DESIGN OF PHOTOVOLTAIC SYSTEM FOR POWERING COMMERCIAL BATTERY CHARGING PHONE BOOTH

By

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ABSTRACT

This paper carried out feasibility studies of using Ampere-hour method of system sizing to design small Solar PV as an alternative source of electricity for powering commercial battery charging phone booth at Dakwa village in Niger State Nigeria, with total power rating of 101W, and total ampere-hour load of 87.16Ah. 5 module of 80W, 2 batteries of 150Ah, 1 charge controller of 30A, and an inverter of 250W was used in designing 400W solar PV. Some basic assumptions were made such as number of sunshine hours (5.33hrs for Niger State), days of autonomy (2 days) the module power conversion efficiency factors (0.9), module de-rate factor (0.9), wire and Battery efficiency factor (0.9, 0.98 resp.), Battery maximum depth of discharge (0.75), temperature corrected factor (0.9), inflation rate, etc.

Key words: ampere-hour method, system sizing, sun shine hours, solar PV

1.0 Introduction

Solar system depends on the energy produced by the sun [4]. Photovoltaic cell is the direct conversion of energy from the sun into electricity. Solar energy is a renewable alternative energy resources and it has a better advantage in electricity generation over conventional sources of electricity. Solar PV Power generation systems are made up of interconnected components for converting sunlight into electricity by photovoltaic process, each with a specific function. Such components are array, balance of system and load. One of the major strengths of PV systems is modularity, as your needs grow individual components can be added or replaced to provide increased capacity.[4] The intensity of the sun rays reaches the earth varies with time of the day, season, location, and weather conditions. The total energy on daily or annual basis is called irradiation and indicates the strength of the sun shines. Irradiation is expressed in $Wh.m^{-2}$ per day[1,4]. Different geographical region experiences different weather patterns, these geographical differences affect the photovoltaic system design, also the orientation of the panels, finding the number of autonomy where the sun does not shine in the skies, and choosing the best tilt-angle of the solar panels,

In Nigeria most of the Commercial battery charging phone booth uses 0.65KVA gasoline generators to power their charging appliances due to inadequate supply of electricity in the country. A particular phone booth located at dakwa village is taken as a case study to design a mini solar PV to power it . The phone booth comprises of Nokia phone chargers, Samsung phone Chargers, L.G phone chargers, Universal Chargers and lightening energy server bulbs. The total power rating of all the appliances in the phone booth is 101watt, and the total ampere-hour load is 87.16Ah.Two Batteries of 150Ah, 12V were used for back up to sustain the phone booth at night hours when the solar supply is inadequate and A Charge Controller of 30A, 12V to keep the batteries, properly fed and to prevent it from over charging or draining, An inverter of 250W, 12V were used to convert DC loads in to AC loads. [3]

1.1 Aim and Objectives

The aim of this paper is to design a small solar PV system that will be used to power a commercial battery charging phone booth.

1.2 Scope of the Study

The work covers designing and costing of solar PV System,

1.3 Justification

This research is done for the following reasons;

- Energy utilization and conservation (Save Energy, save cost)
- Reduce air pollution and CO_2 emission (greenhouse gasses)
- Reduce the use of conventional Energy resources and encourage the use of renewable alternative energy resources

- To avoid waste of resources as the abundant energy we get from the sun is not fully used at all as a result of wastage
- To compute with modern world

