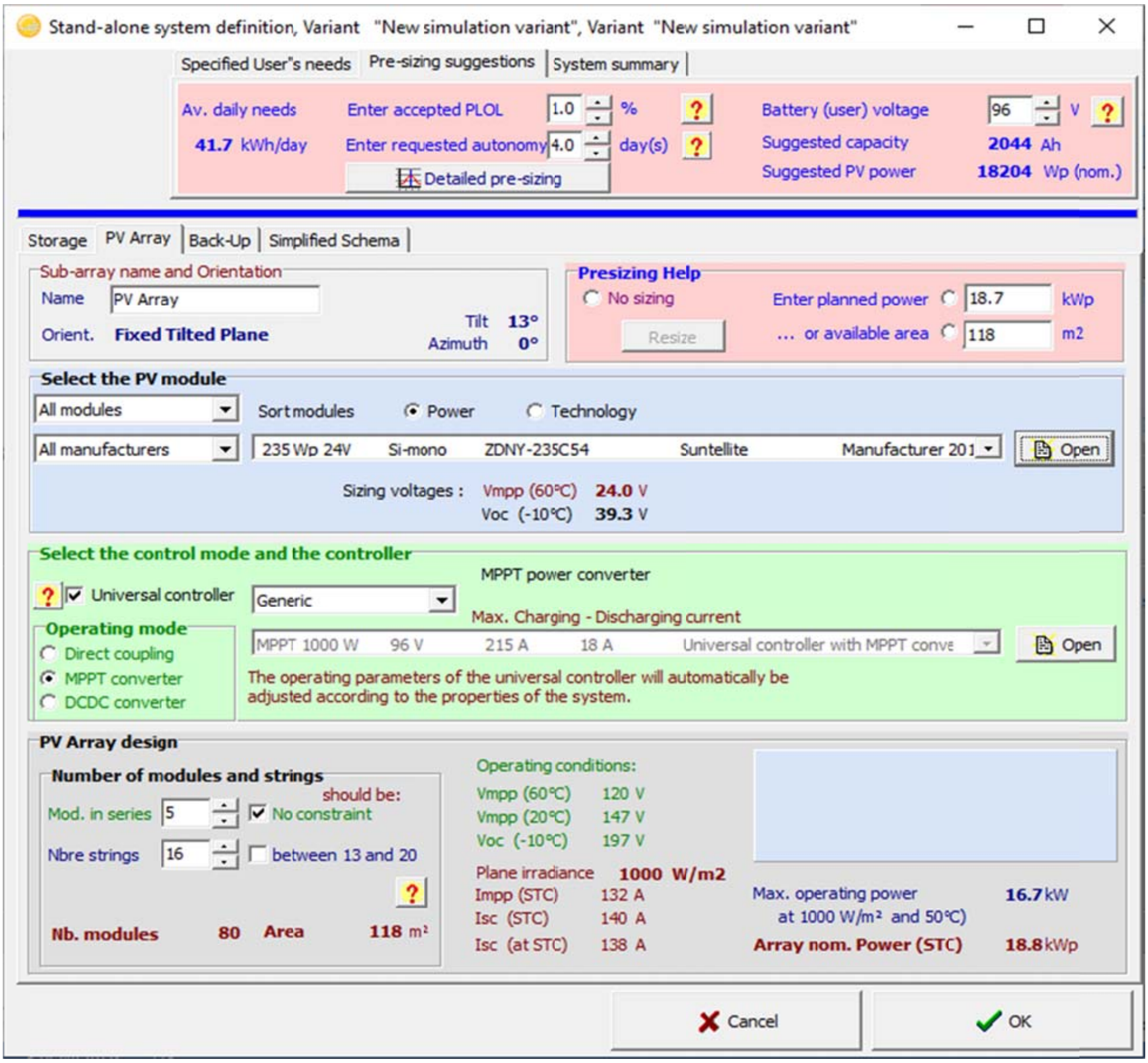

Figure 3 The screenshot of PVSyst software system configuration for the solar power system

3. RESULTS AND DISCUSSION

The screenshot of the PVSyst simulation result showing the key parameters used in the simulation and some other parameters that are generated from the simulations are shown in Figure 4. Specifically, Figure 4 shows the geo-coordinates of the PV installation site, the PV array tilt angle of 13°, the approximate daily energy demand of 42 kWh, the features and capacities of the PV array, the battery bank, the controller and the backup generator which has a nominal power of 3 kW and effective power of 2.7 kW.

