Development And Evaluation Of Load Scheduling Mechanism And Loss Of Load For PV Solar Power System With Dispatchable Load

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***Abstract*—In this work, development and evaluation of load scheduling mechanism and loss of load for PV solar power system with dispatchable load is presented. Specifically, high level flowchart and detailed algorithm for the load scheduling mechanism (LSM) are presented. The case study load is an Automatic Teller Machine (ATM) gallery that has 20 ATM and daily load demand of 475.536 kWh/day. The study location is in Akwa Ibom State (with latitude of 5.013629 and longitude of 7.909871), having annual mean daily solar radiation of 6.2 W-hr/m^2/day and annual mean of temperature of 26.2°C. The design utilized a 12 V, 100 Wp PV module and 12 V, 100 Ah battery which resulted in a 96.214825 kW PV array and 110488.5345 Ah battery bank. Also, the results show that with 3 days of power autonomy the battery can store a maximum of 3,148,923.2 Wh energy out of which 1,889,353.9 Wh energy can be available to the load while 1,259,569.3 Wh is the reserved energy in the battery. Also, 93 % of the load (a little above 18 out of the 20 ATMs) are scheduled while 7 % of the load (less than 2 out of the 20 ATMs) are dropped when the load scheduling mechanism is deployed. Furthermore, with the load scheduling, there is mean daily energy demand 586,217.352 Wh/day which is lower than the mean daily energy yield of 598,295.414 Wh/day, as such there is no missing energy but rather there is excess or unused energy with mean of 8,222.615 Wh/day. In all, the results showed that the load scheduling mechanism prevented loss of load, maintained battery state of charge to a high value which is good for the battery lifespan.**

Keywords:* *Load Scheduling Algorithm, Standalone PV System, Loss of Load, Thermal Loss, Dispatchable Load

1. INTRODUCTION

In order to meet the energy demand in remote locations with limited or no access to the power grid, many organizations have resorted to the use of solar power system [1,2]. Notably, solar energy systems rely on the stochastic solar radiation parameter to determine the appropriate size of the PV panel, the battery bank and other system component sizes [3,4]. In most cases, in order to avoid excessive loss of energy due to oversizing, a moderate component size is adopted for the PV panels and battery bank [5,6]. In such case, the system has loss of load due to the low solar radiation during the rainy season [7,8]. In such situation, appropriate load scheduling can be adopted to still satisfy the load especially in occasions where the load is dispatchable [9]. A typical example of dispatchable load is automatic teller machine (ATMs) gallery where some ATMs can be shut down while the others are powered to render the banking services to the bank clients in a 24 hours per day schedule [10].

Notably, over the years, different simulation software have been desired for the simulation of solar power system. However, the commonly available simulation software, like PVSyst [11] and HOMER [12] do not make provision for dynamic load scheduling by the user. Alternatively, programing tools and languages like MATHLAB, Visual Basic for Application (VBA), Python language and other computer languages can be used to develop programs that can dynamically schedule the load based on the available energy yield due to the fact that solar radiation is stochastic in nature [13]. However, for such load scheduling to be implemented using the programing tools and languages detailed analytical model for the solar power design, model for the load schedule and the models for the system performance evaluation in terms of loss of load and unused energy need to be developed.

Accordingly, the major focus in this work include development of dynamic load scheduling mechanism and the accompanying analytical model for standalone solar-powered ATM gallery which should ensure 24 hours service without loss of load. The study as examine how to develop the procedure for integrating the load scheduling mechanism into the solar PV power system and developed analytical model to evaluate the system performance in terms of loss of load probability, missing energy, unused energy, load scheduling factor and mean battery state of charge.

2 METHODOLOGY

In this work, high level flowchart and detailed algorithm for a load scheduling mechanism (LSM) meant for determination of appropriate fraction of the maximum daily load demand that can be powered on any given day to avert total power outage in a standalone solar power system with battery storage is presented. The LSM is based on the Battery State of Charge (BSoC), the maximum Depth of Discharge (DoD) permitted in the battery bank design, and the maximum daily load demand. The flowchart and detailed algorithm are presented followed by the case study load and meteorological datasets. The key outputs of the evaluation are the load scheduling factor, the energy yield, the loss of load probability, the missing energy, the unused energy and the thermal loss.

2.1 The flowchart for the load scheduling mechanism and loss of load computation

The flowchart used for the sizing of the solar system with load scheduling is shown in Figure 1. Notably, the load scheduling mechanism which determines the appreciate size of the load demand that is powered on any day based on the knowledge of the battery State Of Charge (SoC) in the previous day and the required battery Depth of Charge (DoD).

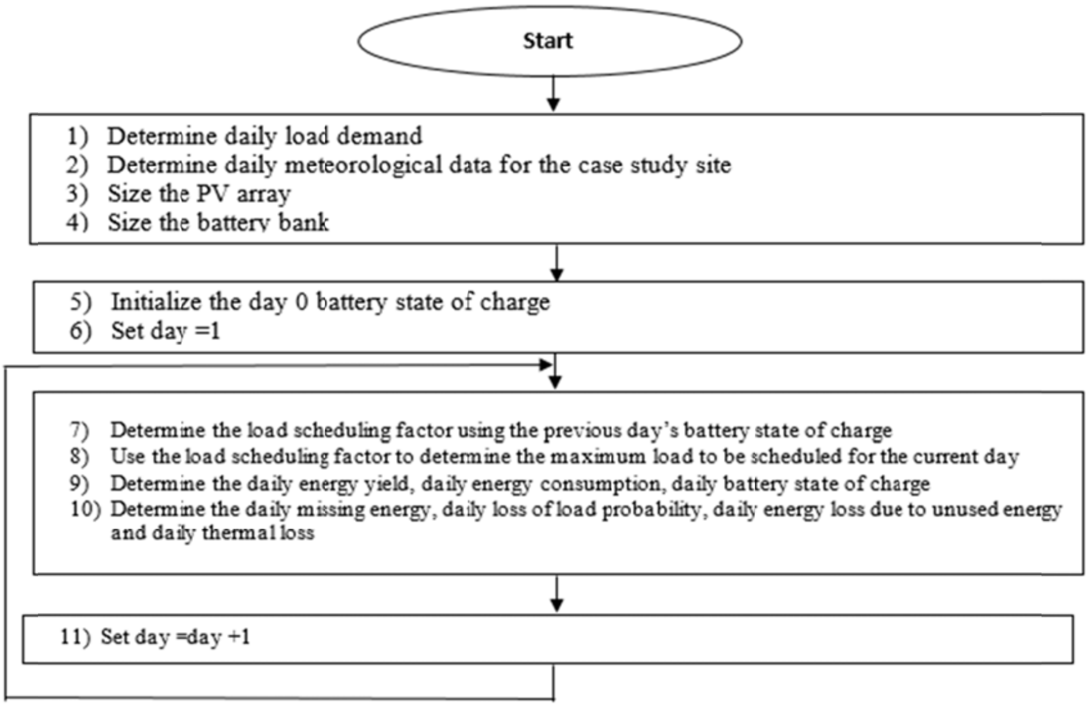

Figure 1 The flowchart used for the sizing of the solar system, the evaluation and determination of the carbon offset with load scheduling

2.2 The detailed algorithm for the implementation of the load scheduling algorithm

The annual mean of the daily temperature (T_{aYrAvg}) and the annual mean of the daily solar radiation (PSH_{AVG}) are used to size the PV array and battery bank. Then, the daily temperature ($T_{a(k)}$) and the daily solar radiation ($G_{(k)}$) values and the battery state of charge (SoC) are used to determine the daily load scheduling factor (LdSchfactor) and the other key system parameters when the load scheduling mechanism is employed. The detailed algorithm for the implementation and evaluation of the load scheduling mechanism is broken into four major modules which are given as follows;

MODULE I: Sizing of The PV Array

This module is used to determine the PV array capacity, the number of PV modules in the array, the number of PV module in series and in parallel.

