

**EVALUATION OF THE POTENTIAL OF SOLAR
RENEWABLE ENERGY: [A CASE STUDY OF A STEVEN
ENERGY INSTITUTE, PORTHARCOURT]**

BY

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EDO STATE

CERTIFICATION

This study entitled “carried out by **ODIYOMA TEGA BETHEL** under our supervision meets the regulation governing the award of the bachelor’s degree in architecture of university of Benin City, Edo state, Nigeria. We certify that it has not been submitted for the bachelor’s degree in this or any other university and is approved for its contribution to knowledge and literary presentation.

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DECLARATION

I, **ODIYOMA TEGA BETHEL**, hereby declare that this Dissertation was written entirely by me under the supervision of **Arc Cecilia Atohengbe**, a lecturer of the department of architecture, University of Benin, Edo state and it has not been presented either entirely or partly. All academic material used in this work and their sources has been duly acknowledged.

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DEDICATION

This research is dedicated to God Almighty for giving me the knowledge and direction throughout this project, my family for also supporting and praying me throughout this journey, my friend Bello Babson for words of encouragement. I really appreciate.

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ABSTRACT

This research provides information about solar energy ,photovoltaic systems, a significant component of Renewable Energy RE ,Photo-Voltaic. The key terms, procedures, and technology about the solar energy are presented. Anyone interested in learning more about solar power as a green alternative to traditional energy generation will have a basic knowledge of the idea and its workings thanks to the literature's absolute clarity. it it gives absolute clarity about how renewable energy has decreased air pollution, improved urban-rural energy accessibility, and reduced global warming and climate change environmental effects can result from further deepening knowledge in this area, especially within the country of Nigeria. The thesis of this study is that acquiring fundamental knowledge on the potentials of solar renewable energy .. It highlights the basic science for the design and selection of components for successfully harnessing solar power.

Keywords solar renewable energy, photovoltaic, solar harnessing

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

According to (Topal *et al.*,2021) Fossil energy has been widely employed to supply the energy needs of countries for centuries due to the simplicity and accessibility of these resources.

However, in recent years, renewable energy sources have drawn a lot of attention due to the shortage of fossil fuels that will be required to meet future energy demands as well as the dangers that these fuels pose to human health and the environment.

The lack of legislation, investments, extensive knowledge, and infrastructure—all essential for this switch—is to blame for the delays in a renewable energy transition. Regrettably, these elements have traditionally favored fossil fuels. This is due to the relatively familiarity and availability associated with which fossil fuels (such "gasoline" and "diesel") can frequently be purchased across the nation creating uncomfortable discomfort such as heat production, unfavorable vibration effects, and noise pollution that often related to the regular functioning of an electric power [fossil fuel] plant, research findings have amply demonstrated beyond all doubt that generator are valid concerns that burning fossil fuels in energy producers has serious effects for human health, the environment, and a number of other areas of our socioeconomic and psychological lives. However, burning fossil fuels releases greenhouse gases into the atmosphere, trapping solar heat and causing global warming.

Solar energy can fill the gap as a result of this flaw in acknowledgment of renewable sources of energy. Even if Nigeria had a limitless supply of fossil fuels, using renewable energy, especially solar energy, is good for the environment. We usually refer to solar energy sources as "clean" or "green" technologies since they emit few or no pollutants. It is an eco-friendly source of energy for sustainable development due to its lack of carbon emissions. One of our planet's most abundant resources is sunlight.as well as widely accessible energy sources. The quantity of solar energy that reaches the earth's surface in a single hour exceeds the total energy needs of the globe for an entire year. The quantity of solar energy we can utilize varies depending on the time

of day, the season of the year, as well as other factors, even if it may seem like a perfect renewable energy source.

1.2 STATEMENT OF THE PROBLEM

According to research, Solar PV is not well known among Nigerian citizens and is not well understood as a sustainable energy choice. This acts as a barrier to the nationwide adoption of solar power or the buy-in of potential energy end users and this is as a result of :

- Financial limitations: High initial prices and protracted payback periods are a fundamental impediment to the advancement of solar energy technologies in Nigeria, a developing nation.
- Lack of technological capacity: Although solar energy technologies are being developed in Nigeria, most components must be imported, which drives up the cost of the investment.
- Utter lack of a National National Energy Strategy: Up until recently, Nigeria had essentially no comprehensive energy policy. There are only policies specific to the energy industry.
- Limited form of Public Awareness: In Nigeria, there is a very low level of public awareness of the enormous socioeconomic and environmental advantages that may be derived from solar energy.

1.3 RESEARCH QUESTIONS

The following research questions are to be investigated in order to elicit a clearer understanding of EVALUATION OF THE POTENTIAL OF SOLAR RENEWABLE ENERGY.

- ✓ The advantages and disadvantages of using solar energy
- ✓ What are the methods of acquisition to harness this solar energy?
- ✓ How does solar energy work?
- ✓ How much electricity is gained from solar energy using the case study
- ✓ How much does it cost and maintenance?

1.4 OBJECTIVE OF STUDY

The main objective of the study is to examine EVALUATION OF THE POTENTIAL OF SOLAR RENEWABLE ENERGY: [A CASE STUDY OF ASTEVEN ENERGY INSTITUTE, PORTHARCOURT] the specifically to seek:

- To create awareness to other researchers about solar energy, how solar energy work and can be accessed.
- To get proper knowledge on solar efficiency using the case study as a point of reference.

1.5 SCOPE OF STUDY

The scope of this study is limited to Port Harcourt on examining the evaluation of the potential of solar renewable energy. the study chosen location was focused for its centered approach on ASTEVEN ENERGY INSTITUTE

1.6 JUSTIFICATION/ SIGNIFICANCE OF STUDY

Electricity can be produced using solar energy in a cost-effective, healthy, and long-lasting manner. The findings of this study project will be utilized to define the merits, potential of transiting into the solar renewable and its efficiency.

1.7 AIM OF STUDY

The research's findings will serve as a source of knowledge for lecturing architects and aspiring professionals and general public on the value and significance of solar renewable energy. This study may also be used to identify flaws in other relevant initiatives in order to support them. After understanding the use of this research , solar energy should be appreciated , recommended and used extensively , as this study examine solar energy as a practical way to generate electricity.

