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Design and Procedure for Stand-Alone Photovoltaic Power System for Ozone Monitor Laboratory at Anyigba, North Central Nigeria

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Abstract: This paper presents the application of photovoltaic power system by the use of direct conversion of solar irradiance, for power generation into electricity. It entails the design of a stand-alone photovoltaic power system as a power source for an ozone monitor Laboratory. The solar radiation data were used. This data was obtained from Tropospheric Data Acquisition Network (TRODAN) project for the chosen location. This is achieved through comprehensive designing, selecting and determining the specifications of the components used in this photovoltaic power system in conformity to the load requirement and estimate. The work depends on the variety of factors such as the geographic location, weather condition, solar irradiance and load consumption, which are all considered in this work. It gives a detailed procedure in specifying each component used in the design. A case study with minimum energy consumption is carried out in Anyigba. Detailed cost analysis and installation of a PV system have been estimated, which shows that, the initial investment is high but within few years will gain a substantial dividend and has a long life span if properly utilized.

Key words: **photovoltaic array, charge controller, battery, inverter, ozone monitor Lab.**

I. INTRODUCTION

Energy is the main factor of any economy. It is one of the most important tools for the national development. Nigeria energy is supplied from different hydro- power and thermal power stations. Energy has a major impact on every aspect of our socio-economic life; In addition energy plays vital roles in the economic, social and political development of our nation [13]. Despite the abundances of energy resources in Nigeria, the country is still in short supply of electrical power.

The concern over the production of adequate electricity to drive economic development is a global issue. More so, the need to generate such magnitude of needed electricity from environmentally friendly and non-toxic sources has further heightened the concern. This has led to various efforts at measuring and assessing the potentials and viability of generating electricity from renewable and reliable energy resources [13]. As such, in this work stand-alone solar power systems are now being contemplated.

Solar energy has been deemed clean, inexhaustible, unlimited, non-polluting, and reliable, require little or no maintenance and environmental friendly [2]. Such characteristics have attracted the energy sector to use renewable energy sources on a large scale. This brings us to the evaluation of potential solar energy in Anyigba in order to provide an alternative source of electricity generation. This energy source having proven to be of advantage for decreasing the depletion rate of fossil, as well as supplying energy to remote rural areas, without harming the environment.

Utilizing solar energy, we can fulfill our daily energy needs during sunshine hours while during night hours when there is no sunshine, extra energy storage device are required to meet the demand.

Total solar irradiance varies with time of the day, location, season and weather condition. Therefore, the design of stand-alone solar system cannot have only one standard. Location is a major aspect that will affect photovoltaic power system design and its specifications vary from place to place [1]. Anyigba is blessed with enough sunshine which can meet our energy demand without any compromise. Stand-alone PV system is a

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necessary power source in the ozone monitor laboratory as constant supply is always needed for proper records of the ozone data.

One of the objectives of this paper is to evaluate the potential of solar photovoltaic power system in Anyigba. For this reason, Ozone monitor laboratory is considered with the load requirement of the lab in mind. Equipment specification are also provided base on the availability of the best components available in the Nigerian market, a detailed cost analysis of the power plant installation has been found to be very expensive, so the cost of solar energy consumption is much more than the conventional energy unit as a result, stand-alone photovoltaic power system meets our set objectives which is a very much economical and cost effective systems.

II. STAND-ALONE PHOTOVOLTAIC SYSTEMS

Stand-alone photovoltaic system is a collection of interconnected electrical components, which can generate electricity from sun-light and satisfy our daily energy requirements without worrying about any interval when the sun-light may not be available [1]. This type of system is important only when there is need of load to run in night time or when sunlight is not available for some time. The photovoltaic system consists of the following components;

i. Solar PV array
ii. Cables
iii. Charge Controller
iv. Inverter
v. Battery
vi. Protection devices

