E-ISSN: 111 – 2716 P-ISSN: 3026 – 8214
MPRI-JAAER | INTERNATIONAL JOURNAL OF APPLIED & ADVANCED ENGINEERING RES.
VOL. 13 NO. 5 JULY, 2026

EFFECTIVE SOLAR POWERED STREET LIGHT SYSTEM DETERMINATION BETWEEN AC AND DC LOADS USING A DESIGNED 500W, 12V/18AH SOLAR SYSTEM.

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DOI: https://doi.org/10.70382/mejaaer.v13i5.061

Abstract

This paper critically looked into the effectiveness of both alternate current (AC) and direct current (DC) lamps when used as street light. A solar system with 500W inverter, 12V18 AH battery was designed and constructed. This solar system has AC and DC sections. Both sections were connected to 20 W AC and 20 W DC loads. The voltage readings on the system were taking at two hours intervals. The graphs of voltage versus time were plotted. Also, bar charts were drawn to represent voltage levels at various hours. From the graphs and bar charts, the rate at which each solar system drains the system can be seen and the most effective solar system can be selected. It was noted that the solar system can sustain the DC load beyond 4 hours while the AC load cannot sustain the load beyond 4 hours. Hence, the DC solar power system conserves battery energy better than the AC solar power system.

Keywords: Battery, energy, hours, inverter, loads, solar, system, power, voltage.

Introduction

The use of solar powered light system will be of great help to every community as tariff will not be paid on power used also, it is a pollution free source of power supply when compared to the use of generating set. The monitoring of our

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communities by the security men will be enhanced at night as the solar power supply will be from dusk till dawn, Load shedding arrangement will not affect the street lighting system, if solar powered system is adopted. The global shift toward sustainable and renewable energy sources has acquired tremendous traction in recent years (Bernhard *et al.,* 2023). Traditional reliance on non-renewable energy source has exacerbated environmental challenges, demanding a rethinking of energy management practices (Ismail *et al.,* 2023). Apart from the initial cost of solar power installation, it is a tariff free source of power supply. One major setback in solar power supply is low PV panel generation when the solar irradiance is low, this depends on climate and geographical location. This low PV panel generation can be overcome with adequate and proper design. To overcome the power shortage and reduction in CO_2 emission, the development of PV in all sector of life is vital (Hussain et al., 2023). The issue of increasing the efficiency of photovoltaic system has become the focus of many manufacturers, developers and researchers in the field of solar energy to find ways to increase their efficiency (Al-Adlami et al.,2018) and (Alaa 2023). Energy efficiency simply refers to reducing excessive energy use to perform continuous task. A decrease in energy use brings up a variety of benefits, including knowing the greenhouse gas emission and reducing the value at the economic and household (Xing et al., 2024). Renewable energy is good for the planet as it helps in reducing excessive pollution and it brings social cohesion as well (Alam et al., 2020). Solar power is the most prevalent and user-friendly form of renewable energy resources (Kaleem et al.,2024).

The justification of this paper will take into consideration, the design and construction of a solar system. Also, the voltage level at intervals when D.C. and A.C. loads are connected at different times would be recorded.

PROBLEM STATEMENT

One of the problems the solar designers have with the installation of solar street light is the determination of solar capacity that would be effective within the needed period. In the past solar installers used AC and DC loads without investigating their power consuming capacities. This study was purposely carried out to monitor which of the loads can be sustained within the required time when use as street light.

OBJECTIVE

The objective of this study is to determine the load either AC or DC that can be sustained within and beyond the needed hours when connected to the designed and constructed 500W, 12V/18AH solar system. This enables me to determine the better load/lamp to be used for solar street light.

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RESEARCH QUESTIONS

The research question are as follows;

- Why are the existing solar street lights not bright from "dusk to dawn"?
- Which type of load will consume lesser/more power from the solar system?
- Which type of load can the solar system sustain within and beyond the required working hours?