2.0 Literature Review

2.1 History of Photovoltaic System

The first discovery of photoelectric effect was in 1839 by Edmund Becquerel, a nineteen years old French physicist [4]. He found that certain materials would produce small amount of electric current when exposed to light in the 1860's an Electrician called Willoughby Smith was testing under water telegraph lines using a material called selenium.[8,9] By chance he discovered that electricity traveled through selenium very well when it was in light, but didn't if the selenium was in darkness. In the late 1870's two American Scientists, [10] Williams Adams and Richard Day became interested in this. They soon discover that the sun energy creates a flow of electricity in selenium. The first conventional photovoltaic cell were produced in the late 1950's and through the 1960's were principally used to provide electrical power for earth-orbiting satellite in the 1970's improvement in manufacturing, performance and quality of PV modules help to reduced cost and opened up a number of opportunities for powering remote terrestrial applications including battery charging for navigational aids signals telecommunication equipments and other critical low-power needs [11]. In the 1980's the photovoltaic became a popular power source for consumer electronic devices including calculators, watches, radios, lanterns and other small battery-charging applications. Following the energy crises of the 1970's significant effort also began to develop PV power system for residential and commercial uses, both for stand-alone, remote power as well as for utility-connected applications. During the same period, international application for PV system to power rural health clinics, refrigeration, water pumping telecommunications, and off-grid [8] households increased drastically, and remain a major portion of the present world market for PV products. Today the industry's production of solar PV module is growing at approximately 25% annually, and the major programs in the U.S. Japan and Europe are rapidly accelerating the implementation of PV System on buildings and interconnection to utility networks. [11]

A similar case is a residence in gaza were by solar PV were used in powering all the electrical appliances in it, [1]

2.2 Problems with solar PV Cell

In 1931 Bruno Lange a German Scientist built a solar cell panel out of selenium. But Lange has the same problem as Fritts. [11] His panel generated such a tiny amount of electricity, it wasn't very useful. Another problem was that the selenium cell didn't last long in strong sun light. For this reason some expert thought PV cells would never be a good way to generate electricity. It wasn't until the 1940's that people became interested in solar electricity generation again *[11]*

2.3.1 System Description

Photovoltaic system can be defined as a set of components needed to convert solar light energy to electrical energy [3]. The components of solar PV System include.

2.3.1 Photovoltaic cell:

This is the direct conversion of sunlight into electricity by photo-electric effect. Solar electric devices are also called photovoltaic or PV devices [3].

2.3.2 Storage medium, battery bank:

Solar battery bank commonly used as an energy storage medium for solar back up that is to make the energy available at night or at days of autonomy (some time called no-sun-day or dark days).[3] It is recommended to buy high quality batteries because what you get what you pay for. Good deep-cycle batteries can be expected to last for 5 to 15 years and some times more. While cheap batteries can give you trouble in half that time

2.3.3 A voltage regulator or charge controller:

Is an essential part of all power systems that charge batteries weather the power source is photovoltaic or utility grid [3]. Its purpose is to keep the battery properly fed and safe for long term. Charge controller block reverse current and prevent battery from getting over charged.

2.3.4 An Inverter or Power Conditioner:

This is a device that changes low dc voltage into a useful ac voltage, as the solar panel generates dc voltage. Inverters are different by the OUTPUT wave format, output power and installation type. There are two types of output format modified sine-wave (MSW) and pure sine-wave (PSW). [3]

2.3.5 Balance of system:

These are protection devices that keep the system component safe during operation, it includes

- **Blocking diodes**:

These device protect the solar PV component from being damaged by the flow of electricity from the battery at night [3]

- **Bypass diodes**:

These are connected across several cells to limit the power dissipated in shaded cells by providing low resistance path for the module current. [3]

- **Lightening–protection**:

This is a device that protects the sensitivity electronic components from the voltage transient. And ground faults. Monitoring, metering, and disconnect devices are additional devices that are used to ensure proper operations of the system. [3]

Wiring:

This is the means through which the components of solar PV systems are connected together [3]. You will need to use correct size wire to ensure low loss of energy and to prevent overheating and possible damage or even fire. The size of the wire must be large enough to carry the maximum current expected without undue voltage losses. All wire has certain amount of resistance to the flow of current. The resistance causes a drop in the voltage from the source to the load. Voltage drop cause inefficiencies especially in low voltage system. [1]