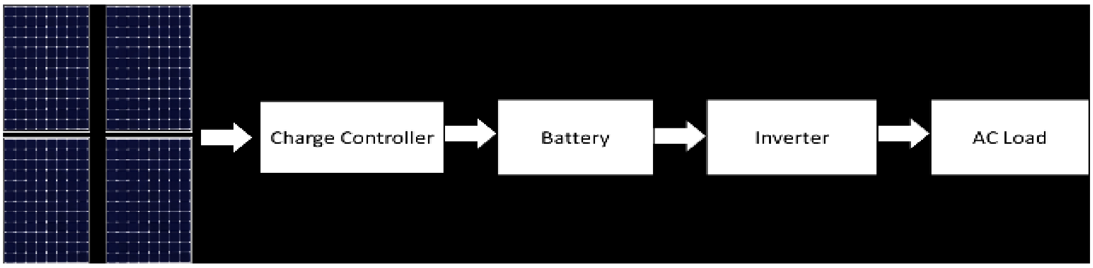

Fig. 1: Stand-alone Photovoltaic System Components.

This figure gives a schematic diagram of interconnection of components of a typical stand-alone photovoltaic power system.
Depending on load requirement and radiation intensity at the site, the components of the system will have to be specified. Below is a brief review of the components. [3].

Solar Photovoltaic Panel

Photovoltaic cell which generates electricity from the sunlight is the main component in a PV system. Current and voltage generated depend on the area of the cell. A 13.5”x13.5” size Photovoltaic cell can generate voltage of about 0.55volts and a current density of 30–35mA/cm^2. [3]. A solar panel is the collection of this basic Photovoltaic cell which can be called solar cells. To meet the power requirements of a particular system, a number of panels are connected in the following form;

(1) Series (to increase voltage)
(2) Parallel (to increase current)

While its combinations form a solar PV array.

Storage Battery

Storage battery is the vital component of a stand-alone PV system. It is to store energy during sunshine hours and supply current to load during non-sunshine hours. These can be in any of the following forms, Lead Acid battery, VRLA battery, Lithium-ion battery, etc. that can be used in solar PV system. The recommended batteries that should be used in stand-alone photovoltaic power system are deep-cycle lead-acid batteries because of their high performance [2]

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Charge controller

This is use to regulate and control the current flow between PV array and battery. The main function of solar charge controller is to limit the flow at which electric current is added to or drawn from batteries. It prevents overcharging and protects battery from voltage fluctuation [9].

Inverter

This is also known as power conditioning unit. It is the heart of the PV system. Most of the applications in a residential building generally use AC current, whereas PV module and battery bank are power source of DC current. Inverter converts DC power to AC power in a PV system. [11].

Protective device

The protective devices, blocking & bypass diodes, lightning-protection system, fuses, bus bar and cable wiring constitute what is known as balance of system components [10]. These components are required to protect the system in an efficient way. Cable size should be chosen in such a way that voltage drop or cable loss is minimized.

AC Load

Power consumption units are load for a PV system to be planned. Proper load estimation is necessary for designing a stand-alone PV system. For the purpose of PV system design, electrical loads (resistive or inductive). Resistive loads do not necessitate any significant surge current when energized. Like light bulb, electric heaters etc. On the other hand, inductive load requires a large amount of surge current when first energized which is about 3.5 times the normal energy requirements such as; fan, electric motor, etc. depending on the load estimation of a building if proper design can be implemented.

III. DESIGN METHODOLOGY FOR PV SYSTEM

This is the process of determining the PV system capacity which is basically in terms of power, voltage and current of each component of a stand-alone PV power system with the aim of meeting the load requirements of the building (ozone monitor lab.) for which the design is made.

Factors affecting the PV system design and installation

PV power systems have a variety and great advantages as discussed above, however it is important to know that it has a high initial cost which is one of the major limitations to its existence. Therefore in order to reduce the overall system cost, the following factors are generally considered as discussed below:

Site inspection and radiation analysis.

The first and the most important part of the design is the geographical location of the installation, site inspection and radiation analysis [12]. It determines whether a stand-alone PV system is viable or not. According to the radiation data of the location, we can find out the number of sunny days in a year. Amount of electrical energy that can be generated depends on the radiation intensity throughout the year. Shadow analysis will help to find out the time duration for which solar radiation falls on solar arrays. Azimuth angle and altitude angle is required to find out the sun path at that location [8].

Reasonable load consumption

Here Principle of Energy Conservation should be applied strictly when calculating the total average energy demand in watt-hour per day. The electrical load of a specific building will dictate how a PV system has to be installed and as such, the load is usually estimated by listing all the loads and their corresponding daily hours when in use.