MODULE II: Sizing of Battery Bank

This module is used to determine the battery bank capacity, the number of batteries in the battery bank, the number of batteries in series and in parallel.

MODULE III: Determination of Load Scheduling Factor

This module is used to determine the load scheduling factor which is the fraction of the total load demand that can be powered in the current day based on the prevailing battery state of charge.

MODULE IV: Determination Of The Distribution Of Daily Energy Yield, Daily Energy Consumption, Daily Energy Storage, Daily Energy Losses With Load Scheduling.

This module is used to determine various key energy-related parameters of the PV power system.

MODULE I: ***Sizing of the PV Array***

//Definition of key terms

$f_{dc/ac}$ is cd/ac de-rating factor,

β is temperature coefficient of the PV module,

$NOCT$ is the normal operating cell temperature ,

E_{lddmnd} is the daily load demand,

W_{pv} is the wath peak rating of each PV module,

V_{syt} is the PV power system line voltage,

V_{pv} is the PV module voltage

//

Step 1.1 Input $f_{dc/ac}, \beta, NOCT, E_{lddmnd}, W_{pv}, V_{syt}, V_{pv}$ \

Step 1.2 For k = 1 to 365 step 1 { Input $G_{(k)}, T_{a(k)}$}

Step 1.3 $G_{YrAvg} = \sum_{d=1}^{365}(G_{(k)})/365$

Step 1.4 $T_{aYrAvg} = \sum_{d=1}^{365}(T_{a(k)})/365$

Step 1.5 $T_{STC} = 25$

Step 1.6 $PSH_{AVG} = G_{YrAvg}$

Step 1.7 Compute T_{cAVG} using the expression [14];

$$T_{cAVG} = T_{aYrAvg} + \left(\frac{NOCT - 20}{800}\right) G_{YrAvg}$$

Step 1.8 Compute f_{temp} using the expression [15];

$$f_{temp} = 1 + \beta(T_{cAVG} - T_{STC})$$

Step 1.9 Compute PSH_{AVG} using the expression;

$$PSH_{AVG} = \frac{G_{AVG(k)}}{G_{STC}} = \frac{G_{AVG(k)}}{1\ \text{kW/m2}}$$

Step 1.10 Compute $W_{pvarray}$ using the expression [16,17];

$$W_{pvarray} = \frac{E_{lddmnd}}{PSH_{AVG}\,(f_{dc/ac})(\ f_{temp})}$$

Step 1.11 Compute N_{pvT} using the expression;

$$N_{pvT} = \left\lceil \frac{W_{pvarray}}{W_{pv}} \right\rceil$$

Step 1.12 Compute N_{pvS} using the expression;

$$N_{pvS} = \frac{V_{syt}}{V_{pv}}$$

Step 1.13 Compute N_{pvP} using the expression;

$$N_{pvP} = \frac{N_{pvT}}{N_{pvS}}$$

MODULE II: ***Sizing of Battery Bank***

// Definition of key terms

Cap_{bat} is the battery bank capacity

V_{syt} is the PV system line voltage

V_{bat} is the battery voltage

η_{Bat} is the number of battery in the battery bank

Dy_{aut} is the number of days of power autonomy

DoD is the battery depth od discharge

LdSchfactor is the load scheduling factor

//

Step 2.1 Input $Cap_{bat}, V_{syt}, V_{bat}, \eta_{Bat}, Dy_{aut}$, DoD

Step 2.2 Compute $E_{lddmndUpd}$ using the expression;

$$E_{lddmndUpd} = \frac{E_{lddmnd}}{(f_{dc/ac})(\text{f}_{\text{temp}})}$$

Step 2.3 Compute C_{batBnk} using the expression [18,19];

$$C_{batBnk} = \frac{(E_{lddmndUpd})(Dy_{aut})}{(\text{DoD})(V_{bat})(\eta_{Bat})}$$

Step 2.4 Compute Cap_{bat} using the expression;

$$N_{batT} = \left\lceil \frac{C_{batBnk}}{Cap_{bat}} \right\rceil$$

Step 2.5 Compute N_{batS} using the expression;

$$N_{batS} = \frac{V_{syt}}{V_{bat}}$$

Step 2.6 Compute N_{batP} using the expression;

$$N_{batP} = \frac{N_{pvT}}{N_{pvS}}$$

MODULE III: ***Determination of Load Scheduling Factor***

//Definition of key terms

Step 3.1 Input $N_{mx}, ReFc_{Ld}, DoD$

Step 3.2 Compute $DoD\%$ using the expression;

$$DoD\% = (DoD)(100)$$

Step 3.3 Compute $SoC\%$

$$\text{Soc}_{(k)}\% = 1 - DoD\%$$

Step 3.4 Compute $ReFc_{Ldx(k)}$

Step 3.5 For k = 1 to 365 step 1 $ReFc_{Ldx(k)} = \left(\left(\frac{1}{-DoD\%}\right)(\text{Soc}_{(k-1)}\% - 100)\right)$

Step 3.6 Compute $N_{mn(k)}$ using the expression;

$$N_{mn(k)} = \left[(ReFc_{Ldx(k)})(N_{mx})\right]$$

Step 3.7 Compute $N_{op(k)}$ using the expression;

$$N_{op(k)} = N_{mx} - N_{mn(k)}$$

Step 3.8 Compute $Re_{op(k)}\%$ using the expression;

$$Re_{op(k)}\% = \left(\frac{N_{op(k)}}{N_{mx}}\right) 100\ \%$$

Step 3.9 The load scheduling factor, LdSchfactor

$$\text{LdSchfactor} = Re_{op(k)}\%$$

MODULE IV: ***Determination Of The Distribution Of Daily Energy Yield, Daily Energy Consumption, Daily Energy Storage , Daily Energy Losses With Load Scheduling***

Step 4.1 Input $E_{bat(k-1)}, C_{batBnk}, V_{bat}, \eta_{Bat}$, DoD, $f_{dc/ac}, \beta, W_{pvarray}, NOCT, E_{lddmnd}, G_{YrAvg}, T_{aYrAvg}$