Design Implementation and Parameters Assessment

The purpose is to implement solar station/system and determine which lighting system is more effective. I need to know the duration the solar system will effectively sustain a lighting system (DC and AC). Below are the Parameters;

1) Components and Rating
   a) Solar Panel; 100W (1)
   b) Battery; 12V,18Ah (1)
   c) Inverter; 12V/220V, 500 Watts (1)
   d) DC load; 4 x 5 Watts DC bulbs.
   e) AC load; 4 x 5 Watts AC bulbs
   f) Charge controller; 12V/ 10 Amps (1)
   g) Circuit Breaker; 230V AC/400V DC/ 4000A (1)
2) Battery capacity and Total energy stored (Watt-hours)
   = Voltage x Amp-hour rating
   = 12V x 18Ah
   = 216 Watt-hour (Wh)

   Hence,

   For 108Wx 2 Hours = 216 Wh,
   54W x 4 Hours = 216 Wh
   27W x 8Hours = 216Wh
   13.5W x 16 Hours = 216Wh

   Therefore, 20W x 10.8 Hours = 216 Wh (when losses due to inverter is not considered).
3) Power consumption
   a) DC load Power consumption
      = 4bulbs x 5Watts
      = 20W
   b) AC load Power consumption
      = 4 bulbs x 5 Watts
      = 20 Watts
4) Duration of operation

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a) Duration (DC) = $\frac{\text{Battery capacity}}{\text{Total DC Power consumption}}$

$= \frac{216\ Wh}{20\ W}$

= 10.8 hours

b) Durati n (AC)

Taking inverter's efficiency into consideration (assuming 90%)

Total AC Power consumption with inverter losses

$= \frac{20W}{0.9}$

= 22.22W

Duration (AC) = $\frac{\text{Battery capacity}}{\text{Total DC Power consumption with inverter losses}}$

$= \frac{216\ Wh}{22.22W}$

= 9.72 hours

5) Battery Charging with the solar panel

Assuming 4.8 peak sun hours (generation factor)

Energy generated per day

= Solar Panel Power x Peak sun hour

= 100Wx 4.8Wh

= 480Wh per day.

Time to fully charge the battery from empty (assuming 100% charging efficiency)

$= \frac{Battery\ capacity}{Energy\ generated\ per\ day}$

$= \frac{216Wh}{480Wh}$

= 0.45 days

i.e 0.45 x 24 hours

= 10.8 hours.

The charging current from the PV Panel through the Charge controller is calculated as

= Short- circuit current I_{sc} x 130%

= 5.5 x 1.30

= 7.15 A

Construction of the Solar System

The Solar System comprises of;

1) Solar box (1)
2) Solar Panel (1, rated 100W)
3) Battery (1, rated 12V,18Ah)

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4) Inverter (1, rated 12V/220V,500W)
5) Charge controller (1, 12V,10A)
6) DC lamps (4, rated 5W each)
7) AC lamps (4, rated 5W each)
8) Smart LDR controller module (2)
9) Switches (2)
10) Socket Outlets
11) Circuit breaker (1, rated 230 V AC/400V DC/4000 A).



Source: Designed and constructed 500W,12V/18AH Solar system.
Plate 1: Solar Power System

It shows the solar system with its cover plate while the solar box was opened. Some tools can be seen around it.

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Source: Bought Photovoltaic Panel.
Plate 2: Picture of 100 W Photovoltaic Panel

It shows the 100 W panel used for the charging of the solar system. It shows the cable connected to the Panel