2.3.6 Alternating current (AC) and Direct Current (DC):

These are loads of the appliances that consume the power generated by the photovoltaic array. [1]

2.3.2 Configuration:

In figure 1 shown below, the system is designed to operate independent of the electric utility grid and is generally designed and sized to supply certain DC electrical loads [3]. A bank of batteries used to store the energy in a form of DC power that is produced by the photovoltaic modules to be used at night or in the no-sun days [3]. The DC output of the battery can be used immediately to run certain low Dc voltage load such as lightening bulbs, or it can be converted to AC voltage to run Ac loads that constitute most appliances. However in utility grid connection power is brought in from the grid to supplement the system output when needed and sold back to the utility when the photovoltaic modules output exceeds the power demand. [3]

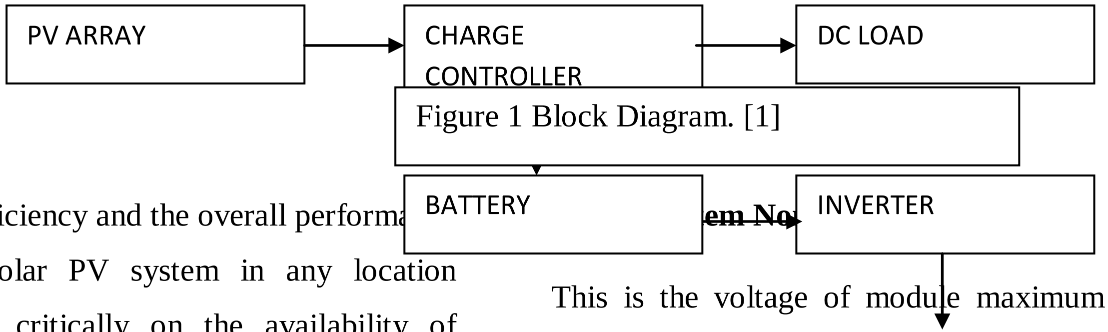

Figure 1 Block Diagram. [1]

The efficiency and the overall performa of a solar PV system in any location depend critically on the availability of solar energy in such location. The solar energy availability on earth surface is site-dependent and varies through the year [3]

2.4.1 Load Evaluation

Another important consideration is to determine the system load or total energy consumption and the pattern of consumption for both AC and DC loads. In order to calculate this, the daily duty cycle (number of our used per day) and weakly duty cycle (the number of days used per week) has to be known. Then daily ampere-hour load of each appliances. [3]

2.4.2 Availability of Hardware

Design with the most available and common system components make enquiry from PV component dealer about the availability of Module, battery, e.t.c before designing any system. [3]

em No

This is the voltage of module maximum power point under actual field conditions. Large stand-alone system or mini-grid system is designed 24V, 48V, or 120V as the case may be, while small size system is assigned 12V during design. [3]

2.4.4 Tilt Angle

Solar panel should be oriented to receive maximum incident solar radiation over the course of the year. The preferred orientation is facing south in the northern hemisphere and facing north in southern hemisphere. [3]

2.5 System Sizing

System sizing can be defined as the process of evaluating the adequate voltage and current rating for each component of the photovoltaic system to meet the electric demand at the facility and at the same time calculating the total price of the entire system from design phase to the fully functional system including shipment and labor. The method of system sizing adopted here is the ampere- hour method [3].

2.5.1 Array Sizing

In order to determine the number of PV modules needed to generate desired amount of electrical the Corrected Total Ampere-Hour Load (AHC), Design Current (DC), De-rated Design Current (DDC), Number of Module in parallel (MP) and in series (MS), has to be determine [3]

2.5.2 Battery sizing

Battery is vital balance of system (BOS) components and its selection and proper integration in to the overall design [3]. In battery sizing the following parameters most be calculated before determining the battery capacity for any PV system. The daily ampere-hour load (AHL), Number of days of autonomy or storage days, Battery maximum depth (DMAX), and Temperature correction factor, has to be known to determine the battery size. The corrected battery capacity, number of batteries in parallel (BP) and in series (BS), Total number of battery required for the design (BTOTAL),has to be Determined [3]