Step 4.2 $T_{STC} = 25$

Step 4.3 Compute the maximum energy stored in the battery bank, E_{batMX} using the expression;

$$E_{batMX} = (C_{batBnk})(V_{bat})(\eta_{Bat})$$

Step 4.4 Compute the energy in the battery bank available to the load, $E_{batAvaLd}$ using the expression;

$$E_{batAvaLd} = (E_{batMX})(\text{DoD})$$

Step 4.5 Compute the energy in the battery bank not available to the load, $E_{batRsev}$ using the expression;

$$E_{batRsev} = (E_{batMX})(1 - \text{DoD})$$

Step 4.6 For k = 1 to 365 step 1 { Input $G_{(k)}, T_{a(k)}$}

Step 4.7 If load scheduling is implemented then

LdSchfactor = CallLoadScheduler()

Else

LdSchfactor =1

Endif

Step 4.8 Compute $T_{c(k)}$ using the expression;

$$T_{c(k)} = T_{a(k)} + \left(\frac{NOCT - 20}{800}\right) G_{(k)}$$

Step 4.9 Compute $f_{temp(k)}$ using the expression;

$$f_{temp(k)} = 1 + \beta(T_{c(k)} - T_{STC})$$

Step 4.10 Compute $PSH_{(k)}$ using the expression;

$$PSH_{(k)} = \frac{G_{(k)}}{G_{STC}} = \frac{G_{(k)}}{1\ \text{kW/m2}}$$

Step 4.11 Compute the energy yield of the PV array in day k, $E_{ylday(k)}$ using the expression;

$$E_{ylday(k)} = W_{pvarray}(PSH_{(k)})[(f_{dc/ac})(f_{temp(k)})]$$

Step 4.12 Compute $E_{tLaVen(k)}$ using the expression;

$$E_{tLaVen(k)} = E_{ylday(k)} + E_{bat(k-1)}$$

Step 4.13 Compute the actual load demand in day k or the operating Load demand in day k using the expression;

$$E_{lddmndOp} = (E_{lddmndUpd})(\text{LdSchfactor})$$

Step 4.14 If $(0 \leq E_{tLaVen(k)} \leq E_{batRsev})$ then using the expression;

$$\left.\begin{array}{l} E_{batSC1(k)} = E_{tLaVen(k)} \\ E_{userSC1(k)} = maximum(0,\ E_{tLaVen(k)} - \boldsymbol{E_{batRsev}}) \\ E_{missingSC1(k)} = E_{lddmndOp} - E_{userSC1(k)} \\ E_{unusedSC1(k)} = maximum(0,\ E_{tLaVen(k)} - E_{batMX} - E_{lddmndOp}) \\ \mathrm{DoDSC1}_{(k)} = \frac{E_{batMX} - E_{batSC1(k)}}{E_{batMX}} \\ \mathrm{SocSC1}_{(k)}\% = (1 - \mathrm{DoD}_{(k)})100\ \% \end{array}\right\}$$

$$E_{bat(k)} = E_{batSC1(k)}$$

$$E_{user(k)} = E_{userSC1(k)}$$

Step 4.15 Elseif $\left(E_{batRsev} < E_{tLaVen(k)} \leq (E_{batRsev} + E_{lddmndOp})\right)$ using the expression;

$$\left.\begin{array}{l} E_{batSC2(k)} = E_{batRsev} \\ E_{userSC2(k)} = E_{tLaVen(k)} - \boldsymbol{E_{batRsev}} \\ E_{missingSC2(k)} = E_{lddmndOp} - E_{userSC2(k)} \\ E_{unusedSC2(k)} = maximum(0,\ E_{tLaVen(k)} - E_{batMX} - E_{lddmndOp}) \\ \mathrm{DoDSC2}_{(k)} = \frac{E_{batMX} - E_{batSC2(k)}}{E_{batMX}} \\ \mathrm{SocSC2}_{(k)}\% = (1 - \mathrm{DoD}_{(k)})100\ \% \end{array}\right\}$$

$$E_{bat(k)} = E_{batS2(k)}$$

$$E_{user(k)} = E_{userSC2(k)}$$

Step 4.16 Elseif $\left((E_{batRsev} + E_{lddmndOp}) < E_{tLaVen(k)} \leq (E_{batRsev} + E_{lddmndOp} + E_{batAvaLd})\right)$ using the expression;

$$\left.\begin{array}{l} E_{batSC3(k)} = E_{batRsev} + (E_{tLaVen(k)} - E_{batRsev} - E_{lddmndOp}) \\ E_{userSC3(k)} = E_{lddmndOp} \\ E_{missingSC3(k)} = E_{lddmndOp} - E_{userSC3(k)} \\ E_{unusedSC3(k)} = maximum(0,\ E_{tLaVen(k)} - E_{batMX} - E_{lddmndOp}) \\ \mathrm{DoDSC3}_{(k)} = \frac{E_{batMX} - E_{batSC3(k)}}{E_{batMX}} \\ \mathrm{SocSC3}_{(k)}\% = (1 - \mathrm{DoD}_{(k)})100\ \% \end{array}\right\}$$

$$E_{bat(k)} = E_{batSC3(k)}$$

$$E_{user(k)} = E_{userSC3(k)}$$

Step 4.17 Else$\left(E_{tLaVen(k)} \geq (E_{batRsev} + E_{lddmndOp} + E_{batAvaLd})\right)$ using the expression;

$$\left.\begin{array}{l} E_{batSC4(k)} = E_{batMX} \\ E_{userSC4(k)} = E_{lddmndOp} \\ E_{missingSC4(k)} = E_{lddmndOp} - E_{userSC4(k)} = 0 \\ E_{unusedSC4(k)} = maximum(0,\ E_{tLaVen(k)} - E_{batMX} - E_{lddmndOp}) \\ \mathrm{DoDSC4}_{(k)} = \frac{E_{batMX} - E_{batSC4(k)}}{E_{batMX}} \\ \mathrm{SocSC4}_{(k)}\% = (1 - \mathrm{DoD}_{(k)})100\ \% \end{array}\right\}$$

$$E_{bat(k)} = E_{batSC4(k)}$$

$$E_{user(k)} = E_{userSC4(k)}$$

Endif

Step 4.18 Using the following expression compute the missing energy in day k;

$$E_{missing(k)} = E_{lddmndOp} - E_{user(k)}$$

Step 4.19 Using the following expression compute the unused energy in day k;

$$E_{unused(k)} = maximum(0,\ E_{tLaVen(k)} - E_{batMX} - E_{lddmndOp})$$

Step 4.20 Using the following expression compute the battery depth of discharge in day k;

$$\mathrm{DoD}_{(k)} = \frac{E_{batMX} - E_{bat(k)}}{E_{batMX}}$$

Step 4.21 Using the following expression compute the battery state of charge in day k;

$$\mathrm{Soc}_{(k)}\% = \left(1 - \mathrm{DoD}_{(k)}\right)100\ \%$$

Step 4.22 Using the following expression compute loss of load probability;

$$\mathrm{LOLP}(\%) = \frac{\sum_{d=1}^{365}\left(E_{missing(k)}\right)}{\sum_{d=1}^{365}\left(E_{lddmndOp}\right)}(\mathbf{100})\%$$