RESULT AND DISCUSSION

Table 1 Voltage level recorded with 20W DC load

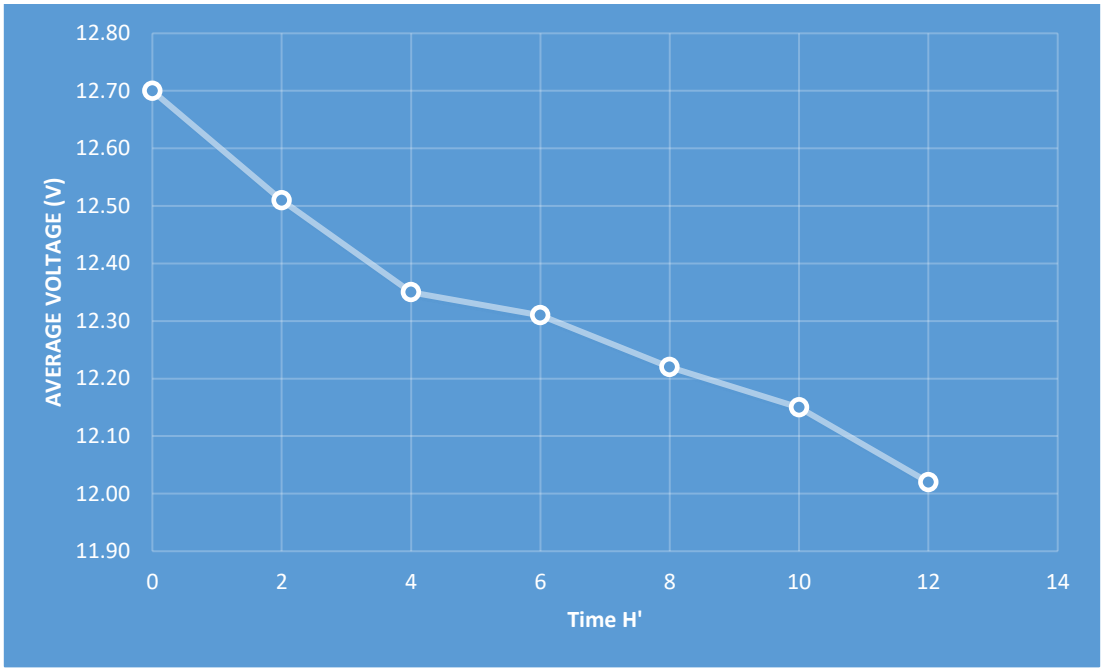
TABLE 1: Voltage level recorded between 4/2/2024 to 6/4/2024, 20W DC Load connected.

Time of the day (H)	Time (H')	WeeK 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Average voltage
7:00PM	0	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70
9:00PM	2	12.50	12.55	12.53	12.49	12.48	12.50	12.51	12.52	12.53	12.51
11:00PM	4	12.35	12.36	12.33	12.34	12.35	12.35	12.36	12.34	12.33	12.35
1:00 AM	6	12.29	12.30	12.29	12.32	12.33	12.31	12.30	12.31	12.32	12.31
3:00 AM	8	12.22	12.24	12.21	12.25	12.23	12.22	12.21	12.23	12.21	12.22
5:00 PM	10	12.14	12.16	12.15	12.14	12.16	12.15	12.14	12.14	12.16	12.15
7:00 AM	12	12.02	12.01	12.00	12.04	12.03	12.04	12.03	12.01	12.03	12.02

Source: Voltage recorded with 20W DC lamp using solar system designed

From the table above, the solar system can sustain 20W DC load up to 12 hours. The information on table 1 was used to plot the graph (figure.1) and bar chart (figure 3).

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Source: Graph plotted based on table 1 data

Figure 1: Graph of relationship between average voltage and time when 20W DC load was connected

The graph above indicates that the solar system can sustain a load of 20W DC for more than 12 hours without switching off, at the same time the voltage level didn't go below 12 volts.