CHAPTER TWO

2.0 Literature Review

According to (Oji *et al.*, 2012) The power of the sun hitting the earth is normally around 1000W/m². The total amount of energy received by the planet on a daily basis is 1353W/m². Every second, around 4 million tons of the sun's matter will be converted into energy. The sun is the most easily accessible and widely available renewable energy source capable of supplying the entire world's energy demands. It has the potential to produce more energy than any other fossil fuel on the planet. Solar radiation reaches the earth at a maximum flux density of roughly 1kw/m² in a wave length range of 0.3 to 2.5m. This is referred to as short wave radiation, and it encompasses the visible spectrum. Nigeria, one of the world's tropical countries, located between 4o and 13o and has a terrain of 9.24 x 10⁵ km². It has an average daily daylight of 6.25 hours, varying from roughly 3.5 hours near the coast to 9.0 hours in the far north border area.

According to (Corkish *et al.*, 2016) The sun powers 99.98% of the world's energy supply, including thermal, photovoltaic, photochemical, photo biological, and hybrid solar, hydro, wind, wave, and bio energy conversion. The sun's energy is derived from fusion reactions in its center. These reactions have been "burning" for 4.5 billion years and are expected to continue for another 6.5 billion years. The sun's total power infrared radiation emitted into space is estimated 3.86 10²⁶ W. Because the sun is approximately 1.5 10¹¹ m from the earth and the earth is approximately 6.3 10⁶ m in radius, it intercepts only 0.000000045% of this power.

2.1 Theoretical Background of Study

2.1.1 Introduction to solar energy

One of the cleanest and most pure sources of energy that we have access to on this planet, solar energy doesn't harm the environment. It is the source of all life processes on earth because of the constant solar radiation that we receive. Even a tenth of the energy from solar rays on Earth could end the world's current energy crisis if we were to systematically tap into this energy.

2.2 Brief history of solar energy

2.21 When did the first solar energy use occur?

According to (Richardson, L., 2022) Theoretically, people have been utilizing solar energy since the seventh century B.C., when it is recorded that they used materials from magnifying glasses to light fires with sunlight. The Greeks and Romans were known to use mirrors and solar energy later, in the third century B.C., to light torches for religious rites. The term "burning mirrors" was adopted to describe these mirrors as a common tool. Mirrors were used for the same purpose in Chinese culture as early as 20 A.D.

2.22 When were solar Energy systems created?

According to (Richardson, L., 2022), The evolution of solar panel technology was iterative, requiring numerous contributions from various scientists. Naturally, there is considerable disagreement about when they were invented and who should be given credit. Some credit the creation of the solar cell to French scientist Edmond Becquerel, who discovered that when two metal electrodes were immersed in a conducting solution, light might boost energy generation. This innovation, known as the "photovoltaic effect," influenced later PV advancements involving the element selenium.

Willoughby Smith found that selenium has photo conductive potential in 1873, which led to the 1876 discovery by William Grylls Adams and Richard Evans Day that selenium generates electricity when exposed to sunlight. Charles Fritts made it a few years later, in 1883. Fritts constructed the first solar cells manufactured from selenium wafers, which is why some historians credit him with the development of solar cells.

Solar cells, as we know them now, are built of silicon, not selenium. As a result, some regard Daryl Chapin, Calvin Fuller, and Gerald Pearson's 1954 synthesis of the silicon photovoltaic (PV) cell at Bell Labs to be the genuine origin of solar panels. Many claim that this was the true development of PV technology because it was the first instance of a solar technology that could truly power an electric device for several hours of the day. The original silicon solar cell could convert sunlight at 4% efficiency, less than a quarter of what modern cells can do.

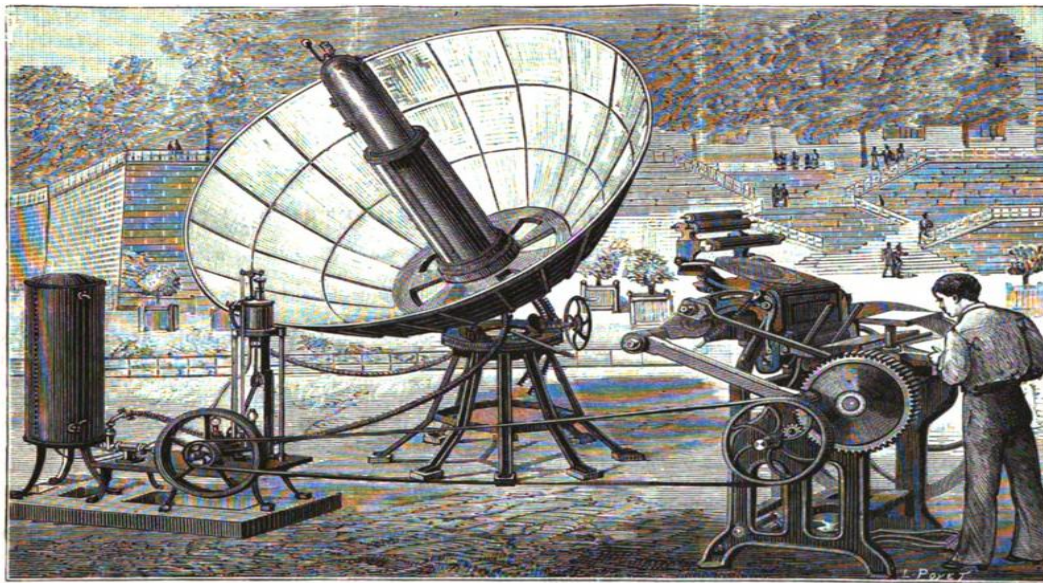


FIG2.1 [THE 19THCENTUARY SOLAR ENIGNE]

2.3 What is solar power?

Solar power is the process of converting solar energy directly into electricity via the use of photovoltaic (PV) or indirectly through the use of concentrated solar power

- ✓ Photovoltaic [pv]
- ✓ concentrated solar-thermal power (CST)

2.31 Photovoltaic [PV]: According to (Arachchige *et ai.*, 2019) The process by which light is changed into electricity is known as the photovoltaic principle. When exposed to light, certain

semiconductor kinds allow electrons to begin to flow. Electric current is produced by the movement of electrons. Types of pv systems include;

➤ **Stand-alone photovoltaic system**

According to (saleh *et al.* , 2019) Stand-alone photovoltaic systems are a group of connected electrical parts that may produce electricity from sunlight and meet our daily energy needs without concern for any time when sunlight might not be present

➤ **Grid-Connected PV Systems without Battery**

A grid-tied inverter is used in a simple installation known as a grid-connected system. It's perfect for people who want to put solar panels in their homes. Net metering can be advantageous for consumers. We can send any extra energy to the grid thanks to net metering. Customers just have to pay for the additional energy they consume in this way. Solar panels on a grid-connected system collect solar energy, which is subsequently converted into direct current (DC). The solar system's inverter uses the DC to convert the energy from DC to alternating current (AC). Then, domestic appliances may utilize the AC in the same manner that they use a grid system.