Step 4.23 Using the following expression compute the percentage of energy lost due to unused energy;

$$\mathrm{LossUnused}\ (\%) = \frac{\sum_{d=1}^{365}\left(E_{unused(k)}\right)}{\sum_{d=1}^{365}\left(E_{ylddday(\mathrm{k})}\right)}(100)\%$$

Step 4.24 Using the following expression compute the percentage of energy lost due to thermal loss;

$$\mathrm{LossTemp} = \frac{\sum_{d=1}^{365}\left(\left(1-\mathrm{f_{temp(k)}}\right)E_{ylddday(\mathrm{k})}\right)}{\sum_{d=1}^{365}\left(E_{ylddday(\mathrm{k})}\right)}(100)\% = \left(1-\mathrm{f_{temp}}\right)(100)\%$$

2.3 THE CASE STUDY DAILY LOAD DEMAND

The case study load is an Automatic Teller Machine (ATM) gallery that has 20 ATM and daily load demand of 475.536 kWh/day (as presented inTable 1) with assumption that the 20 ATM and their accessories are identical; notably, each of the 20 single ATM has a daily load demand of 23.7768 kWh/day when it operates for 24 hours per day (as presented in Table 2).

Table 1 The load profile of the automatic teller machine (ATM) gallery

S/N	Load Description	QTY.	Power (kW)	Duration of operation each day (h)	Total power (kW)	Energy consumption each day (kWh)
1	ATM with internet link	20	0.2	24	4	96
2	CCTV camera	20	0.015	24	0.3	7.2
3	AIR Conditioner	20	0.7457	24	14.914	357.936
4	Light for ATM	20	0.03	24	0.6	14.4
				TOTAL	19.814	475.536

Table 2 The load profile of a single automatic teller machine (ATM)

S/N	Load Description	QTY.	Power (kW)	Duration of operation each day (h)	Total power (kW)	Energy consumption each day (kWh)
1	ATM with internet link	1	0.2	24	0.2	4.8
2	CCTV camera	1	0.015	24	0.015	0.36
3	AIR Conditioner	1	0.7457	24	0.7457	17.8968
4	Light for ATM	1	0.03	24	0.03	0.72
				TOTAL	0.9907	23.7768

2.4 THE DAILY METEOROLOGICAL DATA OF THE PV SYSTEM INSTALLATION SITE

The meteorological data utilized in the study are the daily average solar radiation and daily average air temperature and they are acquired from the NASA portal using the geo-coordinate of the PV solar site in Akwa ibom State (Latitude of 5.013629 and Longitude of 7.909871). The scatter plot of the 2021 daily average solar radiation for Akwa Ibom State is shown in Figure 2 (with annual mean of 6.2 W-hr/m^2/day) while that of the daily average air temperature is presented in Figure 3 (with annual mean of 26.2°C).

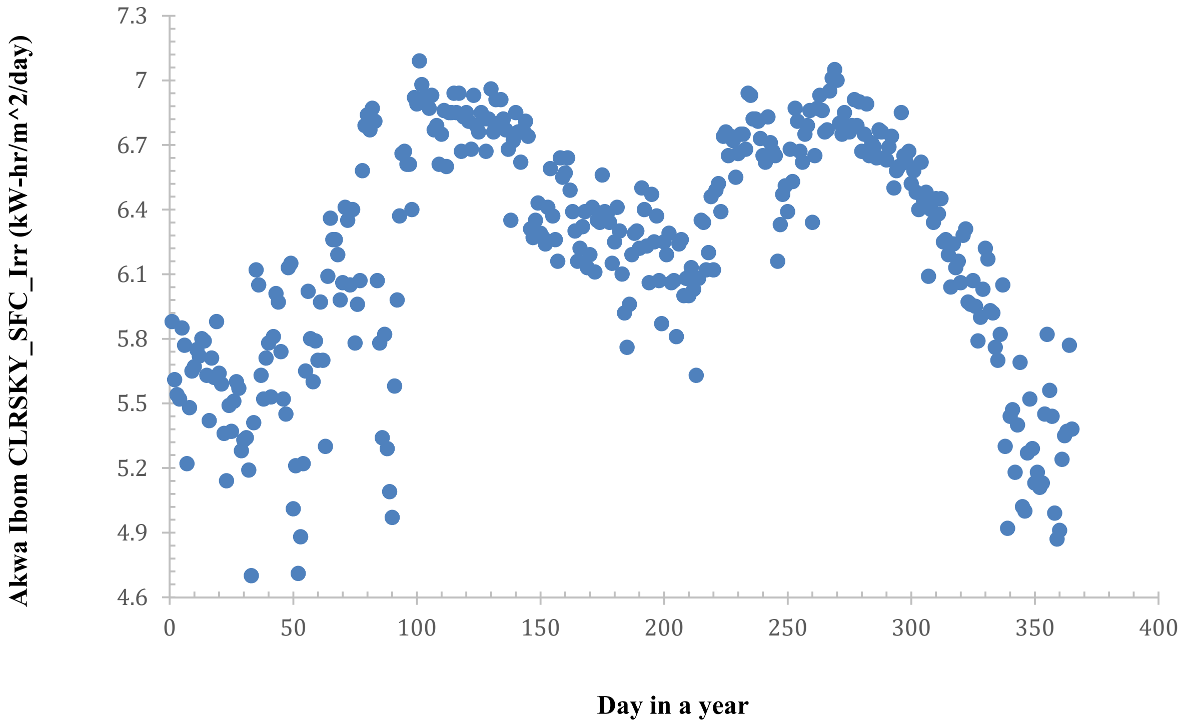

Figure 2 The scatter plot of the 2021 daily average solar radiation for Akwa Ibom State