Optimizing building design

In order to have the optimal energy and minimize the amount of energy that may be required to meet the desired building heating, the building should be provided with adequate insulation, also the southern part of the building should be free from all types of solar irradiance obstacle since the array will be oriented towards the south for effective output of the irradiance.

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Use of reliable and energy efficient loads

The lighting devices should be of the Compact Fluorescent Lamp (CFL) types usually referred to as energy savers so as to reduce energy consumption. Also, cooking and hot water devices are normally not part of a PV power system design.

Choice of low-voltage dc powered components

Low-Voltage dc powered components should be used wherever possible as this will significantly reduce the capacity of inverter and therefore a corresponding reduction of its cost.

Inductive loads consideration

This normally has a large starting inductive current in the building such as AC and refrigerators which must be taken into consideration during the design phase.

Determination of PV size

The Solar PV array is the main component of a stand-alone PV system. It is the combination of solar modules. The PV modules are connected in series to obtain the required voltage and it is called a PV string. The string are then connected in parallel for the system to produce the desired current.

For the size of the PV to be determined, the following vital information should be known

- The DC voltage of the system (V_{dc})
- The average sun hours of the installation site per day (T_{shd})
- The daily average energy demand in watt-hours (E_d)

Also the required daily average energy demand (E_{rdd}) is needed to be determined for accurate PV sizing which is obtained by dividing the daily average Energy demand by the product of the efficiency of all the system components[5] as

$$E_{rdd} = \frac{E_d}{\eta_b \eta_i \eta_c} \quad (1)$$

Where η_b = $Battery\ efficiency$

η_i = $Inverter\ efficiency$

η_c = $Charge\ controller\ efficiency$

The average peak power ($P_{ave,peak}$) which is obtain by dividing the required daily average Energy demand by the sun shine hour per day as

$$P_{ave,peak} = \frac{E_{rdd}}{T_{shd}} \quad (2)$$

The total dc current (I_{dc}) which is obtain by dividing the average peak power by the system dc voltage as

$$I_{dc} = \frac{P_{ave,peak}}{V_{dc}} \quad (3)$$

The number of modules in series (N_{sm}) is obtained by dividing the system dc voltage (V_{dc}) by the rated voltage of each module (V_{rm}) as expressed as system dc voltage divide by the voltage rated of each module as

$$N_{sm} = \frac{V_{dc}}{V_{rm}} \quad (4)$$

The numbers of parallel of module strings (N_{pm}) can be obtain by dividing the total dc current of the system(I_{dc})by the rated current of one module(I_{rm}) as below

$$N_{pm} = \frac{I_{dc}}{I_{rm}} \quad (5)$$

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The total number of modules (N_{tm}) that form the array is determined by multiplying the number of modules in series by the number of parallel modules as shown below

$$N_{tm} = N_{sm} x N_{pm} \tag{6}$$

Determining the specification of the charge controller

The solar charge controller is generally sized in a way that will enable it perform its function of current control. A good charge controller must be able to withstand the array current as well as the total load current and must be designed to match the voltage of the PV array as well as that of the battery bank. MPPT charge controller is specified based on PV array voltage handling capacity. The charge controller sizing is done in a way to ensure that it is able to withstand the product of the total short circuit current of the array ($I_{sc}^{A} = I_{sc}^{M} x N_{pm}$) and a certain safe factor (F_{safe}). The safe factor is necessary in order to allow for a reasonable system expansion. Thus, the desired charge controller current(I_{CC}) is as given as

$$I_{rcc} = I_{sc}^{M} x N_{pm} x F_{safe} \tag{7}$$

WhereI_{sc}^{M} = the short circuit current of the selected module.