➤ **Hybrid PV Systems**

A hybrid PV system combines many power sources to increase electricity availability and efficiency. A system like this may make use of energy from hydrocarbons, the sun, wind, and other sources. To increase the system's efficiency, hybrid PV systems frequently use a battery as a backup. Using a hybrid system has a number of benefits. The system is independent of any one single energy source since it has several energy sources. For instance, the PV array can charge the battery if the environment is not suitable for producing enough solar energy. A wind turbine can meet the battery's charging requirements whether it's windy or cloudy. The greatest locations for hybrid PV systems are remote areas with few other options.

➤ **Grid-Connected PV Systems with Battery**

A grid-connected PV system with a battery adds to the home's energy independence. With the knowledge that electricity may be obtained from the grid in the event that the solar

system is not producing enough power, it results in a decreased dependency on grid electricity and energy merchants.

2.32 Concentrated solar-thermal power (CST): According to (kimi *et al.*, 2022) CST uses solar energy to generate electricity in a similar way to photovoltaic technology (PV). They vary in that CST uses a series of mirrors to concentrate sunlight onto a single small point while PV turns solar radiation directly into electricity according to . Following that, it transforms the accumulated energy into heat that can be stored before being later transformed into electricity.

2.4 Solar radiation

According to(Anteneh *et al.* , (2020) Based on different researches, 51% of the total solar energy reaches at ground, 6% is reflected by the atmosphere, 10% is reflected by the clouds, 4% is reflected from the earth's surface, 16% is absorbed by the atmosphere and the other 3% is absorbed by the clouds.

One of the earliest renewable sources of energy on the planet is solar energy. Solar radiation, which comes from the sun, is used to create this energy. The phrase solar radiation, commonly referred to as solar resources, describes the energy that the sun emits. Light and radioactive energy make up the majority of it.

- Solar radiation has a power component, and the watt (abbreviated "W") is the unit used to measure power.
- Direct radiation is electromagnetic energy that directly reaches the surface of the earth without being reflected or scattered (GB).
- Some of the sunlight is absorbed, dispersed, and reflected as it travels through the atmosphere by air molecules, water vapor, clouds, dust, pollution, and forest fires.
- ✓ Diffuse radiation is the term for scattered radiation that reaches the surface of the earth (GD).

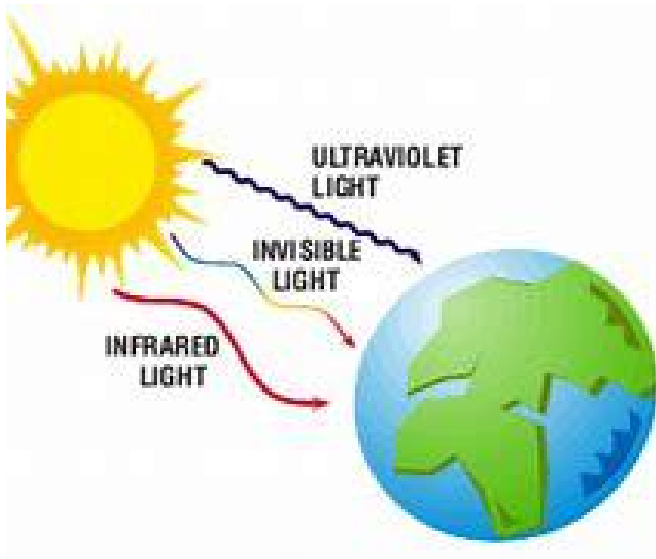


FIG2.2[reflected, diffuse, direct radiation]

2.5 Solar Irradiance

Solar irradiance is the power per unit area (surface power density) received from the Sun in the form of electromagnetic radiation in the wavelength range of the measuring instrument.

Solar irradiance is measured in watts per square meter (W/m^2) in SI units.

Solar irradiance is often integrated over a given time period in order to report the radiant energy emitted into the surrounding environment (joule per square meter, J/m^2) during that time period. This integrated solar irradiance is called solar irradiation, solar exposure, solar insolation, or insolation.

2.6 Distribution of solar resources in Nigeria

Nigeria can be divided into five climatic regions:

- Sahel Savannah
- Sudan Savannah

- Guinea Savannah
- High rainforest
- Mangrove swamp

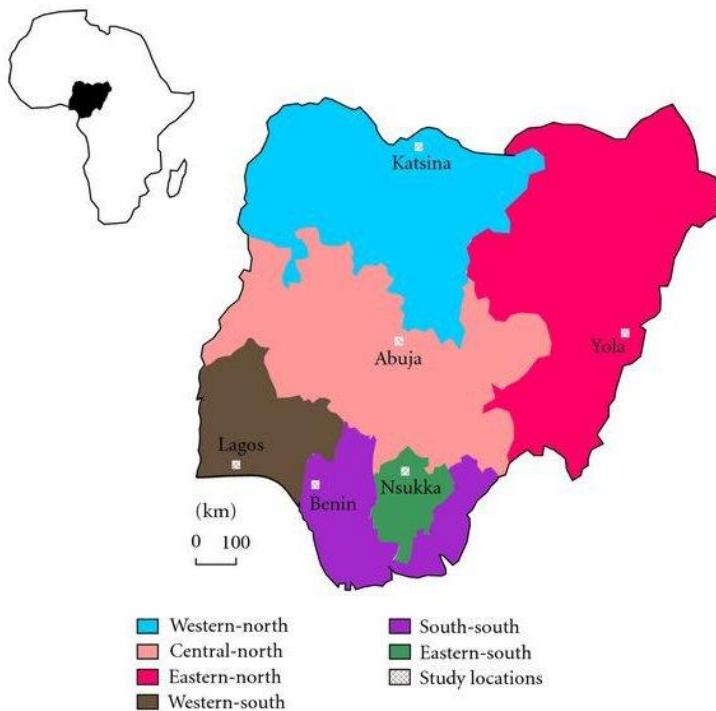


FIG2.3[The climatic region in Nigeria]