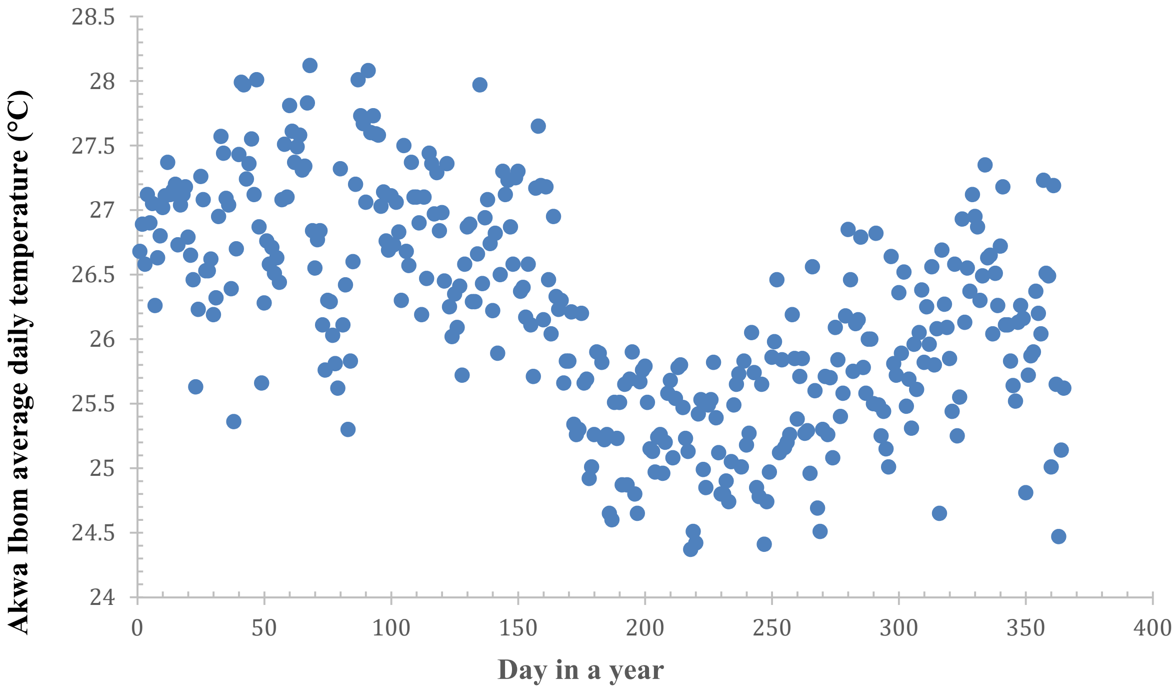

Figure 3.The scatter plot of the 2021 daily average air temperature for Akwa Ibom State

3. RESULTS AND DISCUSSION

The input dataset used in the PV array and battery bank sizing are presented in Table 3. The design utilized a 12 V, 100 Wp PV module and 12 V, 100 Ah battery which resulted in a 96.214825 kW PV array and 110488.5345 Ah battery bank. Also, the results show that with 3 days of power autonomy the battery can store a maximum of 3,148,923.2 Wh energy out of which 1,889,353.9 Wh energy can be available to the load while 1,259,569.3 Wh is the reserved energy in the battery bank which is not available to the load.

Table 3 The input dataset used in sizing of the PV array and battery bank based on mean meteorological data of Akwa Ibom State

S/N	Parameter	Unit	Value
1	Annual mean Ta(k) $=T_{aYrAvg}$	°C	26.20622
2	Annual mean PSH $=G_{YrAvg}$	Hour/day	6.218329
3	$f_{dc/ac}$		0.8
4	β	%	$= -0.08$
5	NOCT	°C	45
6	E_{lddmnd}	kWh/day	475.536
7	W_{pv}	Wp	100
8	V_{syt}	V	24
9	V_{pv}	V	12
10	T_{STC}	°C	25
11	nPv	%	0.1195
12	nbat	%	0.95
13	Dy_{aut}	days	3
14	DoD		0.6
15	Vbat	V	12
16	Cap_{bat}	Ah	100

The result on the effective load with load scheduling and without load scheduling mechanism are shown in Figure 4 while the load scheduling factor with load scheduling and without load scheduling mechanism are shown in Figure 5. Notably, 93 % of the load (a little above 18 out of the 20 ATMs) are scheduled while 7 % of the load (less than 2 out of the 20 ATMs) are dropped when the load scheduling mechanism is deployed.

Specifically, the daily energy demand and daily energy yield with load scheduling are presented in Figure 6, while the corresponding graphs with no load scheduling are shown in Figure 7. The results showed that the mean daily energy demand without load scheduling is 629,784.646 Wh/day which is higher than the mean daily energy yield of 598,295.414 Wh/day (as presented in Figure 7). As such, without load scheduling there is loss of load with a mean of 31,489.232 Wh/day, 0 Wh/day unused energy, and mean thermal loss of 3,905.466 Wh/day (as presented in Figure 8).

On the other hand, with load scheduling there is mean daily energy demand 586,217.352 Wh/day which is lower than the mean daily energy yield of 598,295.414 Wh/day (as presented in Figure 6). As such there is no missing energy or loss of load , there is also some excess or unused energy with mean of 8,222.615 Wh/day) and there is a thermal loss due to ambient temperature with a daily mean of 3,905.466 Wh/day (as presented in Figure 9). .

The graph of battery state of charge (SoC%) and load scheduling factor per day with no load scheduling are shown in Figure 10 while the graph of battery state of charge (SoC%) and load scheduling factor per day with load scheduling are shown in Figure 11. The results show that with on load scheduling, the mean daily battery state of charge (SoC%) is 52.857% (as presented in Figure 9) and the entire load (20 ATM machines are powered on) which gives a mean daily load factor of 100 % (as shown in Figure 4.9 with daily mean of 20 operating ATMs and 0 non-operating ATM) (as presented in Figure 10). On the other hand, with load scheduling, the mean daily SoC% is 94.906 % (as presented in Figure 11) and the a portion of the load (not all the 20 ATM machines are powered on) which gives a mean daily load factor of 93.082 %(as shown in Figure 12 with daily mean of 18.61 operating ATMs and 1.38 non-operating ATM).

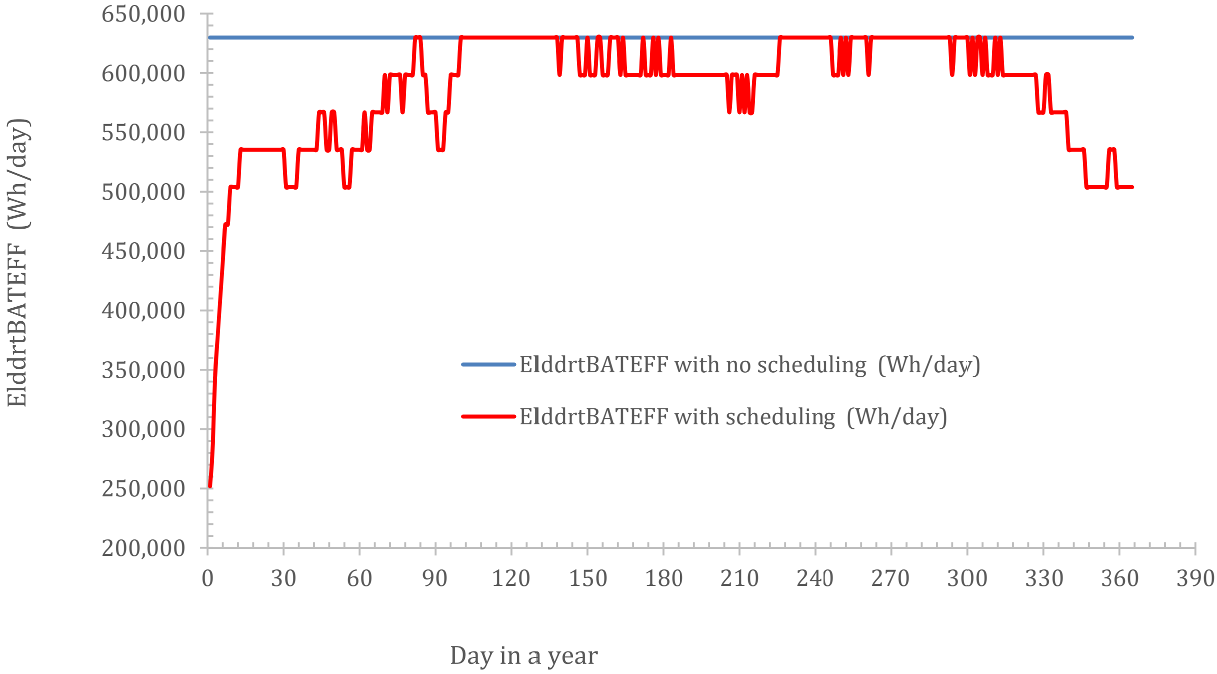

Figure 4.The effective load with load scheduling and without load scheduling mechanism