Require numbers of charge controller is obtained as in the equation below

$$N_{cc} = \frac{I_{rcc}}{I_{cc}} \tag{7a}$$

Total cost of the charge controller is obtained as in the equation below

$$C_{tcost} = N_{cc}\, x\, C_{ccost} \tag{7b}$$

Where C_{ccost} = cost of each charge controller

Determining Capacity of Inverter

Solar PV system delivers DC voltage and power. So an inverter, which converts DC power to AC power, is needed as most of the applications used in the building require AC power. There are still some applications of DC power in some areas. But in this paper, to keep it simple, we have not considered them. An inverter is rated by its output power (P_{KVA}) and DC input voltage (V_{dc}). Power rating of the inverter should not be less than the total power consumed in different loads. On the other hand, it should have the same nominal voltage of battery bank that is charged by solar PV module. In a household, consumption of power in appliances can be classified into two categories: resistive power (P_{res}), such as in light, heater, iron, etc., and inductive power (P_{ind}), such as in fan, motor, etc.Typically, capacity of the inverter is taken to be the sum of all the loads running simultaneously and 3.5 times the total power of the inductive loads to take care of surge protection. Further, the obtained value is to be multiplied by 1.25 to get the requirement, if an option of 25% extra is kept for a reasonable future load expansion [1]. We get the power(P_{inv}) that should be delivered by inverter as follows:

$$P_{inv} = 1.25(TP + 3.5xP_{ind}) \tag{8}$$

Where, P_{inv} = *Power of the inverter*

TP = Power of all loads running simultaneously $(P_{res} + P_{ind})$

P_{ind} = *Power of all inductive loads with large surge current*

However, this is an ideal situation. This power calculation has to be corrected for power factor of inverter. Power rating of inverter (P_{output}) is related to the real power that is delivered by inverter as output and it is given by the following expression of power factor (PF)

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$$PF = \frac{Deliverable\ Real\ Power}{Power\ rating\ of\ the\ inverter} \quad (9)$$

Here ‘Real power’ is the power that is consumed for work on the load ($\mathbf{P_{inv}}$) in this case, it is as calculated from Equation (8).Value of PF is generally taken as 0.8 for most of the inverters. So,

$$P_{KVA} = \frac{P_{inv}}{PF} \quad (10)$$

Determining the Capacity of Battery

The battery type generally considered for use in solar PV power system application is deep cycle battery, specifically designed such that even when it is discharged to low energy level it can still be rapidly recharged over and over again for years. The battery should be large enough to store sufficient energy to operate all loads in all the season of the year and in night, cloudy, rainy and dusty days of the month. Battery storage is conventionally measured in Ah (ampere hour) unit.

The charge storage capacity, which is essentially the energy storage capacity of the battery bank (B_{Ah}) is determined by the daily energy requirement and number of days for backup power (N_{backup}) using the following equation [6]

$$B_{Ah} = \frac{E_{inv} x N_{backup}}{V_{dc} DoD} \ (AHr) \quad (11)$$

Where E_{inv} = Energy of the inverter $\left(\frac{E_d}{\eta_i}\right)$ (12)

N_{backup} = Number of days for backup power

DoD = **Depth** of discharge of the battery, which is the percentage of charge, that is, energy of the battery that can be allowed for running the load.

Now the C-rating is also an important part of choosing a battery. It tells us what will be the optimum charging and discharging rate of a battery. Typically C-10 rated batteries are available in the market.

To meet requirements of the application load a number of batteries has to be connected in series for system voltage specification and in parallel for current specification. The number of batteries connected in series ($\mathbf{N_{Bs}}$) is obtained by system DC voltage and voltage of individual battery using the equation,

$$N_{Bs} = \frac{V_{dc}}{Voltage\ of\ a\ single\ Battery} \quad (13)$$

The number of batteries which will be connected in parallel (N_{Bp}) can be obtained by the equation below,

$$N_{Bp} = \frac{B_{Ah}}{Ah\ capacity\ of\ a\ single\ Battery} \quad (14)$$

The total number of batteries (N_{TB}) can then be obtained by the equation,

$$N_{TB} = N_{Bp} x N_{Bs} \quad (15)$$

If we take battery efficiency (η_b) to be about 85% typically for lead acid battery [6], then energy required (E_{Bat}) from solar PV array to charge the battery bank is given by the equation below:

$$E_{Bat} = \frac{V_{dc} B_{Ah}}{\eta_b} \quad (16)$$

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DC Cable Sizing

The design of a PV power system can be incomplete without the correct size and type of cable selected for wiring the components together. There are two types of DC cable: PV array to battery bank and charge controller cable also inverter to distribution board system of the Lab cable

PV array to battery bank and charge controller

The cable is selected based on the current between the array and the battery bank which is given in equation (7) above.