2.7 Concept of peak sun hours (PSH)

- The peak sun hours for a particular location identify the total amount of solar resource available at a particular location.
- In Nigeria, the PSH can easily be classified based on the different climatic regions
- Peak sun hours is a location-specific concept. It is defined as the average daily solar Irradiation incident on the earth surface at a particular location in units of kilowatts per square meter per day (kWh/m²/day) (Noor,2019)

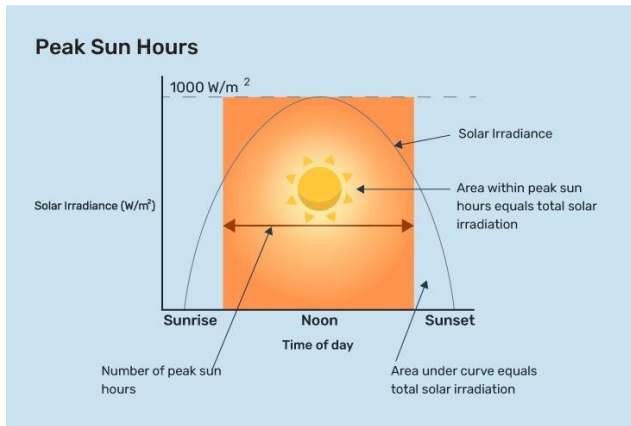


FIG2.4[peak sun hour]

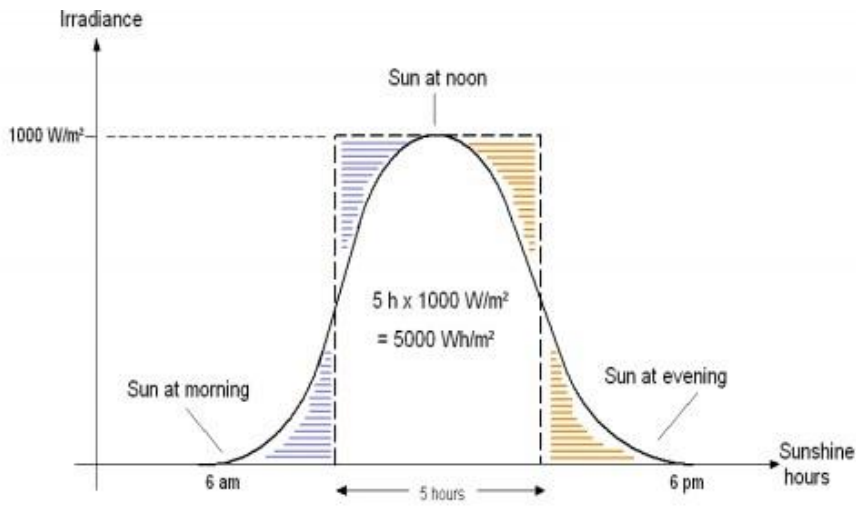


FIG2.5[how to calculate peak sun hours (psh)]

2.8A solar cell

- ✓ A solar cell, sometimes referred to as a photovoltaic cell, is a technological innovation that turns light into electricity.
- ✓ Solar cells can be created from a range of semiconductor substances. But silicon-based solar cells are frequently used in commercial applications.



Fig 2.6[a solar cell]

2.9 STEPS ON HOW SOLAR WORKS

2.9.1 Step 1: Capture Solar Energy with Solar Panels

Solar energy from the sun is converted by solar panels into electricity for your home. The three types of solar panels include the following:

2.9.2 Mono-crystalline solar panels

Mono-crystalline solar cells have a consistent structure and a high degree of purity because they are composed of a single silicon crystal. This yields solar cells that are more efficient than polycrystalline solar cells and have a sleek black appearance. But because they are more expensive, many homeowners cannot afford them.

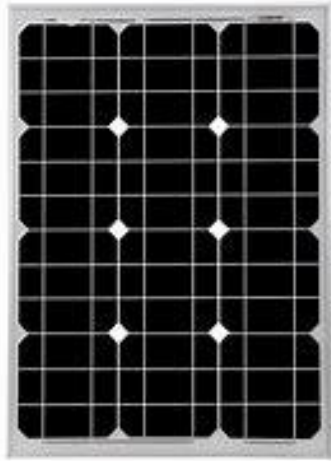


Fig 2.7[mono-crystalline solar panels]

2.9.3 poly-crystalline solar panels:

The silicon in poly-crystalline solar panels comes from multiple sources, which gives them an uneven blue color. The manufacturing process is much easier and less wasteful, as it utilizes smaller bits of silicon. This makes them less expensive than mono-crystalline cells but also reduces their efficiency.



Fig 2.8[poly-crystalline solar panels]

2.10 The steps involved in making a crystalline solar panel:

- Sand: Everything begins with basic material, in this case sand. The majority of solar panels are constructed of silicon, the primary component of natural bench sand. In a high-temperature arc furnace, high-purity silicon is made from quartz sand.
- Ingots: Silicon is gathered in the form of sand rocks. Hundreds of this rock are melted together at a very high temperature to form cylinder-shaped ingots.
- Wafers: Wafers are thin disks formed by slicing ingots. It is necessary to utilize a wire saw.
- Solar cells: the techniques outlined below will transform a wafer into a solar cell capable of converting solar power into electricity. Each wafer is being processed.

2.11 Thin-film solar cells

According to (Bugress,2022) Thin-film solar panels, also called flexible solar panels, are made of one or more layers of thin-film material that absorb light and produce electricity. They're made using amorphous silicon thin film, cadmium telluride thin-film, gallium arsenide or copper indium gallium selenite. They're fast and efficient to manufacture, which often makes them a more affordable solar energy option when compared to other solar technologies.