2.5.3 Charge Controller

In sizing charge controller, Module Short-Circuit Current (MSC), Array Short-Circuits Current (ASC) has to be determined [3]

2.5.4 Inverter sizing

Basically there are two fundamental system parameters to be considered before selecting a particular inverter, which are, System Nominal Voltage and Size of load both in terms of the total watt-hour per day and in terms of the size and type of an individual peak loads such as total AC power demand, Inverter output wave form, Idle current. Common Stand-alone inverters operate at 12V, 24V, 48V, or 120DC input and 120V AC or 240V AC output voltage at frequency 60HZ. Inverters are classified as Squire Wave Inverter, Modified wave Inverters, and Pure Sine Wave Inverters. In general Inverters should be oversized by about 25% of the load to increase reliability and life time. [3]

2.5.5 Wire sizing and Selection

Selection of suitable wires, connectors and protection component that will make the system to last for 25 years or more is an important thing to do. Below is a table showing the Resistance and Capacity Characteristics of THHN insulated wire by American Wire Gauge (AWG) [3]

Wire gauge	**Resistance Ohms/100FT@680F**	**Maximum Recommended Current (A)**
14.000	0.253	15.000
12.000	0.159	20.000
10.000	0.100	30.000
8.000	0.063	55.000
6.000	0.040	75.000
4.000	0.025	95.000
2.000	0.016	130.000
0.000	0.010	170.000
00.000	0.008	195.000
000.000	0.006	225.000
0000.000	0.005	260.000

[3]

2.6 Factors affecting Output

Solar modules output produce DC electricity. The Dc output of solar module is rated by the manufacturer under standard condition (STC). These conditions are easily recreated in the factory, allowing for consistent comparison of products, but need to be modified to estimate output under common outdoor operating conditions. STC conditions are solar cell temperature, which is 25% solar irradiance which is 1000W/m^2 often referred to as peak- sun light intensity. [3]

2.6.1 Temperature

Modules output reduces as the temperature increases. During operation solar module will heat up sometimes inner temperature reaching up to 50^{0c} [3]. For crystalline module a typical temperature reduction factor recommended is 89%. So the 100W module will typically operate at about 85% (95% x 0.89 = 85W) under the fully sun shine condition. [3]

2.6.2 Dirt's and Dust

Dirt's and Dust can accumulate the solar panel module surface, blocking of the sun light and reducing the output, especially during dry season, but during rainy season it is clean up by the rain [3].

2.6.3 Mismatch and Wiring losses

The maximum output of total PV array is always less than the sum of the maximum output of the individual module [3]. These differences are as a result of slight inconsistencies in performance from one module to the next and is Called module mismatch and it amount to at least 2% loss in the system power. Power is also lost to resistance in the system wiring. Theses should be kept to a minimum but it is difficult to keep these losses below 3% for the system. A treasonable reduction for these losses is 95%. [3]

3.0 Methodology

The ampere-hour methods of system sizing were used to size the Array, Battery, Charge Controller, and inverter using the Equations Below.

Equation 1 – 7 for array sizing, Equation 8-11 for Battery sizing, equation 12-13 for charge Controller sizing, while Equation 14 for inverter sizing. The total power rating of all the appliances is 101.1W. Some basic assumptions were made such as number of sunshine hours (SP), the module power conversion efficiency factors (CP), module de-rate factor (MDR), wire and Battery efficiency factor (ΦW, ΦB), Battery maximum depth of discharge (DMAX), temperature corrected factor (TF), inflation rate, etc. [3]