Inverter to Distribution board system of the Lab cable

The cable here is based on the maximum continuous input current which is obtained from the equation below.

$$I_{oi} = \frac{P_i}{V_{oi} x Pf} \quad (17)$$

Where I_{oi} = *Current at the inverter output*

V_{oi} = *Inverter output voltage*

P_i = *Power rating of the inverter*

Pf = *Power factor*

IV. CASE STUDY OF AN OZONE MONITOR LABORATORY AT ANYIGBA

Nigeria is located between latitude 4^0N and 14^0N and longitude 2^0E and 15^0E respectively with total area of 923,768 square kilometres. The country is located between the equator and the tropic of cancer. The latitude of Nigeria falls within the tropical zone but the climatic condition are not entirely tropical in nature. The climatic condition varies in most part of the country. In the north the climatic conditions is arid and to the south there is an equatorial type of climate.

The weather condition can be characterized into wet season and dry season. The scope of this paper is constrained to Anyigba, Kogi State North-central Nigeria located at the latitude $7^{\circ}15^0$N (7.25^0N), longitude $7^0$11 (7.18^0E) and at an altitude of 420m above the sea level. This geographical location implies that the solar array should be inclined at an optimal angle of about 30° facing southward for all year round to maximize solar energy received if it is oriented fixed. The average radiation of this location is about 9.481kWh/m^2/day and average ambient temperature of about 37°C, whereas maximum and minimum ambient temperature are 47.3°C and 19°C, respectively, if the location is devoid of overcasts from nearby trees and buildings. Ozone monitor laboratory in this location is chosen for the analysis of a stand-alone PV system.

Table I. Monthly average radiation data of the site

Month	Irradiance (KWh/m^2/day)
January	8.60
February	9.50
March	11.30
April	11.00
May	10.30
June	10.20
July	7.90
August	9.20
September	9.20
October	8.60
November	8.80
December	8.70
Average	9.48

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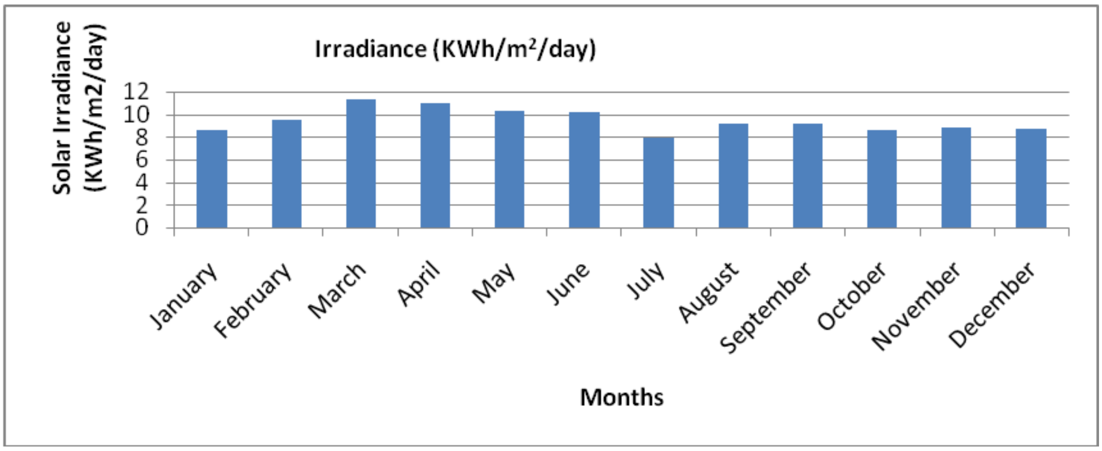

Fig. 2. Monthly Average Variation Solar Irradiance of the location (KWh/m^2/day)

Load profile of the laboratory

The load profile can be determined by itemizing and summing up the power rating and hour of use of all the appliances in the LAB to obtain the total average energy requirement in watt-hours. This can be determined based on the hours of usage per day. An estimation of the requirement done for the LAB is shown in Table ii.

Table II.Total Energy Requirement and Power Rating of the Lab.