The screenshot of the PVSyst simulation result in Figure 5 shows the monthly solar radiation data, the monthly energy yield of the PV array, energy delivered to the elevator (denoted as E-User) , and the solar fraction which is the portion of the load demand that is supplied from the solar power. The results show that in all the month, the solar power supplied all the energy demanded by the elevation, and this is evident with the solar fraction of 1 in all the months. The annual energy yield is 21637 kWh per year, the annual unused energy is 5683.1 kWh per year. That means , the solar power can be used to also power additional load with annual energy demand of 5683.1 kWh.

PVSYST V6.87		11/08/23	Page 1/6

Stand alone system: Simulation parameters

Project :	**Elevator**			
Geographical Site		**Akwa Ibom 1**	Country	**Nigeria**
Situation	Latitude	4.03° N	Longitude	7.02° E
Time defined as	Legal Time	Time zone UT	Altitude	0 m
	Albedo	0.20		
Meteo data:	**Akwa Ibom 1**	Meteonorm 7.2, Sat=100% - Synthetic		
Simulation parameters	System type	**Stand alone with back-up generator**		
Collector Plane Orientation	Tilt	13°	Azimuth	0°
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
User's needs :	daily profile	Constant over the year		
	average	42 kWh/Day		
PV Array Characteristics				
PV module Si-mono	Model	**ZDNY-235C54**		
Original PVsyst database	Manufacturer	Suntellite		
Number of PV modules	In series	5 modules	In parallel	16 strings
Total number of PV modules	Nb. modules	80	Unit Nom. Power	235 Wp
Array global power	Nominal (STC)	**18.80 kWp**	At operating cond.	16.69 kWp (50°C)
Array operating characteristics (50°C)	U mpp	127 V	I mpp	132 A
Total area	Module area	**118 m²**	Cell area	103 m²
System Parameter	System type	**Stand alone system with back-up generator**		
Battery	Model	**MPG 12V 125 F**		
	Manufacturer	Narada		
Battery Pack Characteristics	Nb. of units	8 in series x 17 in parallel		
	Voltage	96 V	Nominal Capacity	2125 Ah
	Discharging min. SOC	20.0 %	Stored energy	168.2 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.	108.3 / 102.6 V
	Discharging	SOC = 0.20 / 0.45	i.e. approx.	95.8 / 99.5 V
	Back-Up Genset Command	SOC = 0.25/0.45	i.e. approx.	97.1 / 99.5 V
Back-up genset	Model	3 kW		
	Manufacturer	Back-up generator		
	Nominal power	3.0 kW	Effective power	2.7 kW
PV Array loss factors				
Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s

Figure 4 The screenshot of the PVSyst simulation result showing the key parameters used in the simulation and some other parameters that are generated from the simulations

Simulation variant : New simulation variant

Close Print Export Help

Balances and main results

	GlobHor kWh/m²	GlobEff kWh/m²	E_Avail kWh	EUnused kWh	E_User kWh	E_Load kWh	SolFrac
January	136.2	139.2	2152	723.9	1292	1292	1.000
February	127.4	127.2	1953	729.7	1167	1167	1.000
March	135.9	131.0	2028	678.7	1292	1292	1.000
April	130.8	121.6	1897	601.2	1250	1251	1.000
May	124.8	112.7	1774	391.4	1292	1292	1.000
June	101.7	90.8	1436	246.7	1250	1251	1.000
July	103.5	92.6	1456	18.0	1292	1292	1.000
August	107.8	99.1	1569	336.3	1292	1292	1.000
September	114.4	108.8	1704	298.2	1250	1251	1.000
October	118.2	116.4	1805	444.7	1292	1292	1.000
November	115.3	117.0	1806	514.6	1250	1251	1.000
December	129.0	132.5	2058	699.7	1292	1292	1.000
Year	1444.9	1388.9	21637	5683.1	15211	15216	1.000