Thin-Film solar panels are less efficient and have lower power capacities than mono and polycrystalline solar cell types. The efficiency of the Thin-Film system varies depending on the type of PV material used in the cells but in general they tend to have efficiencies around 7% and up to 18%.



Fig 2.9[Thin-films solar panels]

2.12 What is the Lifespan for Poly-crystalline and Mono-crystalline Solar Panels?

When we talk about the lifespan of solar panels, we refer to how long they can produce electricity at a minimum level of efficiency. Solar panels can last for decades, but their energy production declines steadily over time. Mono-crystalline panels are expected to produce at higher efficiencies for longer periods of time than poly-crystalline panels, but the technology just isn't old enough to say this definitively.

Most manufacturers offer two warranties on their solar panels: one for performance that covers the first ten years and another for efficiency that covers the first 25 years. Solar panels are expected to lose 10-20% of their efficiency after 25 years and may no longer cover the energy consumption of a household, but they should still produce electricity.

2.13 Step 2: DC to AC Conversion via Solar Inverters, Charge Controllers

2.14 Inverters

An inverter is an equipment that converts a DC voltage to an AC voltage. This implies that for the solar electricity generated by your panels to be used in your home, it must be converted from DC to AC. An inverter is required to convert DC electricity to AC power. System usually employs a string inverter, a solitary box in the middle, next to your circuit breaker. Micro-inverters, which have a separate inverter for each panel, are used in more complex systems. Depending on the energy requirements of

your home, power optimizer and hybrid inverters are other inverter alternatives. [Ravi Kansagara,2018]

2.14.1 Types of inverters

There are three types of inverters which are.

- ✓ The Pure Sine Wave
- ✓ The Modified Sine Wave
- ✓ The Square Wave.

➤ **Pure sine waveform**

A pure sine wave inverter is perfect if you want to use multiple home appliances and other devices with a higher power requirement. A pure sine wave inverter avails power backup for numerous devices at once and fulfills their power consumption needs; hence it falls on the expensive side of the inverter market space. [Ravi kansagara,2018]

➤ **Modified sine waveform**

The modified sine wave inverters work well with multiple devices at once. But unlike the pure sine wave inverter, the modification does not offer a completely smooth transition. So, how inverter works in modified sine waveform? The inverter may take a brief pause while switching on or off during power outages.

Although powerful, the modified sine wave may occasionally affect the efficiency of the home devices. This can lead to dimmed lights or even humming noise from the appliances. These inverters are ideal for appliances with a resistive load and do not need any start-up surge of power. The modified sine wave inverters benefit because they are more budget-friendly than the pure sine wave inverters. [Ravi Kansagara,2018]

➤ **The square waveform**

As the name suggests, these inverters generate a square-shaped waveform. The square wave inverter is less efficient as compared to the pure sine waveform inverter and the modified sine

waveform inverter. This inverter is ideal for you if you need only a few devices connected to the inverter. These are readily available in the market and are easy on the pockets. But having a square waveform inverter can be problematic as these machines tend to get noise. [Ravi kansagara,2018]



Fig 2.10[inverters]

2.15 Charge controllers

A battery charge controller (BCC) regulates the flow of electricity from the PV generator to the battery. Its function is to regulate the voltage and current from the PV array to prevent overcharging and also over discharging of the battery.



Fig 2.11[a mppt charge controller]

2.16 Step 3: Batteries Store Excess Energy

Installing solar battery storage is essential to maximizing the long-term benefits of going solar. If your solar panels generate more solar energy than you can use, you can store that extra electricity in a solar battery. That way, you have electricity available to you when the sun goes down or it's a rainy day - instead of drawing from the electricity grid.(Huanhai *et al* .,2018)

Depending on the type, solar batteries can either store excess DC electricity that's produced by your solar panels, or they can be charged by AC electricity that's already been converted by inverters.



Fig 2.12[solar batteries]

2.17 Step 4: Electrical Panel Distributes Electricity

Electrical panel distributes electricity throughout your home. The circuit breakers in the electrical panel can also cut off the flow of current to an electrical circuit in case a fault or surge occurs, to prevent overload in electrical lines that can cause damage.

While your solar panels generate electricity, they typically aren't connected directly to your appliances or other electronic devices. In terms of understanding how solar panels work, they

provide electricity to the electrical panel, and your electrical panel separates that home solar power into individual circuits that run to everything in the house.

Lastly, electrical panels are also a key component of consumption monitoring. There are devices that can be attached to either the main panel or each individual circuit, allowing you to view more details about your specific energy consumption, which can help you optimize your energy usage over time.

2.18 Basis of electricity in solar energy

The presence or movement of charged particles is electricity. The movement of electrons through a circuit is known as an electric current. When electrons accumulate on an insulator, static electricity results. Electromagnetic induction produces electricity by the rotation of a coil through a magnetic field. The energy for this rotation can come from fossil fuel powered generators, steam driven power plants (with the steam produced from burning fossil fuels, the nuclear process, or from renewable sources like spinning hydro and wind turbines). Solar panels create electricity from light, by a process known as the photovoltaic effect. Batteries store electricity in chemical form –energy is released or absorbed through chemical reactions. Of course, the batteries must be charged, so they are not really a source of energy, but rather are a form of energy storage. There are three fundamental terminologies used in electricity:

- Voltage
- Current
- Resistance

2.19 Voltage

It is the quantitative expression of the potential difference in charge between two points in an electric field.

- The greater the voltage, the greater the flow of current
- VOLTAGE is like the pressure that pushes water through the hose. It is measured in volts (V)
- Volts(E or V) • Electrical pressure or potential • Unit for electromotive force.

2.20 Electric current

- Electric current is the rate of flow of electric charge through a predetermined cross-sectional area in a conductor.
- Current is a measure of the 'intensity' of electricity flowing in a circuit
- Current flow in wire just like water flow in pipe. It is measured in **ampere**.