S/N	Appliance	Quantity	Power Rating (Watt)	Hour of use per day	Energy per day
1	2B Ozone monitor	1	4.43	24	106.32
2	2B Nitric Oxide monitor	1	13	24	312
3	2B Ozone Calibrator	1	5	24	120
4	2B Carbon Oxide monitor	1	4.5	24	108
5	Computer	4	65	24	6240
6	Printer	1	700	0.5	350
7	Compact fluorescent	6	15	6	540
8	Mobile	3	2.5	5	37.5
	Total Energy Demand.				7813.82

Inverter Specification and Sizing

Inverter should be specified according to the resistive load and inductive load requirements of the Lab, which is shown in Table iii. According to this load estimation and the summery of the inverter sizing is given in Table iii. In this system, specifications of a typical inverter, for example, BBT Inverter 5000Pinverter is used.It should have a power rating equal to 125% of the sun of all power the non inductive appliance and 3 times the sun of the power of all the inductive appliances.

The total inverter power is now the sum of the two previous powers (P_{nia}+3P_{ia}) but however, scaled by a factor of 1.25 to take care of reasonable future expansion. The inverter with such power rating is then sourced from the manufacturer at a reasonable cost. The table below presents the summary of the inverter sizing procedure and its cost estimate.

Table III. Inverter Specification and Sizing *BBT Inverter 5000P*

Parameters	Calculated Values	Source
Inductive Load (P_{ind})	996.32W	Table ii
Resistive Load (P_{res})	6817.8W	Table ii
Total continuous output power (TP)	7.8KW	Table ii
Efficiency (η_{inv})	90%	Inverter data sheet
Input power to the inverter(TP1)	8.7KW	Refer to "(12)"

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Input Dc Voltage(V_{dc})	24V	Inverter data sheet
Input Dc current to the inverter(Idc)	94.6A	Refer to "(3)"
Total inverter power(P_{inv1})	14.2KW	Refer to "(8)"
Power factor(PF)	0.8	Inverter data sheet
KVA rating(P_{KVA})	17.7KW	Refer to "(10)"
Inverter cost	N78,400	Market price
Output AC voltage	240V	Inverter data sheet

Battery specification and Sizing

In order to computes the battery bank size, energy storage requirement should be determined. For inverter total input energy needed is 14.2kW or 14200W from battery. System Voltage is 24V. So Battery voltage should be near about 24V. Days of autonomy are also vital information to determine the size of the battery bank. The summary of the battery sizing is given in the following table.

Table IV. Battery specification and Sizing BBT 5000VA/12V

Parameter	Calculated Values	Source
Usage/day	7hrs	Taken
Autonomy(N_{backup})	3 Days	Taken
Depth of discharge(DoD)	80%	Battery data sheet
Required capacity of battery(B_{Ah})	250Ah	Battery data sheet
Battery bank operating voltage(V_{dc})	24V	Battery data sheet
Each battery voltage	12V	Battery data sheet
No. of battery in series(N_{BS})	2	Refer to "(13)"
No. of parallel(N_{BP})	6	Refer to "(14)"
Total no of battery required(N_{TB})	12	Refer to "(15)"
C – rating	C-10	Battery data sheet
Energy required to charge battery(E_{Bat})	38.3KW	Refer to "(16)"
Cost of each battery	N85,000	Market price

PV Specification and Sizing

PV array should be designed based on the energy requirement to charge the battery bank; the required energy obtained is then divided by the average sun-hours per day for Anyigba to obtain the peak power. The peak power is then divided by the selected system dc voltage to obtain the total dc current. Finally, the number of series and parallel modules can then be determined to give the array size. Also to know the cost of an individual module (M_{cost}). Table v presents the summary of the PV array sizing.

Table V. PV Specification and Sizing Solar module SUNTECH STP200-18-UB-1

Parameter	Calculated values	Source
Daily Average Required Energy (E_d)	7.8KW	Table 2
Required Energy demand (E_{rrd})	11.3KWh/day	Refer to "(1)"
System Voltage (V_{dc})	24V	PV data sheet
Maximum voltage (V_{max})	26.2V	PV data sheet
Maximum current (I_{max})	7.63A	PV data sheet
Isc	6.39A	PV data sheet
Total PV array capacity	345WP	PV data sheet
Average Peak Power ($P_{ave,peak}$)	22698.8098W	Refer to "(2)"
Total dc Current (I_{dc})	94.6A	Refer to "(3)"
No. of modules in series (N_{SM})	1	Refer to "(4)"
No. of modules in parallel (N_{PM})	13	Refer to "(5)"
Total No module in the array (N_{tm})	13	Refer to "(6)"
Average sunshine hour (T_{sh})	5hrs	Chosen location, anyigba
Cost of each module (M_{cost})	N87,000	Market price

