DESIGN AND INSTALLATION OF A SOLAR POWERED SYSTEM FOR LIGHTING

BY

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF POST GRADUATE DIPLOMA (PGD) IN AGRICULTURAL AND BIORESOURCES ENGINEERING. FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE, NIGERIA.

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DECLARATION

I hereby declare that this project is a record of research work that was undertaken and written by me. It is has not been presented before for any degree, diploma or certificate at any University or Institution. Information derived from published and unpublished work, the guardians of my project supervisor Engr. Prof, I. N. Itodo and other referenced in the text.

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Abubakar Isah Date

CERTIFICATION

This project titled 'Design and installation of solar powered system for Lighting` by Abubakar Isah meets the regulations governing the award of Post Graduate Diploma (PGD) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This project is dedicated to my parents Late Alhaji Abubakar Tukunji and Mallama Khadijat Abubakar for assisting me through my education.

ACKNOWLEDGEMENT

I have to express my sincere appreciation to a good number of people who contributed to the success of this project. First, I thank almighty Allah for giving me the good health, strength and knowledge to organise the project together.

Some persons are worthy of mention, especially Engr. Professor I.N. Itodo, Project Supervisor who worked tirelessly despite his tight schedule to see that this project was successfully completed .He read through the manuscript and made necessary corrections. Others are Head of Department, Agricultural and Bio resources Engineering, Engr. Dr. A. A. Balami for leadership and guidance. Also my lecturers in the department for imparting the required knowledge which enable me to write this project.

ABSTRACT

A solar powered system was designed and installed for lighting a DC electrical bulb of 30W at the Department of Agriculture Engineering Workshop, Federal University of Technology, Minna. The installed system comprises of a 45W PV module, 100Ah battery and 20A charge controller .The light come on automatically at 1855H and goes off at 0612H daily providing light for 11hours at night. The system current responded linearly to the amount of insulation incident upon the module. The peak power of 40.30 W measured from the PV module at 1200H compared with the manufacturer`s rating of 45W. The cost of the installed system was One hundred and five thousand Naira, (N105,000.00). A life cycle cost analysis showed that as from 140 days after installation the solar system harness more cost effective than the public diesel/petrol energy system while the public utility energy system remain unprofitable.

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LIST OF ABBREVIATIONS

BC	Battery capacity
BOS	Balance of system
LCC	Life cycle cost
KW	Kilo watts
W-h	Watt-hour
W/m^2 /day	Watt per square meter per day
Pvc	Photovoltaic cell
EJ	Exojoules
KWp	Kilo watts-peak

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

Advances in civilizations have been accompanied by an increased of energy consumption. Today, energy consumption appears to be directly related to the level of living of the population and the degree of industrialization of the country. Economic development has gone hand in hand with increase in energy use per capital, beginning in history of solar energy embodies in plant, animals, wind energy and fossil fuels. The convectional energy resources predominantly used in the cities and industries includes natural gas, coal, kerosene ,electricity and wood which serve as a source of fuel supply to the rural dwellers. The use of those sources of fuel for domestics and industries application is growing and getting more expensive with rise in standard of living. Growing number of people are beginning to see the energy crisis in a very different light. All the convectional sources of fuel are exhaustible and non-renewable are underutilized. Natural renewable resources already existing within the biosphere must be channel through our society for optimum utilization without creating heat or other pollutant or changeable to have permanent supply and also maintain a healthy environment. All forms of energy on earth are derived from the sun. However the more conventional forms of energy, the fossil fuels, received their solar energy input millions of years ago and posses the energy in greatly concentration form (Mc veigh, 1979).

Everything possible must be done to take natural renewable sources already existing within the biosphere and channel them through our society to do the work required. Nigeria like other sub-Saharan African countries is blessed with abundant sunshine all year round. Nigeria is located within the sun belt and receives as much as $490W/m^2/day$. Solar energy is used directly in open air crop drying which is usually accomplished by thin layer spreading on tarred road and hanging on wooden platform by subsistent small-scale farmers. This is done everywhere in Nigeria and is the commonly application of solar energy (Mathur and Kandpal,1994).

1.2 Renewable Energy

Energy is one of the most essential needs of man. A major problem that confronts mankind today is the inadequate availability of energy as its conventional sources are fast becoming exhaustive. Energy problem is increasing day by day due to population explosion, environmental degradation and fast depleting resources of fossil fuel (Daniels,1994).

Energy can be classified as renewable and non-renewable energy Sources. The metals and other resources obtainable from the earth as energy sources are non-renewable. Sources which can be renewed by physical, mechanical, or chemical processes are known as renewable. Examples are solar energy, Hydro, forest animals and humans are renewable sources. The ever increasing and fluctuating prices, coupled with their adverse impact on the nation's economy, it has become compelling to explore renewable sources of energy for agricultural and domestic purposes (Garba, et al., 1999).

The total solar energy absorbed by the Earth's atmosphere, oceans and land masses is approximately 3,850,000 EJ per year. In 2002, this was more energy in one hour than the world used in one year Photosynthesis captures approximately 3,000 EJ per year in biomass. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined (Smil,2006).

While total photovoltaic energy production is minuscule, it is likely to increase as fossil fuel resources shrink. In fact, the world's current energy consumption could be supplied by covering less than 1 percent (1%) of the Earth's surface with solar panels. The material requirements would be enormous but feasible, as silicon is the second most abundant element in the Earth's crust. These factors have led solar proponents to envision a future "solar economy" in which practically all of humanity's energy requirements are satisfied by cheap, clean, renewable sunlight (Richard,2009).

Solar energy refers primarily to the use of solar radiation for practical ends. However all renewable energies, other than geothermal and tidal, derive their energy from the sun. Solar technologies are broadly characterized as either passive or active depending on the way they capture, convert and distribute sunlight. The potential for solar energy is enormous, since about 200,000 times the world total daily electric-generating capacity is received by the earth every day in the form of solar energy. However the era of cheap fuel, coal, wood and petroleum to produce lighting is forever, so therefore, the need to exploit and harness renewable energy source is paramount. Solar energy is used to generate electricity for various uses in agriculture; irrigation, post ha rvest activities such as drying, cold storage of fruits and vegetables and livestock products (Foster,2009).