3.1.1 Sizing of Solar Array

The ampere-hour load is determined using

$$AHL = \frac{PRXDDCXWDC}{CPX7XVNS} \text{ ………. Equation (1)}$$

Where PR is the Power Rating of the appliance, DDC is the daily duty cycle

WDC is the weekly duty cycle; CP is the module power conversion efficiency (0.9)

VNS is the system nominal voltage (12V) [3]. The ampere-hour load (AHL) for each appliance were added up to obtain the total ampere-hour load (TOTAL AHL) [3]

The corrected ampere-hour load (AHC) were determined using

$$\boldsymbol{AHC = \frac{TOTALAHL}{\Phi WX\Phi B}} \text{ ....Equation (2)}$$

Where ΦW is the wire efficiency factor which is 0.9, and ΦB is the battery efficiency factor which is 0.9, Total AHL is the total ampere-hour load for all the appliances. [3]

The design current (CD) were determined using $\boldsymbol{CD = \frac{AHC}{SP}}$**..............**Equation (3)

Where AHC is the Corrected ampere-hour load, SP is the peak sun-hour for the location (5.33hr for Abuja). [3]

The de-rated design current (DDC) where obtained using $\boldsymbol{DDC = \frac{CD}{MDR}}$…Equation (4)

Where CD is the design current, MDR is the module de-rate factor (0.9) [3]

Module in parallel is found using

$\boldsymbol{MP = \frac{DDC}{CRM}}$………………Equation (5)

Where DCC is the De-rated design current, CRM is the Rated module current (4.60 for 80W module). [3]

Module in series is found using,

$\boldsymbol{MS = \frac{VNS}{VMS}}$……………………Equation (6)

Where VNS, and VMS are the system and module nominal voltage respectively. [3]

The Total number of module to be used in the design is found using,

$\boldsymbol{Total\ Module = MPXMS}$..Equation (7)

Where MP and MS are the Number of module in parallel and series [3]

3.1.2 Battery Sizing

The battery capacity was determined using

$\boldsymbol{BC = \frac{AHCxSD}{DMAXxTF}}$………Equation (8)

Where AHC, is the corrected ampere-hour load, SD is the storage days that is days of autonomy (2days), DMAX is the maximum depth of discharge (assumed 75%), TF, is the temperature corrected factor (0.9). [3]

The battery in parallel is found using

$\boldsymbol{BP = \frac{BC}{BR}}$……………………Equation (9)

Where BR, is the rated battery capacity (150Ah), BC is the battery capacity obtained above. [3]

The battery in series is found using

$\boldsymbol{BS = \frac{VNS}{VNB}}$ ………………… Equation (10)

Where VNS and VNB are the nominal voltage of the battery and system (12V for each) [3]

The total numbers of batteries required by the system were obtained using

$\boldsymbol{BT = BPxBS}$……………..Equation (11)

Where BP and BS are the number of batteries in parallel and in series [3]

3 .1.3 Charge Controller sizing

The charge controller sizing were determined using

$\boldsymbol{ASC = MSC\ x\ MP}$……Equation (12)

Where ASC, is the Array Short-Circuit, MSC is the Module Short-Circuit (11.50A) [3]

The design controller capacity (CDD) was obtained using.

$\boldsymbol{CDD = (1 + 25\%) x\ ASC = 1.25\ x\ ASC}$……………Equation (13) [3]

3.1.4 Inverter sizing

In general inviters should be over sized by 25% of the load to increase reliability and life time.

Inverter rating (INVR) was obtained using.$\boldsymbol{INVR = pr + (25\%\ x\ pr) = 25\% pr + pr}$………..Equation (14) [3]

Where pr is the total power rating,

The result gives the inverter rating in watts. Then the inverter whose rating is close to the calculated value is selected [3].