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Charge Controller Specification and Sizing

Sizing a suitable charge controller begins with estimating the required total current that the controller can withstand. From the results of the required current, the total number of charge controllers can then be computed and once the cost of a single charge controller is known, the total cost of the controllers can then be determined. Table 5 presents the summary of the Charge Controller sizing procedure and its cost estimate

Table VI. Charge Controller Specification and Sizing Charge Controller LD24305 Safety Factor 1.25

Parameter	Calculated values	Source
System rated voltage	12V/24V	Charge controller data sheet
System rated current	60A	Charge controller data sheet
Required charge controller current (I_{cc})	103.8375A	Refer to "(7)"
Require number of charge controller (N_{cc})	2	Refer to "(7a)"
Cost of each charge controller (C_{ccost})	N 67,500	Market price

Cable specification and Sizing

In a PV system choosing proper cable is a very important aspect in the design. If a DC cable draws more current than its current carrying capacity then it will damage the cable. That's why the cable current rating should be chosen more than the actual capacity. In this design flexible copper cable is chosen based on the current needed

Table VII. DC Cable Specification and Sizing.

Parameter	Calculated Value	Source and selected cable
PV array to Battery Bank through Charge Controller	103.8375A	Refer to "(7)". 3X35mm^2 insulated flexible copper cable
Inverter to DB system of the Lab	26.041667A	Refer to "(8)" 3X4mm^2 flexible copper cable

V. SUMMARY OF THE PV SYSTEM AND COST ESTIMATION

Solar PV modules and the associated components that have been sized which are needed to setup a standard and complete stand-alone power system for the proposed Ozone monitor Laboratory in Anyigba.

The components which are used in this system and the total cost are given in the following tabular form (as shown in Table vii). The cost of equipment (Inverter, Batteries, Modules, Charge Controller, cables, metering and controls) is N 2,570,100.00 while the design and labor cost add up to N 200,700.00. Thus, the total cost of the stand-alone PV power system is N 2,770,000.00.

Table VIII. Summary of the PV System and Cost Estimation

S/N	Component	Qty	Model	Power Rating (W/Ah)	Voltage (V)	Current (A)	Unit price (₦)	Total price (₦)
1	Solar module	13	SUNTECH STP200-18-UB-1	345WP	26.2	7.63	87,000	1,131,000
2	Battery	12	BBT 5000VA/12V	250Ah	12	-	85,000	1,020,000
3	Charge Controller	2	Controller LD24305	-	24	60	67,500	135,000
4	Inverter	1	BBT 5000P	5000W	24/240	-	78,400	78,000
5	Cables	Lot	3X35mm^2 3x4mm^2					85,700
7	Metering and control							120,400
8	Design and							200,700

	labor							
	Grand total							2,770,800

VI. CONCLUSION

The system of photovoltaic source of Energy which uses stand-alone PV solar system is environmental emission free, clean and efficient energy source. This system is generally envisaged for use in an area where constant power supply is needed and in rural remote areas where the national grid system is not rechargeable or available. Though the initial investment of PV system is quite high, however, it is good enough to provide the energy requirement of the Lab; it's beneficial and suitable for a long term investment as the payback period is less than 10 years while the life expectancy of the system period is above 20 years.

The geographical location of Anyigba which is characterized into wet and dry season with an average solar irradiance of 7.2KWh/m^2/day and 11.3KWh/m^2/day respectively which if efficiently tapped, is enough to provide an alternative, clean and environmental friendly energy source. In this paper, the cost estimate of the complete stand-alone PV system which includes design, control devices and labour has also been provided. The result shows that at the optimal configuration for electrifying the lab. About 7.8KW of power is needed. With the help of these systems, we can fulfill our daily demand of energy at any scale. Due to the high capital intensive nature of this alternative and renewable source of energy. It is recommended that respective Government should get involve in providing financial support for the procurement and installation of the PV system which will make it a popular choice and appropriate energy source.

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