2.20.1 Types of Electrical Current

Electric current is divided into two categories:

- direct current (DC)
- alternating current (AC)

(DC). Direct current can only flow in one direction, but alternating current can flow in both directions. As a main energy source in industry, direct current is rarely employed. Most of its uses are low voltage ones, such those for aviation and battery charging. Appliances used in both domestic and industrial and commercial settings are powered by alternating current.

2.21 Current or Amperage

- Amps (I or A)
- Rate of flow of electron in a conductor.
- Current and Amperage are interchangeably
- $1 \text{ amp} = 1 \text{ coulomb/second}$.

2.22 Resistance

Resistance depends on the following:

- Material
- Cross sectional area
- Length

- Temperature.

2.23 Power and Energy

- **Power** is the rate of doing work or of transferring heat, i.e., the amount of energy transferred or converted per unit of time. Having no direction, it is a scalar quantity. In the International System of Units, the unit of power is the joule per second (J/s), known as the watt (W) in honor of James Watt

- Power is the rate of electrical energy consumption or generation

- **Energy(E)** is the amount of power being produced or consumed, in watts, during a period, in hours. Watts times hours equals **Watt-hours**

2.24 Solar arrays

A solar array is a collection of solar panels that are connected to gather solar energy and deliver it to the inverter of your solar system, which transforms it into electrical power that can be used in your house. Depending on the energy requirements of your home, solar arrays might be enormous or tiny.

2.24.1 Positions for efficient solar panel arrays

The suitable position for your solar array will depend on the characteristics of your land because every house is unique. Here are a few typical methods for mounting solar panels:

- **Rooftop arrays**: The most popular kind of solar panel system in use right now is a rooftop array. These fixtures are mounted directly to the roof of the house, ideally on a slope facing south. Rooftop systems can be installed on any roof with enough room and sunlight.
- **Ground mounts** are a wonderful choice for property owners who wish to install more solar panels than their roofs can support or who have properties that are shaded. These mounts let you place several solar panels at a location on your property that receives the maximum sunlight, away from your residence. A ground mount can be connected to rooftop arrays as

well to completely optimize solar energy collecting and lessen the dependency of your home on grid electricity.

- **Exterior building arrays**: If a client has an exterior structure, such as a detached garage, a carport, or a storage shed, they may decide to put solar panels there rather than on their home. Be aware that choosing this alternative can make wiring more challenging.
- **Particularized patio areas**: Some residents clients choose to construct covered patios, decks, or gazebos and use those roof lines for solar arrays. By doing this, you can prevent damaging the roof of your house. These arrays can be used in addition to rooftop arrays.

2.24.2 Power rating of solar array

- The DC size of the PV array, measured in watts or kilowatts, is a typical approach to determine the scale of a PV system.
- Frequently used terms include "6 kW grid direct," "4 kilowatt stand-alone," and "200-watt DC."
- These figures represent the total power output of each panel in the array or the size of a single module.
- The 1,000-watt array in the photo consists of four 250-watt modules. This may also be referred to as a 1-kW array.

2.25 Basic measuring equipment and tools

The list of essential tools that should be a part of every Solar technical professional's toolkit are as follow.

- **Digital multi-meter**

A digital multi meter is the ideal tool for swiftly detecting voltage and is particularly helpful while installing and fixing combiner boxes and inverters. It is essential to have an industrial-strength T-RM multi meter with a wide working temperature range. Look for characteristics like high precision, a wide measurement range, drop resistance, and a dust- and water-resistant cover to help safeguard the instrument when using it outside.

➤ **clamp meter**

Any industrial or commercial solar technician's most crucial and cutting-edge troubleshooting equipment is a clamp meter. The AC/DC load current is verified using a trustworthy and precise clamp meter. Inverters, breakers, combiner boxes, and disconnects should all be able to be measured up to 1000A via the jaws in all ranges and up to 3000A using a flexible clamp. The loads and line frequency in the circuits, as well as solar cells up to 1500V AC and 2000V DC, should all be able to be measured by it.

➤ **Non-contact Infrared Thermometer**

The surface temperature of solar cells, panels, and arrays may be measured quickly and accurately with an infrared thermometer, even in difficult-to-reach places. Fixing on the target item and measuring the surface temperatures is made simple by the included laser guides. The emissivity (capacity to emit infrared radiation) of the surface being examined affects the accuracy of any infrared temperature monitoring equipment. The utilized infrared thermometers need to be calibrated for the emissivity of the PV modules.

➤ **Insulator tester**

As they must test high voltage equipment including cables, switch gear, motors, and conductors, digital insulation testers with insulation resistance measurements up to 10 kV are appropriate for solar technicians and specialists. Insulation testers aid with a range of testing, such as locating power quality issues, breakdown tests, spot inspections, and timed tests.

CHAPTER THREE

3.0 METHODOLOGY

This chapter discusses the study area, research design, sample of the study, Purpose of design , data source and source and collection of data

3.1 The Study Area

The case study **Asteven energy institute** is located in the southern part of Nigeria, Port Harcourt the capital of Rivers state.

Location; PHcampus56 Rumosi farm road, port Harcourt, Rivers state

Latitude:4.824167

Longitude:7.033611

The institute **Asteven energy (ASREA)** is an educational academy that inculcate the knowledge and training of renewable energy to people especially in west Africa.

3.1 Research Design

The case study technique is mostly used by researchers interested in qualitative research (Baskarada, 2014), where information and inquiry on techniques and calculation concerning my research has been discussed extensively in my literature review and theoretical background , understanding my research philosophy approach to my findings (Wilson,2014).

According to the definition given in , a research technique is "a systematic and ordered strategy adopted towards the collecting and analysis of data such that knowledge may be derived from the data . There are three different sorts of study designs: exploratory, descriptive, and explanatory which was use in achieving my findings, This design was chosen with the goal in mind, which was to "clarify" knowledge regarding solar photovoltaic energy as a different source of clean and sustainable energy and how it functions or runs as a system. Using the case study as advantage point, to get the necessary information in line with solar renewable energy.

3.2 Purpose of Research

The purpose of this research is to provide a framework and information for the evaluation on the potentials of solar renewable energy [a case study of **Asteven energy institute**. After conducting

this study, a construction expert or architect should be confident, having gathered all of the required data for a successful and accurate assessment of the possibilities of solar renewable energy.