3.1.5 SOURCES OF DATA

Both primary and secondary data were used, the primary data were recorded directly from the study area (Dakwa village) which are:

- The quantities of phones charge per day, number of hours used per day (DDC), number of days used per week (WDC), and the power ratings of all the appliances in the phone booth from manufactures specifications

The secondary data were collected from [1, 2, 3, 4, 6, and 8]. All the Equations and assumptions made are from the secondary source

4.0 Table of Results

Table 4.1 showing power rating of the entire appliance in the phone booth

S/N	ITEMS	QTY	PR (W)	TOTAL PR (W)	DDC (Hrs)	WDC (Days)
1.00	Nokia Phone Charger	10.00	1.75	17.50	10.00	7.00
2.00	Samsung Phone Charger	10.00	2.61	26.10	10.00	7.00
3.00	L.G. Phone Charger	10.00	2.50	25.00	10.00	7.00
4.00	Universal Charger	10.00	2.25	22.50	10.00	7.00
5.00	Lightening Bulbs	2.00	5.00	10.00	3.00	7.00
6.00	Total Load			101.1		

Source: study area phone booth at Dakwa village

Table 4.2 Array sizing

(TOTAL AHL) / Ah	(AHC) / Ah	(CD) /A	(DDC) /A	(MP)	(MS)	Total Module	M PR (W)
87.16	98.82	18.52	20.57	5.00	1.00	1.00	80.00

[3]

Table 4.3 Battery Sizing

(BR) / Ah, V	(BC) / Ah	BP	BS	Total Batteries
150.00, 12.00	292.80	2.00	1.00	2.00

[3]

Table 4.4 Charge Controllers Sizing

Short-Circuit Current/A	CDD /A	Selected Charge Controller / A
11.50	14.35	20.00

[3]

Table 4.5 Inverter Sizing

Inverter Rating/W	25% of Total Load/W	Selected Inverter/W
177.90	203.01	250.00

[3]

Table 4.6 Cost Estimate of the System Component

Components	Model	Qty	PR/W/Ah	Price/N	Amount/N	Life exp./ years
Module	Mono crystalline.	5.00	80.00	17,000	85,000	25.00
Battery		2.00	150.00	40,000	80,000	10.00
C/Controller	WS-C2430	1.00		30,000.	30,000.00	
Inverter	Xantrex 801-3255	1.00	250.00	30,000	30,000	
Installation				15,000	15,000	
Transport				5,000.0	5,000	
Total					245,000	

[7]

5.0 Conclusion

From the results of this study, it could be concluded that mini Solar PV was design to power the Phone Booth with a capacity of 400W, at the cost of N 245, 000. 00,

The specific findings from this work are as follows:

i. Mini Solar PV was design at N 245,000.00
ii. Solar PV initial design cost is very expensive
iii. The total power rating of all the appliances is 101.1W, the total ampere-hour load of all the appliances is 87.16Ah, maximum daily usage is 10hrs, maximum weekly usage is 7 days
iv. 5 modules of 80W, 2 batteries of 150Ah, 1charge controller of 30A, and 1 inverter of 250W was used in achieving this
v. Solar PV is more advantageous than gasoline generator in powering the commercial phone booth. Which includes; no air pollution, no noise, no irregular supply of current due to mechanical fault as there are no moving parts no voltage fluctuation, it can be upgraded when certain loads are added to the phone booth and finally no green house gases.

5.1 Recommendation

- Government should encourage and support renewable energy research programs in all research institutes.
- Government should give tax relieve on solar PV components
- Government and financial institutions should intervene by giving empowerment inform of soft loan to those involve in this kind of business, as the cost of a solar PV is very expensive cannot be afforded by many small scale business man.
- Government in collaboration with energy research centers should carry out public enlighten program throughout the nation That will make people understand the importance of utilizing energy from the sun, not relying on one source of energy that is the fossil fuel to power electrical appliances.

