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FEASIBILITY STUDY OF USING PV SYSTEM AS AN ALTERNATIVE BACK-UP SOURCE OF ELECTRIC POWER: A CASE STUDY OF ZION HOSTEL, UNIVERSITY OF JOS

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Abstract

The geographical position of Nigeria gives it an advantage in terms of harnessing solar energy. Jos, a city which is located in Plateau State Nigeria, belongs to the north-central region and has latitudes and longitudes of 09°38'N and 08°57'E respectively and is about 1290 meters above sea level. Jos has an average annual temperature of around 27.43ºC. In this research, we have used the solar installation as a prototype to design a solar backup system for the Zion Hostel, University of Jos with the aim of a better, cleaner, cost effective and more efficient alternate energy source.

Keywords: *Solar PV Modules, Battery-Banks, Inverters, Panel Generating Factor, Solar Controllers.*

1.0 INTRODUCTION

The modern industrial economy cannot thrive without energy as this provides an essential ingredient to virtually all human activities such as transportation, communication, industrialization[1], etc. In search of energy, there has been a lot of pollution from generators leading to health hazards. Noise pollution is also a source of concern and not left out is the high cost of maintaining the power grid[2] which at one point or another has affected students in the hostel. This high demand for energy has led to negative consequences to the environment such as global warming[2-3], therefore making it necessary to use an alternate environmentally friendly energy source as the solar energy[4-6]. Solar energy is one of the most abundant energy resources on earth and as a renewable energy source, it is more desirable compared to fossil fuel since it is less harmful to the environment[2,6-8]. Solar energy system technologies convert heat or sunlight into another form of energy for use. There are two categories of technologies that use solar energy, the solar photovoltaic and solar thermal. Solar Photovoltaic (or PV) is a technology that uses semiconductors to convert sunlight into direct current while solar thermal is a technology that uses the sun's thermal energy or heat to generate electricity. In 2018 solar power supplied about 19MW of Nigeria total energy supply [9]. The technology is gaining popularity in the country due to the persistent energy crises. There are many competing technologies of photoelectric cells such as thin film, monocrystalline silicon, polycrystalline silicon, and amorphous cells. Supplying electricity to individual homes from central photovoltaic systems may be environmental friendly but is hindered by high initial investment cost and also maintenance issues [1,7,8]. Using renewable energy sources such as biomass, solar, wind and geothermal energies can help in combating the energy crisis[2,10].

Solar energy has a huge potential given that it is clean, renewable and environmentally friendly and with advancement in technology, it use within the homes and the industry has gradually increased especially in rural communities that have no still connected to the national electricity grid [10,11]. Though solar energy has face challenges of storage and distribution[1,12]. In this work we have carried out a case study of the Zion Hostel, University of Jos and have explored the potentials of using solar energy as an alternate energy supply.

2.0 MATIRIALS AND METHOD

To design the proposed alternative photovoltaic energy system we have analyzed the requirements including the total load to be supplied and its individual energy efficiency based on the manufacturer's label on the individual devices. The average

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energy consumption was calculated based on the difference in energy rating from the manufacturer's label. Also, the total energy requirement of the Zion hostel was calculated by adding up the individual consumers to be supplied. The total energy requirement per day was selected based on the hostel's daily energy requirement and the total energy requirement per day was calculated. The sizing of the solar panel, batteries, charge controller, inverter and connecting cables were calculated according to the full load specification.

2.1 Sizing the system

In the block A of the Zion hostel, 88 rooms have been examined. The total light point, laptops, phone charges, lamp chargers, power banks, sound boxes and electrical irons have been examined and presented in Table 1.

Table 1. Total Electrical Load of Block-A Zion Hostel with 88 Rooms

S/N	Load	Minimum Watts (W)	Maximum Watts (W)	Average Watts (W)	Numbers Of load	Total Watt (W)	Hour Of usage per day (hr)	Total Watts Hour Per day (Wh/day)
1	Light point	18.0	26.0	31.0	362.0	11222.0	16.0	179552.0
2	Laptop PC	45.0	90.0	67.5	40.0	2700.0	6.0	16200.0
3	Phone charger	5.0	60.0	35.0	65.0	2275.0	12.0	27300.0
4	Lamp charger	2.0	7.0	4.5	20.0	90.0	3.0	370.0
5	Power bank	10.0	20.0	15.0	5.0	75.0	4.0	300.0
6	Sound box	5.0	5.0	5.0	2.0	10.0	5.0	50.0
7	Electric iron	1000.0	2400.0	1700.0	7.0	11900.0	3.0	35700.0
8	Total	1085.0	2608.0	1856.0	501.0	28272.0	49.0	259372.0

2.2 Sizing the Panel

The total watt-hour computed per day is multiplied by 1.3 which results in the total watt hour per day which must be supplied by the solar panels. Hence the total energy needed from solar PV panels is 259372 x 1.3 = 337183.6wh/day or 337.1836kwh/day,total W_p is given by [13].