EArray - Effective energy at the output of the array
E_Load - Energy need of the user (Load)
E_User - Energy supplied to the user
E_BkUp - Back-up Generator Energy
SolFrac - Solar fraction (EUsed / ELoad)

Figure 5 The screenshot of the PVSyst simulation result for the energy yield and solar fraction

The screenshot of the PVSyst simulation result for the system performance is presented in Figure 6 which shows annual performance ratio of 0.562 or 56.2 %. In essence, about 56.2 % of the energy yield are utilized whereas the remaining 43.8% of the energy are losses of which 25.12 % is loss due to unused energy, as shown in Figure 7 .

The screenshot of the PVSyst simulation result for the balance of the system is presented in Figure 8. The results shows that the backup generator is never used as it shows zero ampere-hour (Ah) value. Also the annual battery self discharge is 732.5 Ah, the batter energy charge/discharge efficiency is 92.8 %. In all, the solar power system designed for the elevator can adequately power the elevator without any loss of load and without requiring any backup power system. Also, the unused energy realized can be used to power additional 25 % of the elevator energy demand.

Simulation variant : New simulation variant

Close Print Export Help

Normalized Performance Coefficients

	Yr kWh/m².day	Lu	Yu kWh/kWp/da	Lc	Ya kWh/kWp/da	Ls	Yf kWh/kWp/da	PR
January	4.64	1.242	4.64	2.041	2.60	0.386	2.22	0.477
February	4.69	1.386	4.69	2.227	2.47	0.251	2.22	0.472
March	4.38	1.164	4.38	1.920	2.46	0.243	2.22	0.506
April	4.21	1.066	4.21	1.766	2.44	0.223	2.22	0.527
May	3.79	0.672	3.79	1.270	2.52	0.303	2.22	0.585
June	3.15	0.437	3.15	0.915	2.24	0.021	2.22	0.703
July	3.11	0.031	3.11	0.496	2.62	0.401	2.22	0.712
August	3.32	0.577	3.32	1.077	2.24	0.027	2.22	0.668
September	3.77	0.529	3.76	1.118	2.65	0.430	2.22	0.589
October	3.89	0.763	3.89	1.408	2.48	0.262	2.22	0.570
November	4.03	0.912	4.03	1.600	2.43	0.215	2.22	0.550
December	4.42	1.201	4.42	1.948	2.48	0.259	2.22	0.501
Year	3.95	0.828	3.95	1.478	2.47	0.252	2.22	0.562

Yr - Reference Incident Energy in coll. plane
Lu - Normalized Unused (Full battery) Loss
Yu - Normalized Potential production
Lc - Normalized Array Losses
Ya - Normalized Array Production
Ls - Normalized System Losses
Yf - Normalized System Production
PR - Performance Ratio

Figure 6 The screenshot of the PVSyst simulation result for the system performance