1.3 Statement of the problem

The energy crisis resulting from the world-wide shortage of petroleum emphasises the need for alternative energy sources. Presently, Nigeria is at the peak of her energy crisis in relation to electrical power generation. The current installed capacity generation station is 7,000MW of which about 50% is available (Gekpe,2008). This is because over 70% of the country power comes from conventional sources. Power generation can best be met by diversifying the sources of generation. Solar energy is the renewable energy sources that has abundant potential in Nigeria; less than 1% of this potential has been utilized in Nigeria (Jesuleye et al 2004).

1.4 Objectives of the study

i. To design and install a solar powered system which will serve as means of lighting, non-polluting and noiseless operation in the departmental workshop.

ii. To encourage the use of solar energy for lighting, thus reduce the dependence on expensive electricity from the grid.

1.5 Justification of the study

The economic implication in the construction, maintenance of dams and laying power transmission cable are extremely expensive, The cost of dam construction means that they must operate for many decades to become profitable. The flooding of large areas of land when the dams spill excess water means that the natural environment is destroyed, which is uneconomical. The hydro-generated electric power sources can be supplemented with the use of solar power system, which has less maintenance cost, provide profit within a short period, help to sustain the environment and slow down global warming.

CHAPTER TWO

2.0 LITERATURE REVIEW

The primary material used in the modern collection of solar energy is silicon. Even though it takes 100 times more surface area of silicon than that of other solid-state materials to collect the same amount of energy, silicon was already developed and in mass production when solar energy collection technology was developed, and so it was the practical choice. However, any semiconductor is acceptable. The semiconductor is part of a panel called a photovoltaic, or solar cell. This cell absorbs sunlight and transfers it into electricity, typically with a 15-20% efficiency. The true principle of this study (the factor observed) centres not on the inner processes involved in the energy transfer, but rather on the efficiency of the solar cell. (Carlson and Wagaer, 2002).

2.1 Development of solar cells

The development of solar cell technology stems from the work of the Antoine-César Becquerel in 1839. Becquerel discovered the photovoltaic effect while experimenting with a solid electrode in an electrolyte solution; he observed that voltage developed when light fell upon the electrode. About 50 years later, Charles Frits constructed the first true solar cells using junctions formed by coating the semiconductor selenium with an ultrathin, nearly transparent layer of gold. Frits' devices were very inefficient converters of energy; they transformed less than 1 percent (1%) of absorbed light energy into electrical energy. Though inefficient by today's standards, these early solar cells fostered among some a vision of abundant, clean power (Paul,1981).

Another metal-semiconductor-junction solar cell, in this case made of copper and the semiconductor copper oxide, had been demonstrated. By the 1930s both the selenium cell and the copper oxide cell were being employed in light-sensitive devices, such as photometers, for use in photography. These early solar cells, however, still had energy-conversion efficiencies of less than 1 percent (1%). This impasse was finally overcome with the development of the silicon solar cell by Russell Ohl in 1941. Thirteen years later, aided by the rapid commercialization of silicon technology needed to fabricate the transistor, three other American researchers-Gerald Pearson, Daryl Chapin, and Calvin Fuller-demonstrated a silicon solar cell capable of a 6 percent (6%) energy-conversion efficiency when used in direct sunlight. By the late 1980s silicon cells, as well as cells made of gallium arsenide, with efficiencies of more than 20 percent (20%) had been fabricated. In 1989 a concentrator solar cell in which sunlight was concentrated onto the cell surface by means of lenses achieved an efficiency of 37 percent (37%) owing to the increased intensity of the collected energy. By connecting cells of different semiconductors optically and electrically in series, even higher efficiencies are possible, but at increased cost and added complexity. In general, solar cells of widely varying efficiencies and cost are now available (Mark,2001).

Sunlight can be converted into electricity using photovoltaic (PV), concentrating solar power (CSP), and various experimental technologies. PV has mainly been used to power small and medium-sized applications, from the calculator powered by a single solar cell to off-grid homes powered by a photovoltaic array. For large-scale generation, CSP plants (also called solar thermoelectric plants) like SEGS, have been the norm but recently multi-megawatt PV plants are becoming common. Completed in 2007, the 14 MW power station in Clark county, Nevada, United States and the 20 MW site in Beneixama, Spain are characteristic of the trend toward larger photovoltaic power stations in the United States and Europe (Mark, 2009).

2.2 Sun as Basic Resources for Solar Energy

The Sun is the basic resources for all solar energy systems. Solar energy appears to be the most promising among the non-conventional sources of energy. The sun's great energy output is the result of an elaboration chemical process in the sun's core-a process of thermo-nuclear fusion like the reaction in hydrogen bomb. Sun radiates energy to about $3.5x10^{23}$Kw in to space and only $20x10^{14}$Kw reaches the earth. Sunlight, or solar energy, can be used for heating, lighting and cooling homes and other buildings, generating electricity, water heating, and a variety of industrial processes. Most forms of renewable energy come either directly or indirectly from the sun. For example, heat from the sun causes the wind to blow, contributes to the growth of trees and other plants that are used for biomass energy, and plays an essential role in the cycle of evaporation and precipitation that makes hydropower possible (Douglas, 1995)

The Sun is the source of most of the energy on Earth--the power source for plants, the cause of flows of atmosphere and of water, the source of the warmth which makes life possible. None would exist without it. At the Earth's orbit, neglecting absorption by the atmosphere, each square meter of area facing the Sun receives about 1380 Joules per second (nearly 2 horsepower) (David, 1999).

The intensity of extra-terrestrial radiation often referred to as the solar constant is fairly constant and is estimated to be 1353W/m^2 but varies according to

Length (Mbanisi,2008). The sun emits radiation which travels at a velocity of $3x10^8$ m/s. The radiation from the sun is attenuated by atmospheric extinction thus making the radiation on the earth's surface less than the emitted radiation. The radiation on the earth surface is estimated to be $5x10^{-8}$ percent of the emitted radiation from sun (Itodo el al.,2004; Itodo, 2007).Variation during the year in the distance between the sun and the earth lead to annual variation in the solar constant of $\pm$3.5% (about 50Wm^{-2}) (Ekeh, 2003).

2.3 Availability of solar energy

In designing solar collector and solar devices, the daily movement of the sun from the East in the morning to its highest point at mid day and then setting in the West is due to the rotation of the earth about its axis while the change in climate as indicated by the season is as a result of the tilt of the earth's axis and its orbit about the sun it takes one orbit. The angle of tilt of the axis to the plane of the orbit is about 23.5^o. The hemisphere, that is angled towards the sun at a given time during the earth's orbit about the sun will receive greater proportion of bean radiation for a greater time each day than the other hemisphere (Schaffer, 1992).