3.3 DATA COLLECTION & DATA TYPES

➤ CASE STUDY METHOD OF DATA COLLECTION.

This research utilized the case-study method of data collection and analysis. The data was collected by observation and requesting for information from officials within the environment of case study. This study used qualitative data, which entails gathering exploratory, descriptive, and explanatory data on diverse natural settings to better understand the subject matter and answer issues such as how and why particular occurrences occur and how they interact with one another.

CHAPTER FOUR

4.0 DATA PRESENTATION, ANALYSIS & DISCUSSION OF FINDINGS.

4.1 CASE STUDY

BUILDING: Asteven Renewable Energy Academy (ASERA), Nigeria

LOCATION: PHcampus56 Rumosi farm road, port Harcourt, Rivers state.

FOUNDER; DR. SUNNY AKPOYIBO PH.D.

4.1.1 ABOUT THE CASE STUDY

Asteven Energy Institute is the first Innovation Enterprise Institution (IEI) approved by the Federal Ministry of Education (FME) and accredited by Nigeria's National Board for Technical Education (NBTE) to offer a National Innovation Diploma (NID) in Solar Energy Technology. The institute is equipped with modern and state-of-the-art facilities for hands-on training.

Asteven institute was commissioned on February 28th, 2018 as a solar training academy and since its inception has trained, certified, and empowered over 3000 able-bodied men and women across Nigeria in solar photovoltaic (PV) installation and entrepreneurship. It is accredited by the ECOWAS centre for Renewable Energy and Energy Efficiency (ECREEE) as a recognized institution for training and certification in Solar Photovoltaic (Off Grid) Installation in Nigeria.

We have campuses in Ogun state, Rivers state, Delta state and the UK with well-furnished hostel accommodations.

4.2 THE DESIGN

In this event, a photovoltaic system was erected in the institute (ASREA PH BRANCH). Figure 4.1 depicts the planar arrangement of (72pieces of panel). Solar panels power rating of (280w), with 3pieces (10 strings) combiner boxes of direct current, a 2pieces (10KVA) inverters, a 8pieces (220Ah/12V) flooded battery, a 3 pieces (80a) charge controller switch boxes of alternating current, voltage step-up transformers, high-voltage distributors, wholesale electric meters.



Fig 4.1 [ASERA PH BRANCH, car park solar arrays off grid] sourced from researchers fieldwork

According to (lin , 2015)The solar cell arrays are arranged from North to South as the first row vertically (PV-1-PV-4) and the second row (PV-5-PV-8) of this photovoltaic system and its environmental conditions are as follows: (PV-15-PV-18)

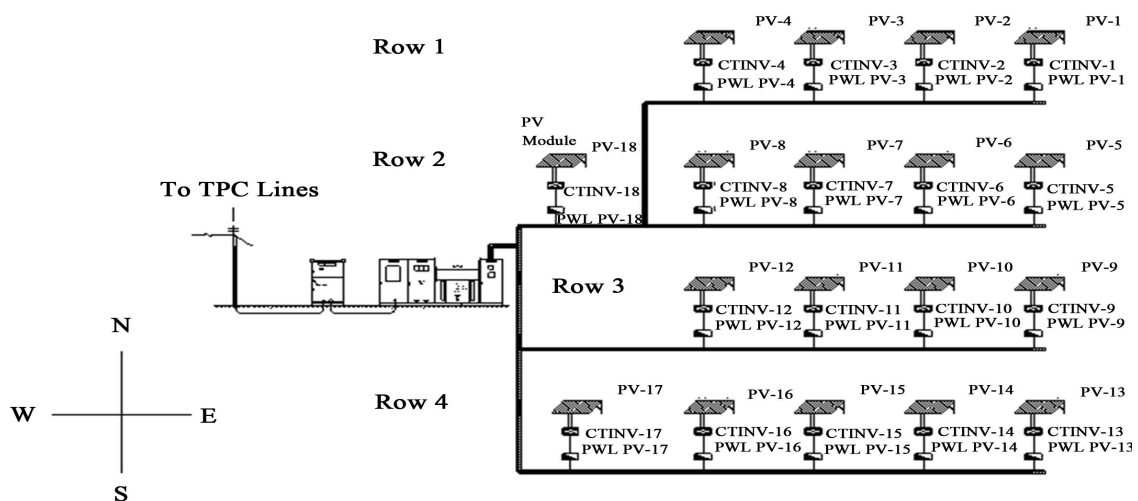


Fig 4.2 [Power plane configuration of the photovoltaic system.]

The facilities in the environment include the following:

- A classroom
- Workshop classroom
- Restrooms
- The workshop
- The storage
- The four-bedroom guest house
- The power room
- The gate house
- The admin building

In each of facilities in d buildings contain each of the following in the table below ;

S/N	LOADS	POWER NEED [WATTS]	QTY	DAILY USUAGE [HRS]	TOTAL ENERGY [WATT/HR]	TOTAL POWER NEED
1	AIR CONDITION	3500	7	8	$3500*8=2800$	$3500*7=24500$
2	BULBS	100	35	4	$100*4=400$	$100*35=3500$
3	FRIDGE	800	2	8	$800*8=6400$	$800*2=1600$
4	WATER DISPENSER	100	1	4	$100*4=400$	$100*1=100$
5	DESKTOP	250	2	8	$250*7=1750$	$250*2=500$
6	LAPTOPS	60	6	8	$60*8=420$	$60*6=360$
7	TV	117	2	4	$117*4=468$	$117*2=234$
8	PROJECTOR	80	1	4	$80*4=320$	$80*1=80$
					TOTAL=12,958	TOTAL=30874

Tables 4.1 showing calculation for total power and energy in watt/hr

According to the solved calculation in the table the total energy needed is 12,958 watt/hr on a daily basis.

According to the the solved calculation in the table the total power needed is 30874 on a daily basis.

The power output of a single panel is 280 watt. Therefore the total power output of each panel is 20,160(72* 280 watts). which is not enough to power all the building , but with the addition of a good inverters and battery which aid in storing power that has not been utilized, will cover up the 10,714 remaining power.