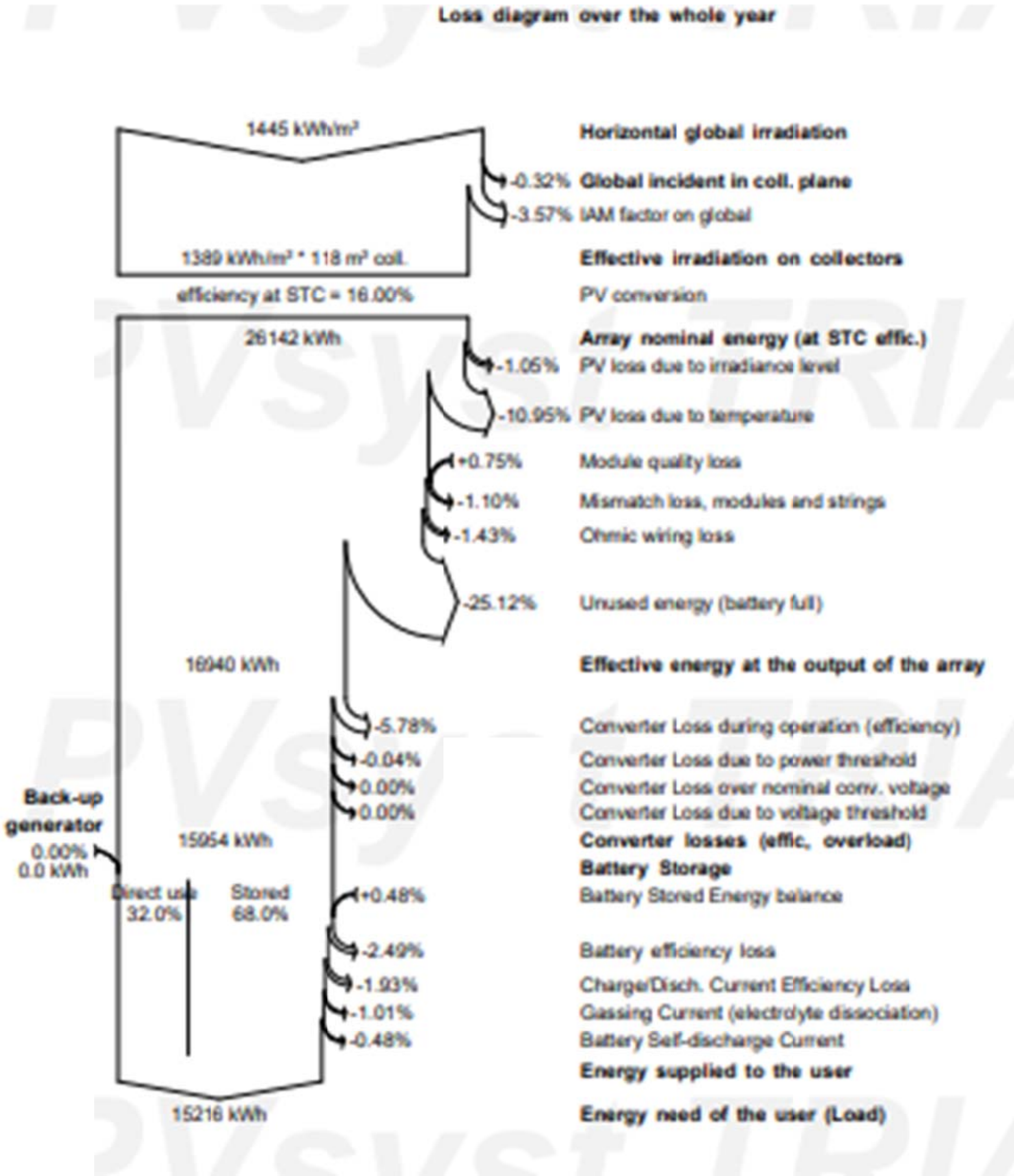

Figure 7 The screenshot of the PVSyst simulation result for the system loss diagram