The movement of the sun is such that on June, 22, the sun is at its most northerly point as it is directly overhead at the topic of cancer (23.5^{0}N) as a result of which the northern hemisphere receives a relatively large amount of sun shine at this time of the year. The sun then continues to move south words towards the equators. On September 22, the sun is directly overhead at the equator in each case both hemisphere receives the same amount of insulation, On December 22,the sun is vertically overhead at the tropic of Capricorn (23.5^{o}S). On this day, the northern hemisphere has its shortest period of sun light and the southern hemisphere the longest. The sun then begins to move northwards crossing the equator .The yearly movement of the sun is important in determining the direction to face solar collectors and other solar devices in order to receive maximum beam radiation (Lof et-al,1996). The angle of declination, which is the angle subtended by the sun and the plane of the equator is use to determining the most appropriate slope angle to capture maximum beam radiation for solar collector devise. This angle usually ranges from 23.45^0 (December) to 23.45^0 June. This is important in determining the slope and focusing direction of the PVC module for maximum output (Itodo et al., 2004).

2.4 Solar Collectors

The use of solar energy starts essentially from the choice of appropriate collector. There are basically two types of solar collectors, the flat plate and the concentrating collectors. The difference between the two is how they interact with radiation. The choice of a collector type for a particular application depends on the required temperature elevation for application (James,2010).

2.5 Glazed Flat Plate Collectors

Glazed flat-plate collectors are very common and available as liquid and air–based collectors. These collectors are better suited for moderate temperature application where the demand temperature is 30-70^0C and /or for application that require heat during the winter months. The air-based collectors are most commonly used for the heating of domestic and commercial hot water (Geoff and Jones, 2006).

2.6 Concentration Solar Collectors

The concentration solar collector uses reflectors to concentrate sunlight on absorber, the size of the which can be dramatically reduced, which reduces heat losses and increases efficiency at high temperature. This class of collector is used for high temperature application such as steam production for the generation of electricity and thermal detoxification. They are best suited to climate that have an abundance of clear sky days (Geoff and Jones, 2006)

2.7 Solar Panel Design

Most solar cells are a few square centimetres in area and protected from the environment by a thin coating of glass or transparent plastic. Because a typical 10 cm × 10 cm (4 inch × 4 inch) solar cell generates only about 2W of electrical power (15 to 20 percent of the energy of light incident on their surface), cells are usually combined in series to boost the voltage or in parallel to increase the current. A solar, or photovoltaic (PV), module generally consists of 36 interconnected cells laminated to glass within an aluminium frame. In turn, one or more of these modules may be wired and framed together to form a solar panel. Solar panels are slightly less efficient at energy conversion per surface area than individual cells, because of inevitable inactive areas in the assembly and cell-to-cell variations in performance. The back of each solar panel is equipped with standardized sockets so that its output can be combined with other solar panels to form a solar array. A complete photovoltaic system may consist of many solar panels, a power system for accommodating different electrical loads, an external circuit, and storage batteries. Photovoltaic systems are broadly classifiable as either stand-alone or grid-connected systems (Mark, 2009).

2.8 Solar Array

The solar array chosen will depend on what the need is. Someone looking for enough electrical energy to power an entire house, strictly on solar energy, and includes electrically heating water, will need a totally different solar array than one that heats water directly with solar energy. There are two more traditional styles of solar energy panels used in residential, commercial and industrial areas today. The two most popular are photovoltaic energy and photo thermal energy. Most solar arrays to date have been a mixture of these two viable systems (James,2010).

Heating water can be pretty expensive for those who use electrical water heaters, either centralized or directly on the showerhead, such as in countries where the climate is usually very hot and people are rarely in need of hot bath .In those places taking hot bath is no more important year round, the house will completely prepared for both hot and cold water at some aspects, but there is a central water heater that is once again either electric, gas, or even oil powered (Hottel, 1995).

2.9 Balance of System (BoS)

The components used in a solar photovoltaic (PV) system other than the array (a number of solar cell modules connected in series and /or parallel) are referred to as the balance of system. The components are divided into three categories: Structure and installation, power conditioning and control and storage batteries (Mark,2001).

2.10 Power Condition Control

Power condition generally consists of a blocking diode, a voltage regulator and inverter or convector. The blocking diode prevent current from leaking back into array during non-sunlight hours when the system is not maintains a constant voltage across the load and protects the batteries. If you live a climate that is cloudy most of the time or dark a great deal of the time, it will affect solar PV efficiency. Unless the solar PV are exposed to direct sunlight for most of the day every day, the more sun the more power, you can generated (Danis, 2010).

2.11 Structure and Installation

The solar PV system is normally mounted on rooftop or at higher elevation, where it will be exposed directly to sunlight. If there is enough land or roof or wall space to put the solar panels on the house the solar energy could be effective. Local build codes should be restricted in local governments so as to enhance the efficiency of solar panels on a buildings (Richard,2001).

2.12 Solar Inverter

Solar inverter or PV inverter is a critical component in a solar energy system. It performs the conversion of the variable DC output of the Photovoltaic (PV) modules into a utility frequency AC current that can be fed into the commercial electrical grid or used locally, off-grid electrical network. An inverter allows use of ordinary mains-operated appliances on a direct current system. Solar inverters have special functions adapted for use with PV arrays, including maximum power point tracking and anti-islanding protection (Mark, 2009).

2.13 Solar Road Ways

The Solar Roadway is a series of structurally-engineered solar panels that are driven upon. The idea is to replace all current petroleum-based asphalt roads, parking lots, and driveways with Solar Road Panels that collect energy to be used by our homes and businesses. Our ultimate goal is to be able to store excess energy in or alongside the Solar Roadways. This renewable energy replaces the need for the current fossil fuels used for the generation of electricity. This, in turn, cuts greenhouse gases literally in half. In December 2008, the Oregon Department of Transportation placed in service the nation's first solar photovoltaic system in a U.S. highway right-of-way. The 104-kilowatt (kW) array produces enough electricity to offset approximately one-third of the electricity needed to light the Interstate highway interchange where it is located (Mc Donald and Pearce, 2010).

2.14 Energy Storage (Battery)

Batteries store electricity for night time in off grid solar systems. An off grid home will have 4 to 6 days of storage in the batteries, while grid tie systems may have no batteries at all. Batteries also help loads to run at a constant voltage, while allowing the solar modules (or other power sources) to still charge as much as it can. In on Grid homes, batteries are only used to power loads if there is a blackout. Batteries are the "weakest link" in a modern solar system. They're heavy, full of lead and sulphuric acid, require regular maintenance, and will wear out sooner than any other component. Most complaints on older systems are due to old batteries (James,2010).