Total W_p of PV panel capacity needed= $\frac{\text{Total pv watt-hour needed per day}}{\text{panel generating factor}}$ (1)

$= \frac{337183.6}{5.0}$

Hence total W_p of PV capacity = 67436.72 W_p

Based on the use of 350watts solar panel, we have calculated the number of panels as in equation 2[14]

Total number of PV panels needed= $\frac{\text{PV panel capacity (Wp)}}{\text{350watts (single panel watt)}}$ (2)

$= \frac{67436.72}{350}$

=192.6763429 ≈ 193 PV panels

Therefore Zion Hostel block A would need to be powered by at least 193 PV modules of 350watts capacity

2.3 Battery Sizing

The capacity of battery is measure in ampere-hours (Ah). It is calculated by using equation 3[15]

Battery Capacity (Ah) = $\frac{totalwatt-hoursperdayusedbyappliances}{0.85\times 0.6\times nominalbatteryvoltage}$ x days of autonomy (3)

Using a nominal battery voltage or 48v with 2 days of autonomy, we have calculated the battery capacity (Ah) as

Battery capacity (Ah) = $\frac{259372}{0.85\ x\ 0.6\ x\ 48}$x 2

= 21190.52288 ≈ 21191Ah

Using readily available batteries of 200Ah at 12v, we would therefore need a total of approximately 106 battery banks where 4 batteries are connected in series to give 48v.

2.4 Solar Charge Controller Sizing

Using an Indian solar model DESERV 356-350Wp 24v high performance monocrystalline module with a short circuit current of 9.55A (Isc) , we obtain the solar charge controller rating as

Solar charge controller rating = (short circuit current of PV module) x (modules in Parallel) x 1.25 (4)

=1157.9372 ≈ 1158Amps

2.5 Inverter Sizing:

The inverter size is given by[15]:

Inverter size = Total wattage of appliance + (0.30 x total watts of appliance) (5)

Given total wattage of appliances =28.272kw

$=28.272 + (0.30\ x\ 28.272)$

= 36.7536 ≈ 37kw

Apparent power = $\frac{Realpower}{powerfactor\ (0.8)}$ (6)

$=\frac{37000}{0.8}$

= 46.250 ≈ 46KVA

This implies that an inverter size of between 46KVA and 50KVA at 48v could be used.

Now, for the Block B of the Zion hostel, 87 rooms have been investigated with the electrical appliances as shown in table 2.

Table 2. Total Electrical Load of Block-B Zion Hostel with 87 Rooms

S/N	Load	Minimum Watts(W)	Maximum Watts(W)	Average Watts(W)	Numbers of loads	Total watts (W)	Hour of usage per day	Total watts hour per day wh /day
1	Light point	18.0	26.0	22.0	358.0	7876.0	16.0	126016.0
2	Laptop charger	40.0	90.0	65.0	30.0	1950.0	6.0	11700.0
3	Phone charger	5.0	24.0	14.5	40.0	580.0	12.0	6960.0
4	Lamp charger	1.0	5.0	3.0	15.0	45.0	3.0	135.0
5	Power bank	10.0	20.0	15.0	4.0	60.0	4.0	240.0
6	Sound box	5.0	28.0	16.5	3.0	49.5.0	5.0	247.5
7	Electric iron	1000.0	2200.0	1600.0	10.0	16000.0	3.0	48000.0
8	Total	1079.0	2393.0	1736.0	460.0	26560.5	49.0	193298.5

3.0 RESULT

From table 3, we summarize the results from our calculations for the solar system sizing.

Table 3. Summary of solar system sizing of Zion hostel block A and B

S/N	**SYSTEM SIZING**	**VALUE FOR BLOCK A**	**VALUE FOR BLOCK B**
1	Energy consumption per day	259.372kwh	193.2985kwh
2	Solar PV energy needed per day	337.1836kwh	251.28805kwh
3	Panel generation factor	5.0	5.0
4	Total watt peak of the PV panel capacity needed	67436.72W_p	50257.61W_p
5	Total number of panels needed	193	144
6	Inverter sizing	46KVA- 50KVA At 48v	44KVA-45KVA At 48v
7	Battery sizing	21191Ah; 106 battery banks comparising of 4 sets of 200Ah at 12v	15792; 80 battery banks comparising of 4 sets of 200Ah at 12v
8	Solar charge controller sizing	1157.9372≈ 1158$Amps$	859.5 ≈ 860$Amps$

4.0 CONCLUSION

From the results and findings presented in this paper, it has been shown that the initial cost of implementing the solar system for Zion Hostel block A and block B can be high, however, when compared to JEDC (Jos Electricity Distribution Company) over a 10 years period, it is still efficient and can last a long time with proper maintenance, with the added advantage of being environmentally friendly. Therefore, we have shown that the photovoltaic system can be used as an electrical backup to light the hostel and charge phones and laptops, which is very economical and environmentally friendly.

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