Simulation variant : New simulation variant

Close Print Export Help

Balances of Currents in the system

	IArray Ah	IBatCh Ah	IBatDis Ah	IBGass Ah	IBSelf Ah	I_BkUp Ah	EffBatI %	EffBatE %
January	12059.4	10046.8	8846.1	127.5	62.2	0.0	87.4	86.8
February	10321.1	8378.7	7947.2	164.7	56.2	0.0	93.7	93.4
March	11357.2	9077.3	8633.3	166.2	62.2	0.0	93.9	93.7
April	10797.6	8590.2	8249.8	162.8	60.2	0.0	93.8	94.6
May	11398.5	8981.6	8196.9	200.9	62.2	0.0	93.4	90.0
June	9746.0	7247.7	7915.5	111.6	60.2	0.0	93.8	107.6
July	11762.9	8865.5	7470.3	94.9	62.2	0.0	95.1	83.3
August	10069.8	7603.3	8267.6	123.7	62.2	0.0	93.7	107.1
September	11583.3	9179.8	7708.6	72.6	60.2	0.0	95.3	82.9
October	11287.8	8785.4	8210.1	119.3	62.2	0.0	94.0	92.2
November	10754.6	8542.4	8222.6	77.1	60.2	0.0	94.7	95.0
December	11391.1	9383.9	8863.0	149.2	62.2	0.0	94.0	93.0
Year	132529.1	104682.5	98531.0	1570.6	732.5	0.0	93.4	92.8

IArray - Array Current
IBatCh - Battery Charging Current
IBatDis - Battery Discharging Current
IBGass - Gassing Current (electrolyte dissociation)
IBSelf - Battery Self-discharge Current
I_BkUp - Back-up Generator Current
EffBatI - Battery current charge/discharge efficiency
EffBatE - Battery energy charge/discharge efficiency

Figure 8 The screenshot of the PVSyst simulation result for the balance of the system

4. CONCLUSION

A solar power system for powering an elevator is presented. The focus is to use PVSyst software for the sizing of the PV array, the battery bank and the other relevant components of the solar power and also to evaluate the performance of the system. The sizing is based on the analytically computed daily energy demand of the elevator and the solar radiation data of the installation site. The simulation results show that the selected PV array and battery bank can effectively power the elevator without any loss of load and without requiring any backup power system. Also, the unused energy realized can be used to power additional 25 % of the elevator energy demand.

REFERENCES

1. Das, P., Ghosh, S., Chatterjee, S., & De, S. (2022). A low cost outdoor air pollution monitoring device with power controlled built-in PM sensor. *IEEE Sensors Journal*, *22*(13), 13682-13695.
2. Ali, S., Glass, T., Parr, B., Potgieter, J., & Alam, F. (2020). Low cost sensor with IoT LoRaWAN connectivity and machine learning-based calibration for air pollution monitoring. *IEEE Transactions on Instrumentation and Measurement*, *70*, 1-11.
3. Kombo, O. H., Kumaran, S., & Bovim, A. (2021). Design and application of a low-cost, low-power, LoRa-GSM, IoT enabled system for monitoring of groundwater resources with energy harvesting integration. *IEEE Access*, *9*, 128417-128433.
4. Ragnoli, M., Leoni, A., Barile, G., Ferri, G., & Stornelli, V. (2022). LoRa-Based Wireless Sensors Network for Rockfall and Landslide Monitoring: A Case Study in Pantelleria Island with Portable LoRaWAN Access. *Journal of Low Power Electronics and Applications*, *12*(3), 47.
5. Kökten, E., Çalışkan, B. C., Karamzadeh, S., & Soyak, E. G. (2020). Low-power agriculture IoT system with LoRa: Open field storage observation. *The Scientific Journal of Riga Technical University-Electrical, Control and Communication Engineering*, *16*(2), 88-94.
6. Yu, D., Li, Z., Fan, S., & Sun, T. (2023). Optimal management of an energy-water-carbon nexus employing carbon capturing and storing technology via downside risk constraint approach. *Journal of Cleaner Production*, 138168.
7. Voumik, L. C., Islam, M. A., Ray, S., Mohamed Yusop, N. Y., & Ridzuan, A. R. (2023). CO2 emissions from renewable and non-renewable electricity generation sources in the G7 countries: static and dynamic panel assessment. *Energies*, *16*(3), 1044.
8. Kabeyi, M. J. B., & Olanrewaju, O. A. (2022). Sustainable energy transition for renewable and low carbon grid electricity generation and supply. *Frontiers in Energy research*, *9*, 1032.