2.15 Buildings

Photovoltaic arrays are often associated with buildings: either integrated into them, mounted on them or mounted nearby on the ground. Alternatively, an array can be located separately from the building but connected by cable to supply power for the building. In 2010, more than four-fifths of the 9,000 MW of solar PV operating in Germany was installed on rooftops. The power output of photovoltaic systems for installation in buildings is usually described in kilowatt-peak units (KWp) (Mark,2010).

2.16 Transportation

PV has traditionally been used for electric power in space. PV is rarely used to provide motive power in transport applications, but is being used increasingly to provide auxiliary power in boats and cars. A self-contained solar vehicle would have limited power and low utility, but a solar-charged vehicle would allow use of solar power for transportation. Solar-powered cars have been demonstrated (Danis,2010).

2.17 Standalone Devices

Until a decade or so ago, PV was used frequently to power calculators and novelty devices. Improvements in integrated circuits and low power liquid crystal display makes it possible to power such devices for several years between battery changes, making PV use less common. In contrast, solar power remote fixed devices have see increasing use recently in locations where significant connection cost makes grid power prohibitively expensive. Such application include: Water pumps, parking meters and temporary traffic signs. These are usually utility substitute. They generally include solar charging modules, storage batteries and charge controller. If AC power is desired inverter will be required (Paul,1981).

2.18 Rural Electrification

Developing countries where many villages are often more than 5 kilometers away from grid power have begun using photovoltaic. In remote location rural lighting program has been providing solar powered LED lighting to replace kerosene lamps. Some remote villages in Nigeria to the national grid remain a mirage even in years to come, this is primarily due to the huge cost of laying power transmission cable along a span of over 100 km only to power a village settlement of a little above 20 households The solar application will be able to rescue many villages in country by providing two categories of generation designs. Namely; Central Generating system and Stand-alone Generating system. In Central Generating Systems, energy is generated from the pool of solar arrays and the electricity generated thereof is connected to a utility line and then distributed to individual household. The Stand-alone unit is a decentralized generator where the energy is generated at the point of need and the modules are placed on the roof of individual household (Smil,2006). .

2.19 Industrial Applications

In recent years, the power consumption of telecommunication equipment has considerably reduced due to solid state devices. Transmitters and relay stations now consume 50-100W. These stations often located in remote and difficult to access areas like mountaintops, island or deserts. The importance of communication in today's world cannot be over emphasized; in fact communication has come to play a leading role in human existence. It is therefore necessary to ensure that there is a reliable supply of electricity for all communication equipment. Solar system remains the best, reliable and cost effective means of power supply to communication equipment. Solar electric generators have been in use by MTN Communication Nigeria Limited to power their micro cells and repeater stations (Mbanisi,2008).

2.20 Solar Street Light

Solar Street Light has come to play an important role in rural and urban settings serving both as a means of improving the outlook of such environment and even more importantly, providing additional security at night for parking lots, garage, rural villages, farms etc. The system is 100% powered by the sun and can be designed to operate for at least 5 consecutive days without sunlight (Mark,2009).

2.21 Economic, Environmental and Safety Issues

There are many benefits to the environment when solar energy is used to heat and power homes. There are also many benefits for homeowners. At first the cost on installing a solar array to power a home might seem very expensive but over time the solar energy panels will be more cheaper. Solar panels last a long time. If solar panel array is installed properly it can last for 20 years or longer. Proper maintenance is required to keep it functioning well but the solar panels themselves shouldn't need to be replaced for at least 20 years. Solar roof shingles can last even longer depending on the type of climate. Solar panels create quiet energy. The heat and electricity generated by solar panels is practically noiseless making your home a lot quieter to live in when you switch to solar energy. Solar panels do require some maintenance but overall they are pretty easy to take care of. After they are installed they should be checked regularly for damage and replace any broken or damaged PV cell. Solar panels can protect roof and sidings. Since the solar panel array shades the house, it means that roof and siding will last longer because the solar panels will act as a buffer between home and the elements (Danis,2010).

Solar PVC system increased home value. Installing solar panels is really an investment in home, because the resale value of home will rise significantly. There is a lot of interest in living in a more environmentally responsible way these days and customers that are looking for new homes are concerned about the impact of their homes on the environment. Having solar power is quite a draw for home buyers. Solar energy saves money. Even though installing solar panels isn't cheap once the solar panels start to create energy there will be a huge savings in monthly electric and heating bills. That is probably the biggest reason that so many homeowners are considering switching to solar energy (Roger and Jerry 2004).

CHAPTER 3

MATERIALS AND METHODS

3.1 Description of Solar Lighting System

Fig.3.1 is the circuit diagram of the solar powered lighting system. The battery terminals were connected to the charge controller. The solar module was connected to the battery through a charge controller to provides a charging current to the battery that prevents short circuiting of the battery. Other functions of the charge controller include protection of slight voltage from the solar module. The load was also connected to the charge controller.

The red LED indicator lights on the charge controller indicates that the battery is low and should be charged before completing the system installation. The connections were made using a copper wire of 2.5mm diameter. The charge controller was preset as LED display `L` ready to receive sunlight for the period of 13hours. The electrical power was sent from the solar module through the charge controller to charge the battery during the day. At night, current is taken from the battery through the charge controller to power the load.