APPENDIX A

1. $For\ Nokia\ Phone\ Chargers, AHL = \frac{PRXDDCXWDC}{CPX7XVNS} = \frac{17.5*10*7}{0.9*7\ x*12} = 16.20Ah$

2. For Samsung Phone Charger, $AHL = \frac{PRXDDCXWDC}{CPX7XVNS} = \frac{26.13*10*7}{0.9*7x*12} = 24.20Ah$
3. $For\ L.G\ Phone\ Charger, AHL = \frac{PRXDDCXWDC}{CPX7XVNS} = \frac{25*10*7}{0.9*7*12} = 23.15Ah$
4. $For\ Universal\ Charger, \quad AHL = \frac{PRXDDCXWDC}{CPX7XVNS} = \frac{22.5*10*7}{0.9*7*12} = 20.83Ah$
5. $For\ Lightening\ Bulb, AHL = \frac{PRXDDCXWDC}{CPX7XVNS} = \frac{10*3*7}{0.9*7*12} =$ 2.78Ah
6. $TotalAHL = 16.20 + 24.20 + 23.15 + 20.83 + 2.75 = 87.16Ah$
7. The Corrected ampere − hour load$AHC = \frac{\boldsymbol{TOTALAHL}}{\Phi\boldsymbol{WX}\Phi\boldsymbol{B}} = \frac{87.16}{0.9*0.98} = 98.82Ah$
8. Design Current, $CD = \frac{\boldsymbol{AHC}}{\boldsymbol{SP}} = \frac{98.82}{5.337} = 18.52A$
9. Derated Design Current, $DDC = \frac{\boldsymbol{CD}}{\boldsymbol{MDR}} = \frac{18.52}{0.9} = 20.57A$
10. Module in Parallel, $MP = \frac{\boldsymbol{DDC}}{\boldsymbol{CRM}} = \frac{20.57}{4.60} \approx 5.0$Module in series, $MS = \frac{\boldsymbol{VNS}}{\boldsymbol{VMS}} = \frac{12}{12} = 1$
11. Total number of Module, $MT = \boldsymbol{MPXMS} = 5\ x\ 1 = 5$Module of 12V, 80W capacity would be used

APPENDIX B

Calculation for the result of table 4.3

1. $\boldsymbol{Bc = \frac{AHCxSD}{DMAXxTF} = \frac{98.82*2}{0.75*o.9} =}$ **292.8AH**
2. $\boldsymbol{BP = \frac{BC}{BR} = \frac{298.2}{150} \approx 2}$
3. $\boldsymbol{BS = \frac{VNS}{VNB} = \frac{12}{12} = 1}$
4. $\boldsymbol{BT = BPxBS = 2\ x\ 1 = 2}$

APPENDIX C

Calculation for the Result of Table 4.4

$\boldsymbol{ASC = MSC\ x\ MP}$

$\boldsymbol{CDD = (1 + 25\%)x\ ASC = 1.25\ x\ ASC}$

1. $ASC = MSC * MP = 4.6 * 5 = 18.23A$
2. $CDD = 1.25 * Asc = 1.25\ x * 18.23 = 23.79A.$

For this design 30A, 12V charge controller Selected

APPENDIX D

Calculation for the Result of table 4.5

1. $Invr = \frac{CD*VNS}{1.25} = \frac{18.52*12}{1.25} = 177.9\ W$
2. $25\%\ of\ total\ load = 101.1\ x\ 0.25 = 25.28$
3. $therefore\ 25.28 + 1779.9 = 203.096W$

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4. Finally a 250W 12V pure sine wave inverter was recommended

Calculation for the Result of Table 4.7

1. $Module = 5 * 17{,}000 = N85{,}000$
2. $Batteries = 2 * 40{,}000 = N80{,}000$
3. $Charge\ controller = 1 * 30{,}000 = N30{,}000$
4. $Inverter = 1 * 30{,}000 = 30{,}000$
5. Installation = N15,000
6. Transportation = N5,000
7. $Total\ cost\ of\ design = 85{,}000 + 80{,}000 + 30{,}000 + 30{,}000 + 15{,}000 + 5000 = N245{,}000.00$

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