9. Babajide, A., & Brito, M. C. (2021). Solar PV systems to eliminate or reduce the use of diesel generators at no additional cost: A case study of Lagos, Nigeria. *Renewable Energy*, *172*, 209-218.
10. Anugwom, E. E., Anugwom, K. N., & Eya, O. I. (2020). Clean energy transition in a developing society: Perspectives on the socioeconomic determinants of Solar Home Systems adoption among urban households in southeastern Nigeria. *African Journal of Science, Technology, Innovation and Development*, *12*(5), 653-661.
11. Agbo, E. P., Edet, C. O., Magu, T. O., Njok, A. O., Ekpo, C. M., & Louis, H. (2021). Solar energy: A panacea for the electricity generation crisis in Nigeria. *Heliyon*, *7*(5).
12. Chanchangi, Y. N., Adu, F., Ghosh, A., Sundaram, S., & Mallick, T. K. (2023). Nigeria's energy review: Focusing on solar energy potential and penetration. *Environment, Development and Sustainability*, *25*(7), 5755-5796.
13. Othman, S. A., Mohammed, J. A. K., & Mohammed, F. M. (2021, August). Variable speed drives in electric elevator systems: A review. In *Journal of Physics: Conference Series* (Vol. 1973, No. 1, p. 012028). IOP Publishing.
14. Dalala, Z., Alwahsh, T., & Saadeh, O. (2021). Energy recovery control in elevators with automatic rescue application. *Journal of Energy Storage*, *43*, 103168.
15. Terzic, V., & Villanueva, P. K. (2021). Method for probabilistic evaluation of post-earthquake functionality of building systems. *Engineering Structures*, *241*, 112370.
16. Odjugo, T., Baba, Y., Aliyu, A., Okereke, N., Oloyede, L., & Onifade, O. (2020). Optimisation of Artificial Lifts Using Prosper Nodal Analysis for BARBRA-1 Well in Niger Delta. *Nigerian Journal of Technological Development*, *17*(3), 150-155.
17. Akinbomi, J. G., Ezeilo, L. C., Fagbuyi, O., & Onyebueke, L. (2021). Optimal microgrid power supply system for Nigerian detached communities: Environmental impact and energy cost criteria. *Nigerian Journal of Technology*, *40*(3), 491-500.
18. Mbamalu, M., & Okoro, N. M. (2021). THE MEDIA AND A GREEN ENVIRONMENT: ASSESSING NEWSPAPER COVERAGE OF RENEWABLE ENERGY IN NIGERIA. *Electronic Green Journal*, *1*(45).
19. Ajayi, S. O., Ogunode, N. J., & Ayoko, V. O. (2023). CHALLENGES FACING E-LEARNING IN BASIC EDUCATION IN NIGERIA AND THE WAY FORWARD. *TA'LIM VA RIVOJLANISH TAHLILI ONLAYN ILMIY JURNALI*, *3*(5), 17-28.
20. 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.
21. Belmahdi, B., & El Bouardi, A. (2020). Solar potential assessment using PVsyst software in the northern zone of Morocco. *Procedia Manufacturing*, *46*, 738-745.
22. Belmahdi, B., & El Bouardi, A. (2020). Solar potential assessment using PVsyst software in the northern zone of Morocco. *Procedia Manufacturing*, *46*, 738-745.
23. Uwho, K. O., Idoniboyeobu, D. C., & Amadi, H. N. (2022). Design and Simulation of 500kW Grid Connected PV System for Faculty of Engineering, Rivers State University Using Pvsyst software. *Iconic Research and Engineering Journals*, *5*(8), 2456-8880.
24. 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.
25. Barney, G., & Lorente, A. (2013, September). Simplified energy calculations for lifts based on ISO/DIS 25745-2. In *3rd Symposium on Lift and Escalator Technologies* (Vol. 3, No. 1, pp. 16-25).