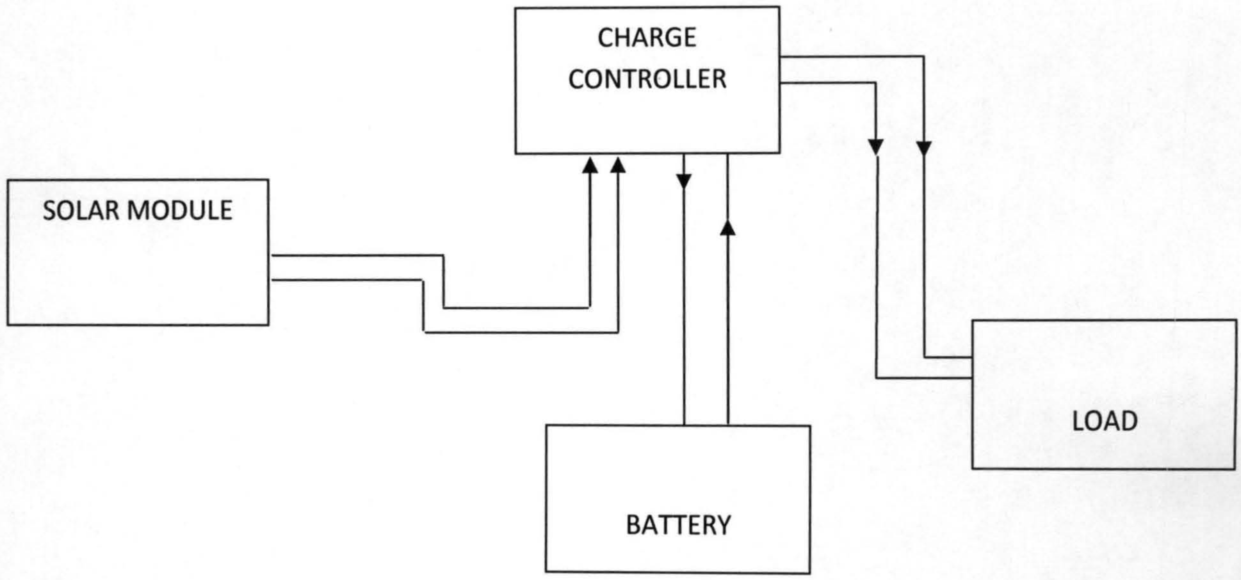

Fig.3.1: circuit diagram of the solar powered lighting system.

3.2. Design Analysis

Location: This project was located in the Department of Agricultural and Bio resources Engineering, Federal University of Technology, Minna, Nigeria. It is situated at latitude 09^0.37N, longitude 006^0 32^1E and 290m above sea level. The average ambient temperature between 30^0c and 35^0c all year round. The location is characterized with a wet season which is between April and October and a dry season, which last between November and March.

3.2.1 Electrical Consumption

The system is expected to provide a lighting point with power rating of 45Watt at 12V

3.3 Design Parameters

The following parameters were considered in the design of the system. The system is expected to:

1. Provide lighting from 1855H to 0612H at night amounting to 11hours at night.
2. Hours of bright sunshine for Minna is 7hr
3. Number of days of cloudiness is 2days
4. The selected system voltage is 12V

3.3.1 Load Requirement (Lr)

The load requirement was estimated from equation 1

$$Lr = \in c \times hu \times 1.25 \qquad 1$$

$\in c = electrical\ load\ (W)$

$hu = hours\ of\ use\ (h)$

3.3.2 Ampere-hour Requirement (Ah)

The Ah requirement was obtained from equation 2

$$Ah = Lr \div Vs \qquad 2$$

$Vs\ is\ system\ voltage.$

3.3.3 $charging\ current.$

$the\ charging\ current\ Ic\ was\ estimated\ from\ equation$ 3

$$Ic = Ah \div hb \qquad 3$$

$where\ hb\ is\ the\ hours\ of\ bright\ sunshine\ for\ minna\ location.$

3.3.4 $number\ of\ module\ in\ parallel\ (Np)$

$the\ number\ of\ module\ in\ parallel\ was\ determined\ from\ equation$ 4

$$Np = Ic \div Im \qquad 4$$

$Im\ is\ the\ current\ maximum$

3.3.5 $number\ of\ module\ in\ series\ was\ (Ns)$

$the\ number\ of\ module\ in\ series\ was\ determined\ from\ equation$ 5

$$Ns = Ms \div Sv \qquad 5$$

$where$

$M = module\ voltage\ (V)$

$Sv = system\ voltage\ (V)$

3.3.6 *Array sizing* (As)

the sizing was estimated from equation 6

$$As = Ns \times Np \qquad 6$$

3.3.7 *Battery capacity* (Bc)

the battery capacity was estimated from equation 7

where

$$Bc = Ah \times d/DOD \qquad 7$$

Where

$Ah = Ampere - hour$

$d = No\ of\ cloudiness$

$DOD = Depth\ of\ discharge\ of\ battery.$

Specification of module

Table 3.1: Rating of solar module

Specification	rated value	units
Power output	45	Watts
Short circuit current (Isc)	2.98	A
Open circuit voltage (voc)	21.5	V
Current at Pmax	2.61	A
Voltage at P(max) Vmp	17.5	V
Maximum system voltage	1000	V
Dimensions	630x540x30	MM
Temperature	25	^oC

3.4 Specification of Charge Controller.

The charge controller is selected based on the charging current of the system. The selected capacity of the charge controller should not be less than the charging current of the system.

Table3.2: Rating for Solar Charge Controller

Specification	Rated value ranges	
	12volt	24volt
Rated solar input	5/10A	5/10A
Rated load	5/10A	5/10A
25% current overload	1min	1min
Load disconnect	11.1V	22.2V
Load reconnect	12.6V	25.20V
Equalization voltage (30minutes)	14.6V	29.2V
Boast voltage (30minutes)	14.4V	28.8V
Float voltage	13.6V	27.2V
Temp. comp (MV/^{O}c	-30MV	-60MV
Temperature -35^{0}C to +55^{0}c		

Table 3.3: Specification of the Designed Solar System.

Parameter	value
Load	30W at12V
Load requirement	412.2W-h
Ampere-hour	34.38AH
System voltage	12V
Charging current	5A
Number of module in parallel	1
Number of module in series	1
Array size	1x1=1Module
Battery capacity	100Ah
Battery DOD	0.70
Number of battery	**1**

Table 3.4: Cost of Materials for Solar Power Lighting

S/No	Materials	specification	Qty	Unit cost	Total
1	Solar Module	630x540x30mm	1	45,000	45,000
2	Charge controller	12v,20Amps	1	15,000	15,000
3	Security light	12v,30w	1	3,000	3,000
4	Deep Cycle Battery	100AH	1	27,000	27,000
5	Cable	2.5mm	1boundle	3,000	3,000
6	Transport	-	-	-	5,000
7	Pole	4m	1	4,000	4,000
8	Labour and Miscellaneous-		-	-	3,000
Grand total					N105, 000

3.4 Installation of Solar Powered System

A site behind the Department of Agricultural and Bioresources workshop was chosen as the most suitable place for the installation of the module. The following features are taken into consideration;

i. The modules is installed where no shadow casting will affect it throughout the day.

ii. The solar module was mounted on a pole and is adjustable in the North-South for the yearly movement of the sun between the North and south hemisphere. The system was installed during the month of June when the sun is at northern hemisphere. The module was installed facing the North and sloping at an of 23^0N at 0^0 azimuth angle

iii. The charge controller and battery were installed inside the workshop.