According to To calculate the approximate solar efficiency :

$$\text{efficiency} = \frac{\text{panel power (in kW)}}{\text{panel length} \times \text{panel width (in m)}} \times 100\%$$

In Asteven pH branch , they have 72 pieces panel that carry :

Watt - 280 each

Panel length-1.624m

Panel width-0.992m

Therefore the solar cells power generation efficiency of each panel is 17%. According to (Jayesh ,2020). Poly-crystalline solar panels have an efficiency range of 16% to 18%.

CHAPTER FIVE

CONCLUSION & RECOMMENDATIONS

The goal of this research was to promote awareness of solar photovoltaic (PV) as a crucial component of renewable energy. In order to make the clean generation of electricity a competitive alternative to fossil or nuclear fuel, emphasis was placed on elaborating on its idea, techniques, and components.

The study is based on the supposition that there is a gap caused by a relative lack of literature spreading fundamental information about the subject field, i.e., a preponderance of literature focus on techniques, calculation and other knowledge of solar renewable energy. Consequently, this paper includes a critical evaluation that highlights, clarifies, and explains solar renewable energy, making it easier for an observer to understand since they are the main energy consumers and a crucial component of the ongoing radical shift from unsustainable energy to clean, renewable energy.

According to the survey of data the total power output is not enough to backup the available devices in the building but with the aid of a powerful inverter and batteries , power is stored and utilized when necessary, also the solar efficiency of the panel is 17% which is effective according to standard.

REFERENCES

- Anteneh, D., & Alene, B. (2020). Design and optimized of solar PV system a case study of KIOT administration offices. *Journal Electrical and Electronic Engineering*, 8(1), 27. <https://doi.org/10.11648/j.jeee.20200801.15>
- Arachchige, U. S. P., & Weliwaththage, S. R. G. (2020, January 1). *Digital Object Identifier System*. Doi.Org; unknown. <https://doi.org/>
- Burgess, D. (2020, January 23). thin-film solar cell. *Encyclopedia Britannica*.
<https://www.britannica.com/technology/thin-film-solar-cell>
- Corkish, R., Lipiński, W., & Patterson, R. J. (2016). Introduction to Solar Energy. In *Solar Energy* (pp. 1–29). unknown.
- Current electricity pdf- Definition, Direct current, Alternating current, Ohm's law formula. (2018, June 30). BYJUS; BYJU'S. <https://byjus.com/physics/current-electricity-pdf/>
- "Energy Sources: Solar". *Department of Energy*. Archived from the original on 14 April 2011. Retrieved 19 April 2011.
- From Space to Earth: The Story of Solar Electricity. (n.d.). Google Books. Retrieved 17 January 2023, from https://books.google.com/books/about/From_Space_to_Earth.html?id=xHFK9cM77a8C
- Genus. (2021, February 16). What Do You Need to Know About the Different Types of Solar PV Systems? Genus. <https://www.genusinnovation.com/blogs/types-of-solar-pv-system>
- Habash, G. (2017). *Architecture of solar energy: Appropriating photovoltaic technology for the design of sustainable buildings*. Carleton University
- Huanhai, H. (2018). Photovoltaic power generation system. *Materials Science Materials Review*, 1(1). <https://doi.org/10.18063/msmr.v1i1.503>
- Introduction to Different Types of Inverters*. (n.d.). Circuitdigest.Com. Retrieved 18 January 2023, from <https://circuitdigest.com/tutorial/different-types-of-inverters>
- Jayesh.(2020, March 3). What are Polycrystalline solar panels? Lets Save Electricity.<https://letsaveelectricity.com/what-are-polycrystalline-solar-panels/>. Polycrystalline solar panels have 16 % – 18 % efficiency, which means out of 100% sunlight falling on the solar panel 18% of it is converted in electricity and rest is wasted.

kimi, Imad. "Photovoltaic Vs Concentrated Solar Power the key differences". Voltagea. Dr. imad. Retrieved 29 December 2022.

Lin, C.-L. (2015). Case study of solar power producing efficiency from a photovoltaic system. *Open Journal of Energy Efficiency*, 04(03), 45–52. <https://doi.org/10.4236/ojee.2015.43005>

Noor, U. (2019, March 27). Peak Sun Hours for Solar Panels by Region. 8MSolar. <https://8msolar.com/what-is-a-peak-sun-hour-psh/>

Oji, J., Idusuyi, N., O. Aliu, T., O. Petinrin, M., A. Odejobi, O., & R. Adetunji, A. (2012). Utilization of solar energy for power generation in Nigeria. *International Journal of Energy and Engineering*, 2(2), 54–59. <https://doi.org/10.5923/j.ijee.20120202.07>

Power Vs. Energy. (2016, November 30). BYJUS; BYJU'S. <https://byjus.com/physics/power-and-energy-difference/>

Richardson, L. (2022, May 3). History of Solar Energy: Timeline & Invention of Solar Panels. EnergySage Blog; EnergySage. <https://news.energysage.com/the-history-and-invention-of-solar-panel-technology/>

Saleh, U. A., Haruna, Y. S., & Gwaram, U. A. (2019, November 5). Digital Object Identifier System. Doi.Org; unknown. <https://doi.org/>

Topal, A., Özoğlu, B., & Ekşi, D. (2021). The evaluation of factors in utilizing the potential of solar energy: The case of turkey. *Environmental Research and Technology*. <https://doi.org/10.35208/ert.972541>

<https://www.eajournals.org/wp-content/uploads/Solar-Pv-Power-Generation.pdf>

(N. d.). Nic.In. Retrieved 17 January 2023, from <http://www.gpcenvis.nic.in/PDF/1solar.pdf>

Wikipedia contributors. (2022, December 24). Solar irradiance. Wikipedia, The Free Encyclopedia. https://en.wikipedia.org/w/index.php?title=Solar_irradiance&oldid=1129249470

Wikipedia contributors. (2023, January 13). Voltage. Wikipedia, The Free Encyclopedia. <https://en.wikipedia.org/w/index.php?title=Voltage&oldid=1133342814>

APPENDIX



Sourced from field work showing how to get the efficiency
Of a battery.



sourced from field work , showing how panels are arranged in arrays



Sourced from field work showing maintenance of a solar panel and a closer look on the panel.



Sourced from field work showing how the connection of
Inverters, charge controllers and battery