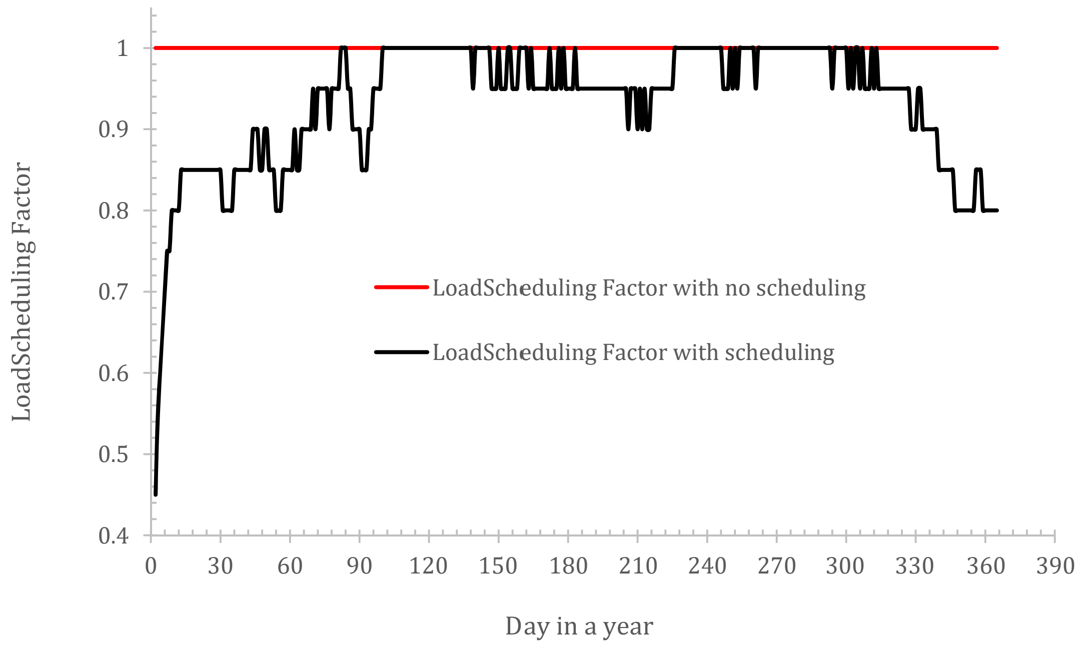

Figure 5 The load scheduling factor with load scheduling and without load scheduling mechanism

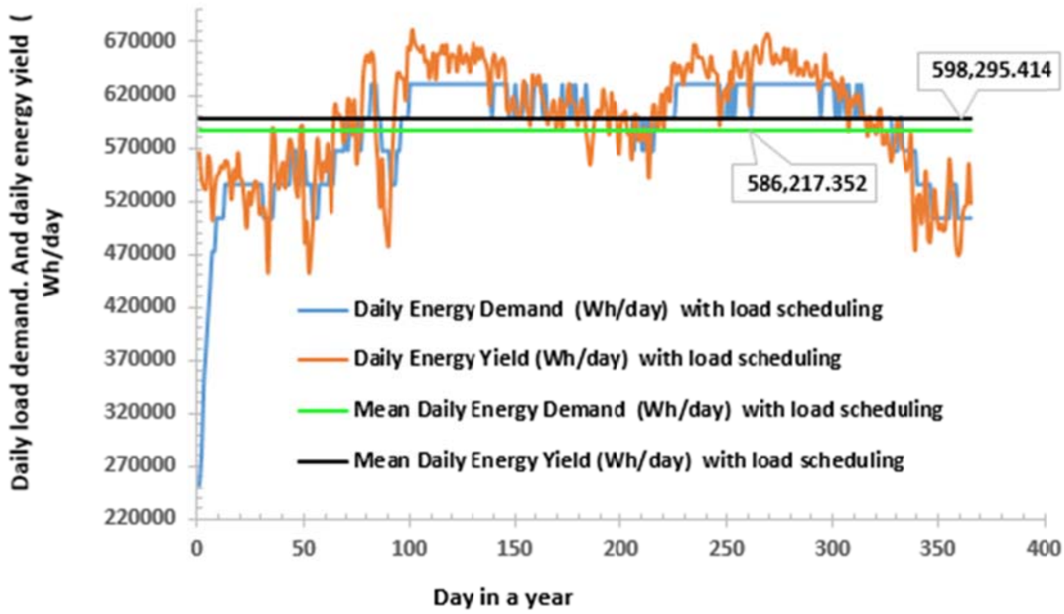

Figure 6 The graph of the daily energy demand and daily energy yield with load scheduling mechanism

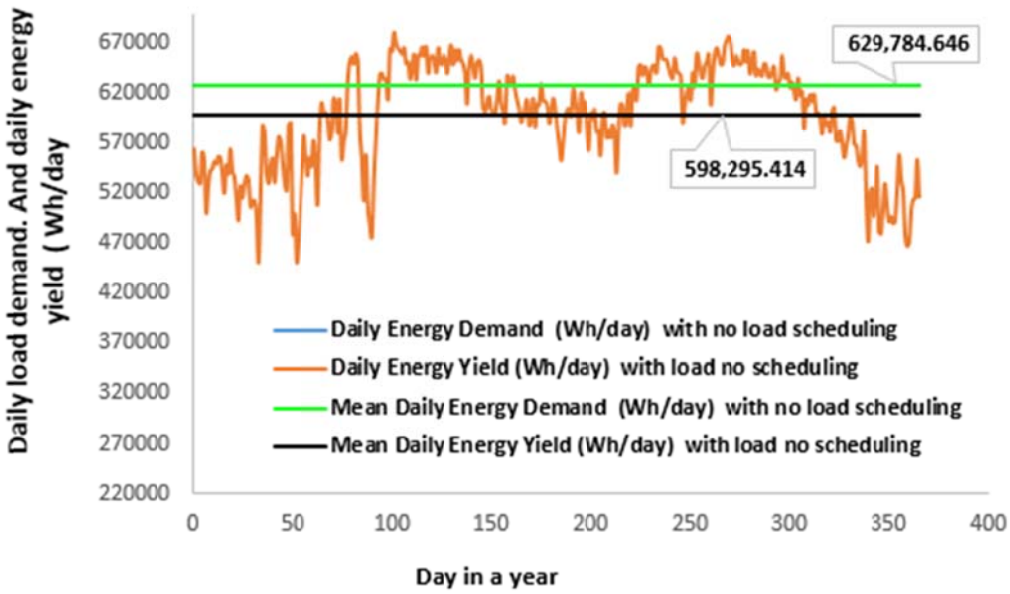

Figure 7 The graph of the daily energy demand and daily energy yield with no load scheduling mechanism