3.5 System Maintenance

The maintenance of the solar module involves the following

i. Routine monitoring of the installed components such as tighten of the bolts and nuts of the module on the pole and charging circuit at an interval of time.

ii. Cleaning of the module to avoid dust cover, which reduces its output.

3.6 Life Cycle Cost (LCC) Analysis

This analysis was undertaken to determine the equivalent cost of the petrol/diesel generator and equivalent cost from the public utilities. The following are the comparative cost of the three energy sources.

Equivalent cost of petrol/diesel generator (100W/h)

Initial cost of purchase	N15,000
10 Litres of oil/petrol per day	N750.00

Maintenance	N100
Total	N15,850

Daily cost will be = N850, monthly = N25,500 and yearly = N306,000.00k

Equivalent Cost of Public Utilities (PHCN)

The public utilities provide the most affordable initial cost profile as follow:

Energy charge	N5.90
Meter maintenance charge	N204.00
Fixed charge	N61.00
Vat 5%	13.54
Total	284.44

The cost of the cumulative energy consumption for the three energy options was plotted against time in days to determine the best option.

CHAPTER FOUR

4.0 RESULTS

4.1 Presentation of Results.

Table 4.1: Summary of Measured Parameters

Time (H)	circuit voltage (Vs)	circuit current (A)	power (W)
0900	13.80	1.43	19.73
1000	14.15	2.15	30.42
1100	15.45	2.32	35.84
1200	16.45	2.45	40.30
1300	15.04	2.15	32.34
1400	14.90	2.05	30.55
1500	14.52	2.01	29.19
1600	14.00	1.31	18.34
Mean	14.79	1.98	

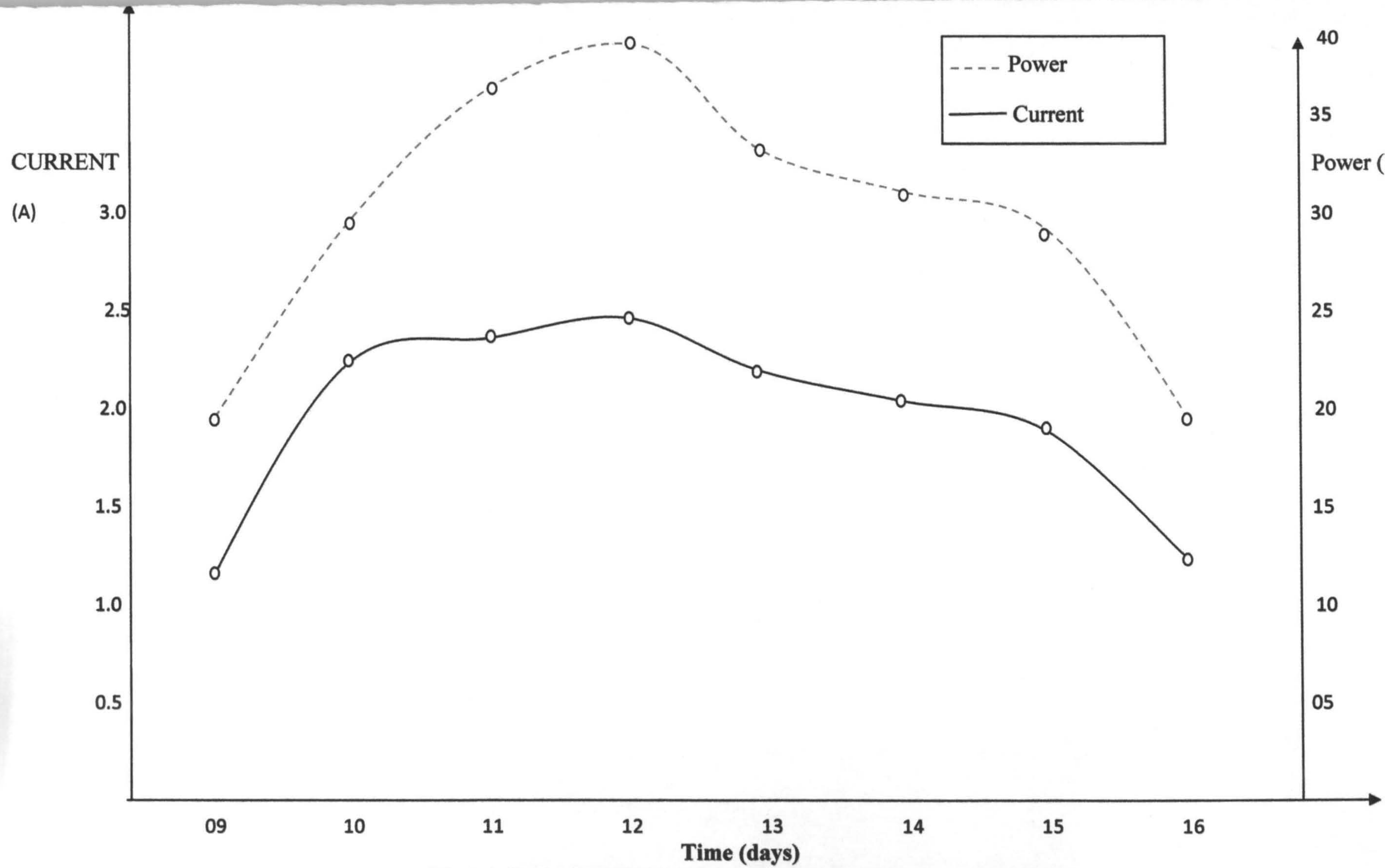

Fig.4.1: Daily fluctuation of module power and current output.