Table 2 Voltage level recorded with 20 W AC load

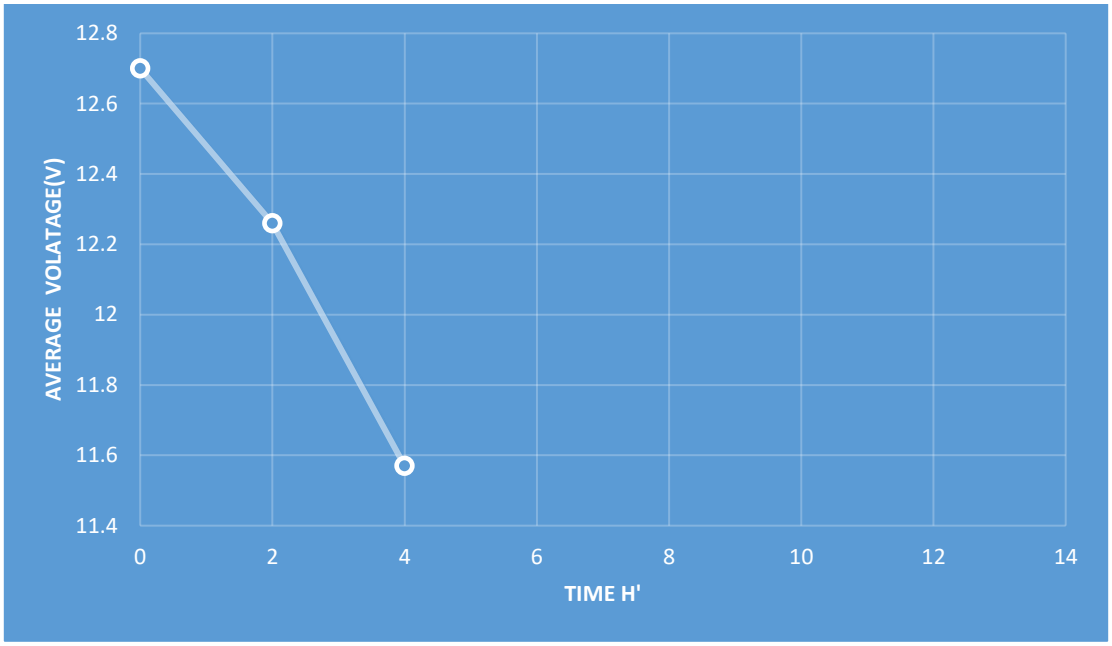
TABLE 2: Voltage level recorded between 4/2/2024 to 6/4/2024, 20W AC Load connected.

Time of the day (H)	Time (H')	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Average voltage
7:00PM	0	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70
9:00PM	2	12.26	12.24	12.26	12.27	12.28	12.25	12.26	12.24	12.26	12.26
11:00PM	4	11.58	11.57	11.59	11.55	11.56	11.59	11.57	11.56	11.58	11.57
1:00 AM	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:00 AM	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:00 PM	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7:00 AM	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Voltage recorded with 20W AC lamp using solar system designed

From the table above, the solar system can not sustain the 20WAC load beyond 4 hours. The information on table 2 will be used to plot the graph (fig.2) and bar chart (fig.3)

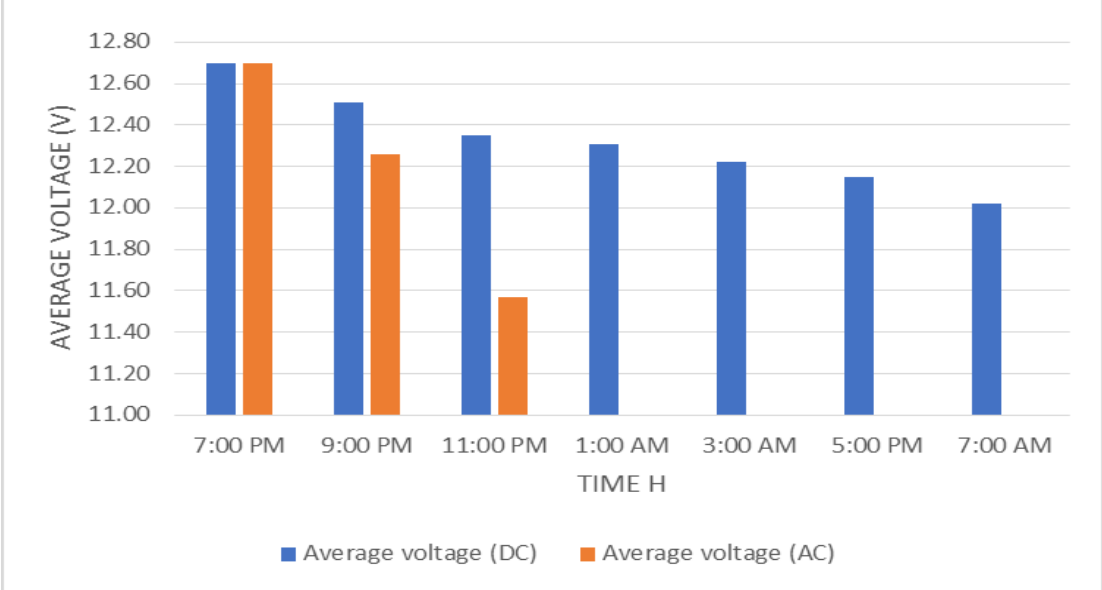
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Source: Graph plotted based on Table 2 data