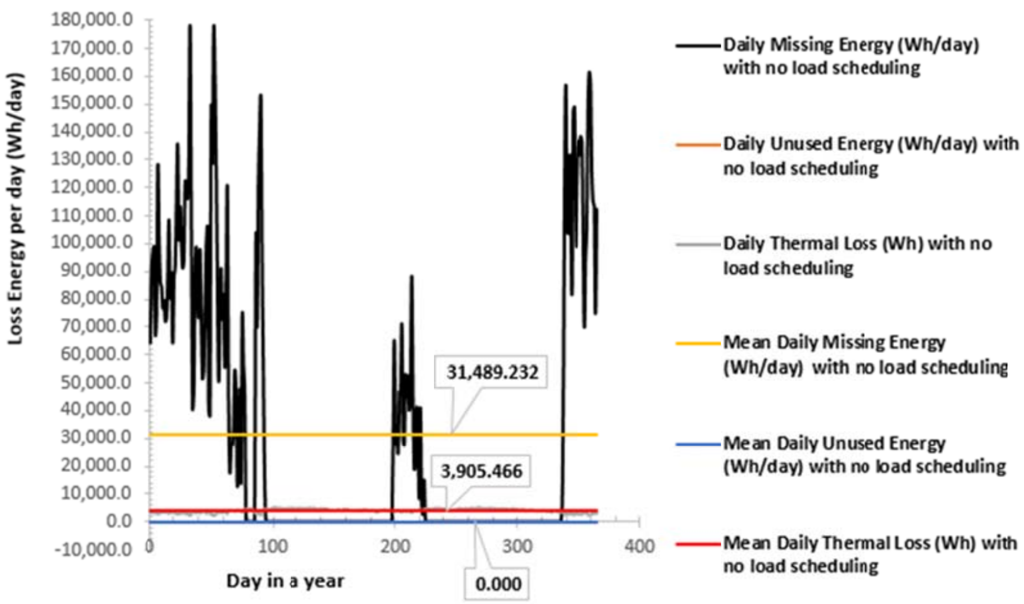

Figure 8 The graph of missing energy and unused energy per day with no load scheduling

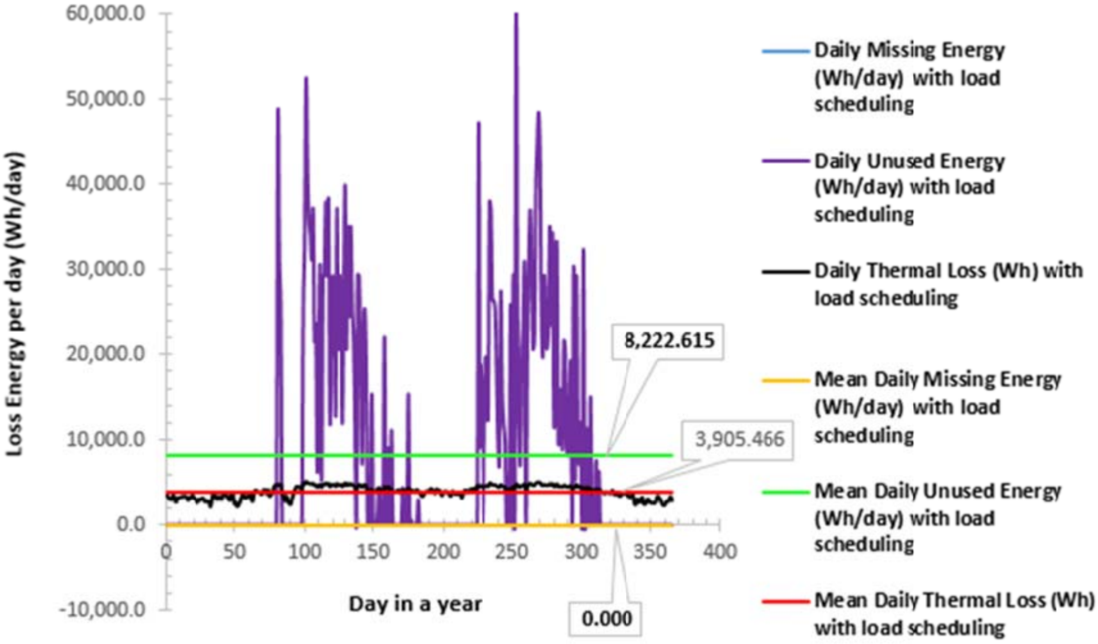

Figure 9 The graph of missing energy and unused energy per day with load scheduling

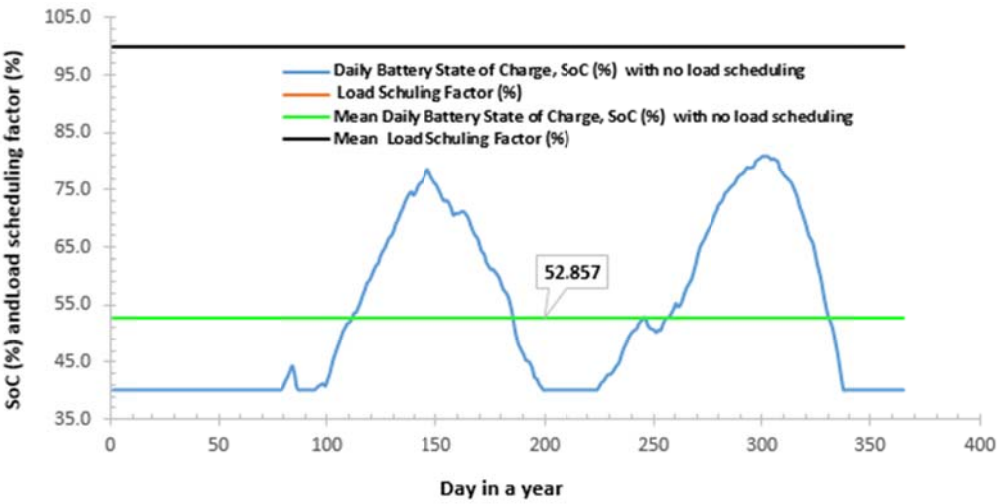

Figure 10 The graph of battery state of charge (SoC%) and load scheduling factor per day with no load scheduling