Table 4.2: Cost of cumulative energy consumption for three energy options

Days	cost of PV system N'ooo	cost of diesel/petrol generator (N'ooo)	cost of public utilities utilities (PHCN) (N'ooo)
1	105	15.85	0.28
20	105	17.00	5.6
40	105	34.00	11.2
60	105	51.00	16.8
80	105	68.00	22.4
100	105	85.00	28.0
120	105	102.00	33.6
140	105	119.00	39.2

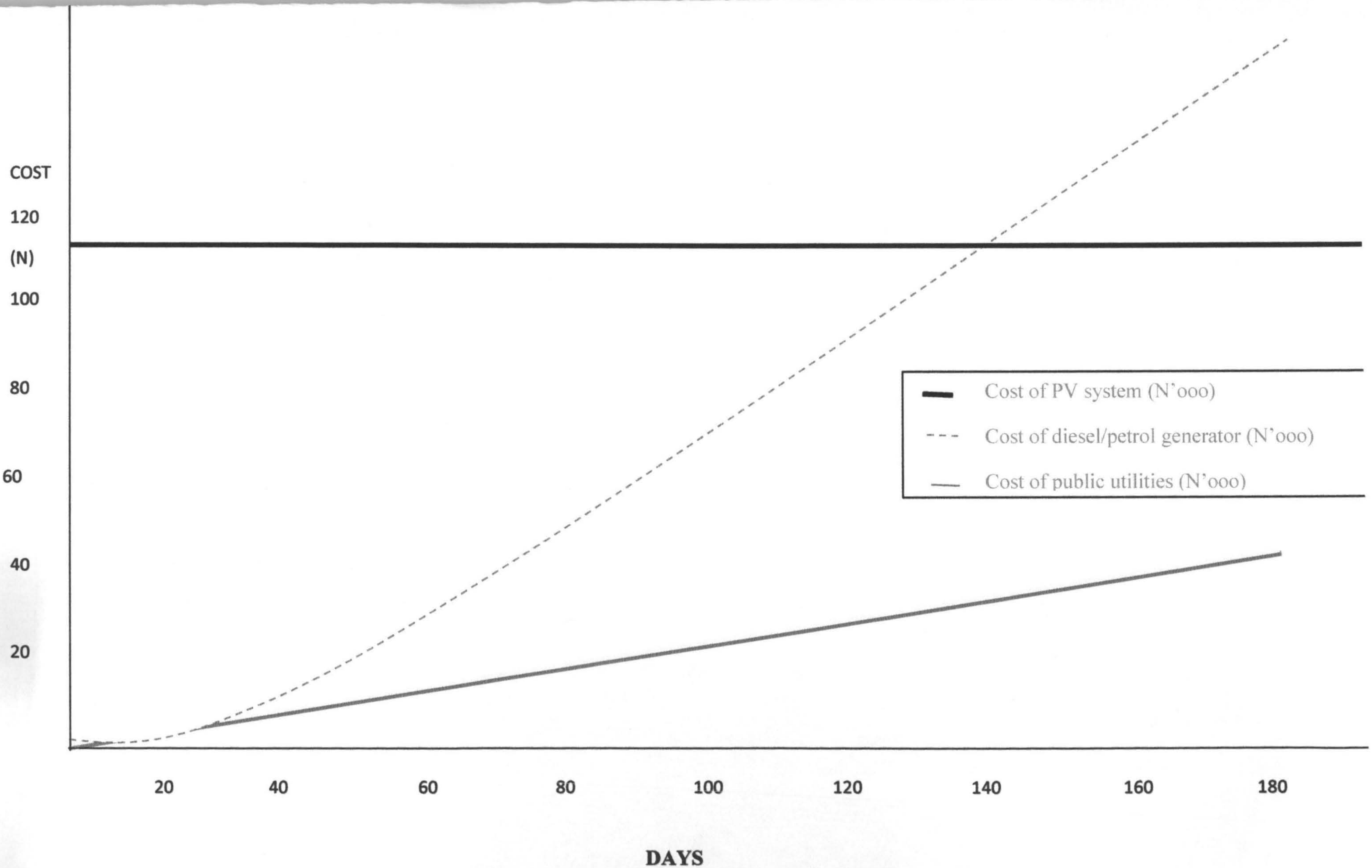

Fig:4.2 Graph of cumulative energy consumption of three options

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

Table 4.1 is the summary of the measured parameter of the installed system. The Circuit current, power output (Fig.4.1) showed that the current raises between 0900H and 1100H and peaks between 1200H. The current showed a little variation of 2.45A compared to the output current of the solar module of 2.61A. This could be attributed to losses, climate and weather condition which to a large extend affects the availability of insulation on the PV module. Table 5 also indicate the power output of the module.Fig.4.1 showed that the peak power output of 40.30W also occurred between 1200H.The peak power output was lower than the manufacturer`s rating of 45W.This may be attributed to the lower insulation due to cloud cover within this period.

Table 4.2 is a comparative cost analysis between the solar powered system, the public utilities (PHCN), and diesel/petrol engine. Fig.4.2 showed that the cost of the solar system while that of the diesel/petrol engine system increased steeply. This can also be used to simulate the break even period between the solar module and public utility. Fig 4.2 clearly indicated that as from 140 days the solar system become more cost effective than the diesel/petrol generator while public utility remained unprofitable. This showed the wastage in associated with the use of diesel/petrol energy system.

5.2 Conclusion

The technological and industrial greatness of any nation depends on the availability and stability of it electric power supply, the solar energy, if properly harness can go a long way in reducing the supply problem in Nigeria. Since it can be used in remote current and voltage not connected to the National grid. The geographical location and climatic factors of Minna in Nigeria favours the use of solar power system. The successful implementation of solar power programs in Nigeria will go a long way in minimizing poverty and climatic changes.

This study demonstrated the cost effectiveness of the powered system over the use of diesel/petrol generator and the grid electricity.

5.3 Recommendation

A model for determining the breakeven point between the public utilities (PHCN) and the solar module system could be developed to predict the cost effectiveness of the different energy consumption options in Nigeria.

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APPENDIX

DESIGN ANALYSIS

Load

A lighting point 30Watts

Hours of use

Provide lighting from 7pm to 6am =11hours.

Load requirement

30w x 11hours = 330w-h

Because of anticipated losses.

330 x 1.25.

412.2w-h

System voltage

A Solar systems of 12V.