Figure 2: Graph of relationship between average voltage and time when 20W AC was connected.

Base on the graph, the solar system was unable to sustain the 20 W AC load beyond 4 hours, meaning the AC load drained the solar system faster than the DC load.



Source: Bar chat plotted based on tables 1 and 2

Figure 3: Bar chart of relationship between average voltage and time when 20W DC & AC loads were connected

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The bar chart indicates that the solar system can supply the DC load for longer hours than the AC load.

Based on monitoring, it was noted that when DC loads are connected the voltage level of the solar power design will go below 12V, this is recorded on tables 1. For the AC load, the voltage went below 12V, it is usually around 10.50V (the system had been programmed to switch off at this voltage, so as to prevent excessive drainage of the battery).

The graph for DC loads went down steadily till it approaches 12 hours on the x-axis of the graph. The solar power system was able to sustain this load beyond 12 hour until it senses light. This is illustrated in figures 1.

FINDINGS

a) The solar powered system was able to sustain DC load for longer hours than the AC load,
b) The AC load drains the battery faster due to the presence of an inverter that has coil, hence, an inductive load. An inductive load utilizes reactive power, a power that can flow from source to load or even load to source. This power is going forward and coming backward like a pendulum without doing any useful work in the system.

CONCLUSIONS AND RECOMMENDATION

- DC solar powered street light is considered more effective because its duration of operation is longer than that of AC solar powered system. The evidence for this was illustrated on the graphs and bar charts used.
- I recommend that DC solar powered street light system should be adopted as analysis indicated that it is the most effective solar system for street lighting project.

REFERENCES

Alaa S.M and Mustafa T.(2023): Improving the efficiency of Solar systems by Tracking The MPP under Different Test condition. Progress in electromagnetic research 99:83-102.

Al-Adlami Y. and Erceleb E. (2018). "A plasmonic monopole Antenna Array on flexible Photovoltaic Panels for further use of the green Energy harvesting". Progress in Electromagnetic research, 68: 143-157.

Alam M.S, Al-Ismail F.S, Salem A. and Abido M.A. (2020): High-level penetration of r Renewable energy sources into grid utility: Challenges and solutions, IEEE Access,8:190277-190299.

Bernhard T., Stefan P., Andreas W. and Gerhard P. (2023). Hybrid model predictive control of renewable microgrids and seasonal hydrogen storage. International Journal of Hydrogen Energy. 48: 38125-38142.

Hussain M., Sultan M., Uzma F. Longsheng C., Malik M.Y., Bult A.R.and Sajjad A.Y. (2022). A comparative analysis of renewable and non-renewable energy generation to regulate CO₂ emissions and general cost in household Systems.

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Ismail, M., Tawfik G., Badr M. A., Khalid A., Ahmed A., Mansor A. and Hsan H.A. (2023): Integration of Renewable-Energy-Based Green Hydrogen into the Energy Future. Processes. 11: 2685.

Kaleem U, Majid A.T, Zalid U,MuhammadT.E, Muhammad J.A,MuhammedA. and Ritesh T. (2024). Ancillary servicesgrids: A comprehensivereview and simulator study: Renewable Sustainable Energy.118:032701.

Xing C,Dingguo H, Qingchun R,Yong Y. and Ye Y.(2024). Improving the efficiency and Reliability of Renewable Energy Systems: A Study of parallel and distributed Architeture for Integrated wind and Solar Power Generation ScalableComputing Practice and Experience,25(2):639-645.

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