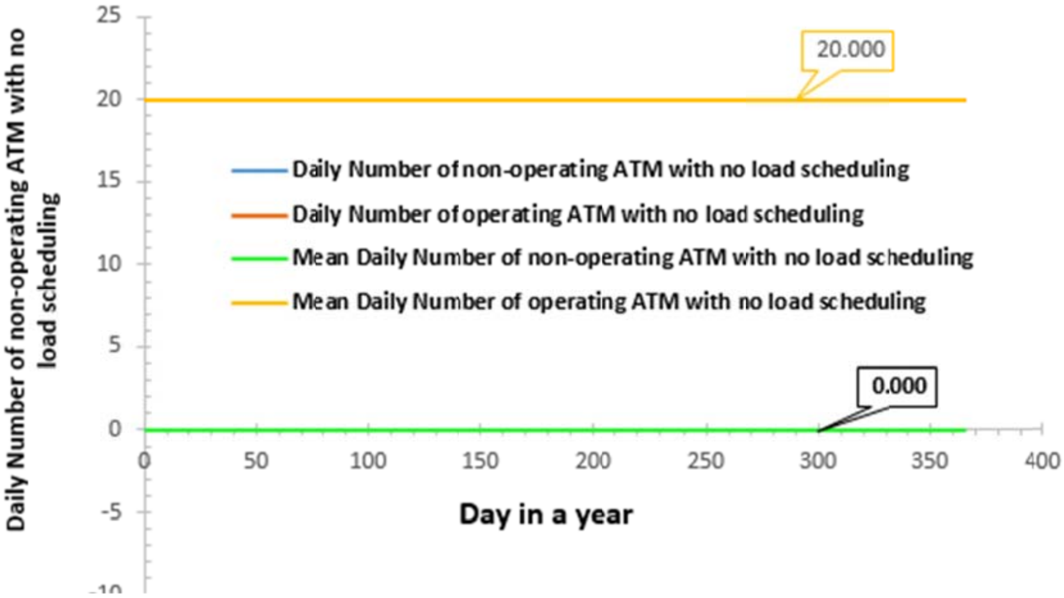

Figure 11 The graph of daily number of operating and non-operating ATM with no load scheduling

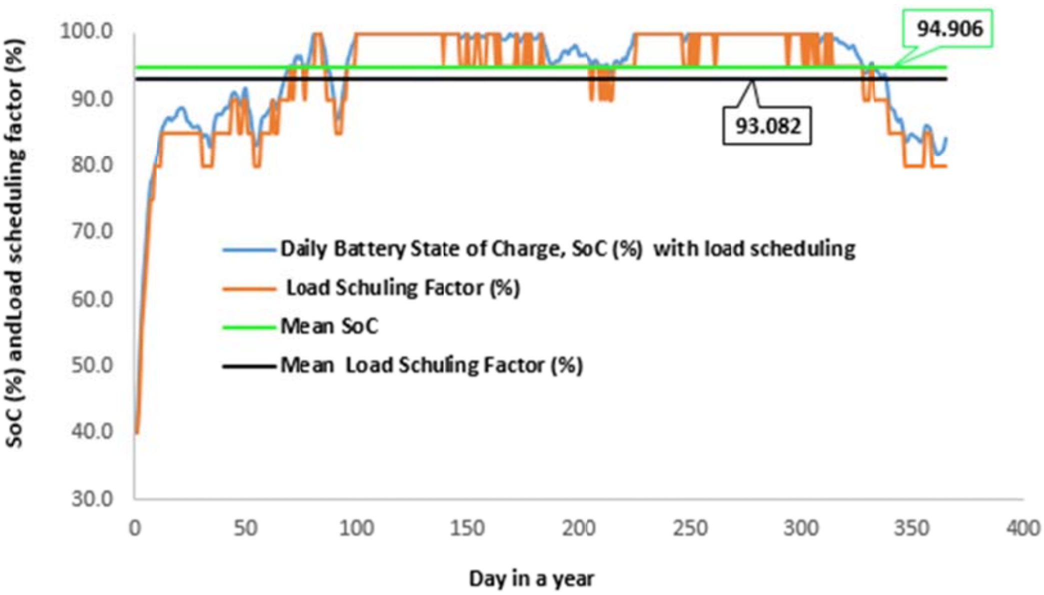

Figure 12 The graph of battery state of charge (SoC%) and load scheduling factor per day with load scheduling

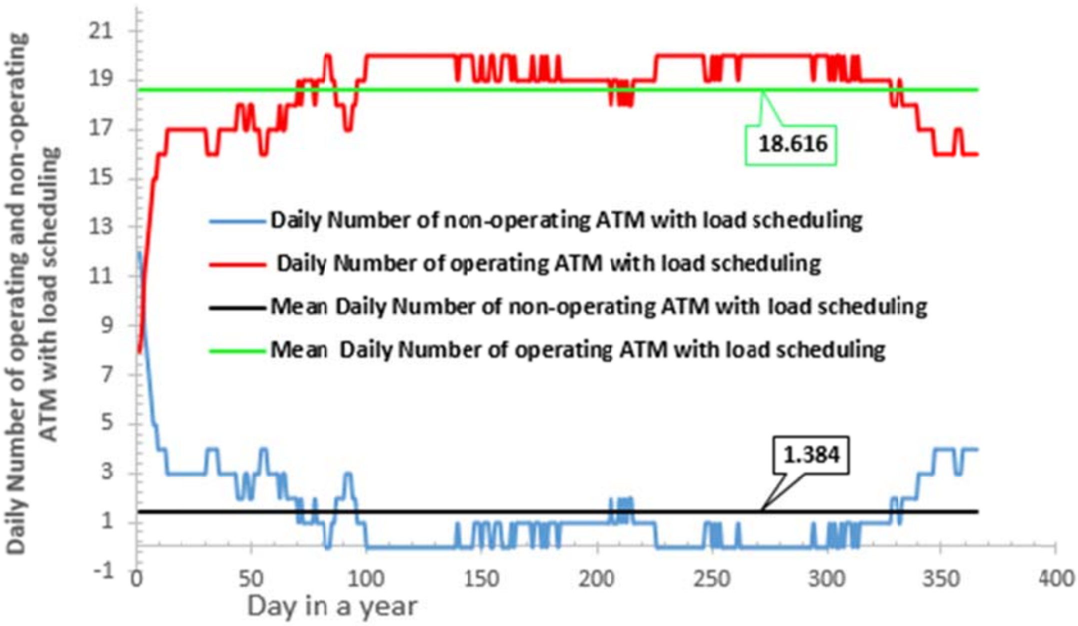

Figure 4.10 The graph of daily number of operating and non-operating ATM with load scheduling

4. CONCLUSION

The mechanism for scheduling load for a standalone solar power system that has storage battery is presented. The mechanism enables the effective load to be adjusted so as to avoid total power outage in the system. The load adjustment is based on the battery state of charge, the required maximum depth of battery discharge and the maximum load demand. The study presented the algorithm for sizing the solar power system components and for the determination of the load scheduling factor which is employed by the load scheduling mechanism to compute the effective load that should be scheduled on each given day. The mechanism was tested using meteorological data for location in Akwa Ibom State. The results showed that the load scheduling mechanism prevented loss of load, maintained battery state of charge to a high value which is good for the battery lifespan.

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