Amp hours requirement

$$\frac{412.5\ \text{Avh}}{12\text{V}} = 34.38\text{Ah}$$

Charging current

Hours of bright sunshine for Minna location= 7hour

$$Ic = \frac{34.38}{7} = 4.9A$$

$$\approx 5A$$

Array size

Selection module specification

45@12V =3.75A

Module Current = 3.8A

$$\text{Number of module in parallel} = \frac{4.9A}{3.8A} = 1.3$$

$$\text{Number of module in series} = \frac{12v}{12v} = 1$$

Array size =1x1 =1

Battery capacity (Bc) Deep cycle batteries; DOD= 0.70

$$Bc = \frac{34.38x2}{0.70} = 98.228Ah$$

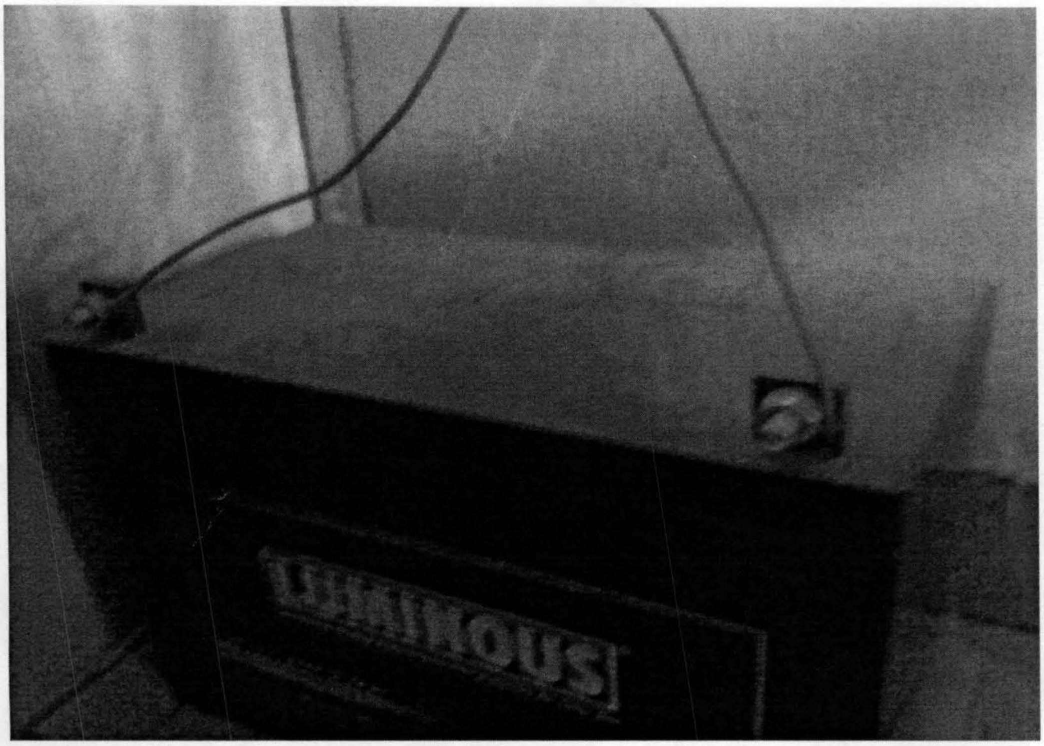
Selected battery capacity = 100Ah

$$\text{Number of battery} = \frac{98.29Ah}{100Ah}$$

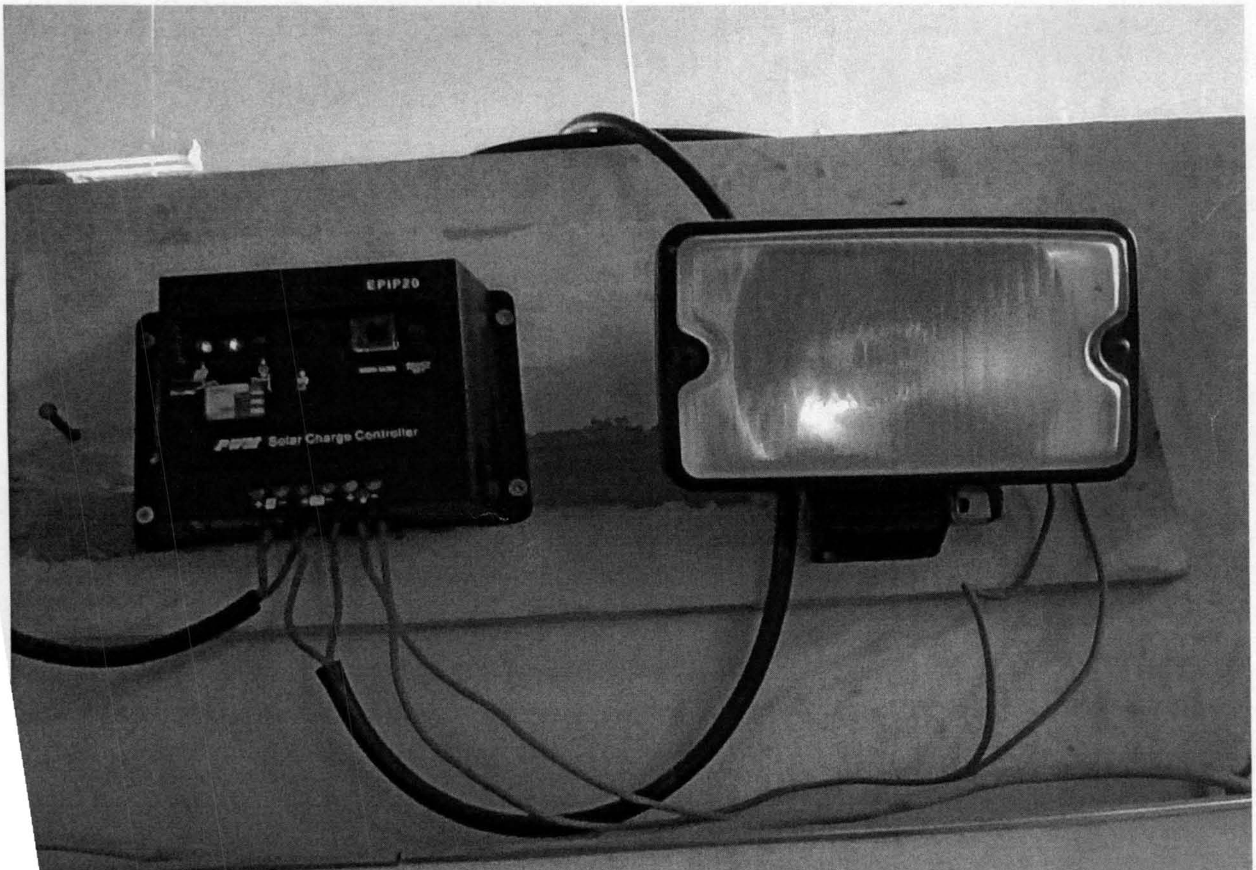
$$= 0.98$$

$$\approx 1 \text{ Battery}$$

SOLAR MODULE



100 Ah DEEP CYCLE BATTERY



SOLAR CHARGE CONTROLLER AND 30 WATTS BULB