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# **CHALLENGES FACING SOLAR ENERGY PROJECTS IN NIGERIA.**

A Case Study of Lagos State.



Bachelor's thesis

Degree Programme in Industrial Management

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ABSTRACT

The idea of Photovoltaic systems (PV systems) has been mainly suggested for energy procurement in remote areas, areas where other means of power supply are not effective, where transmission line extension is not feasible or perhaps not economically efficient. PV power is the most environmentally friendly source of power. It is also on the high completion side with generator systems installations like diesel, despite the fact that PV modules and its installation have a very high initial cost. (José 2008).

The main goal of this thesis work was to understudy the current solar energy powered projects in Lagos state, Nigeria, analyzing the failed projects, understanding the reasons for the failure of these projects, improve the processes involved in manufacture, installations and the routine maintenance required to keeping every single solar energy powered projects working as expected.

This research work was conducted for the Connect-project; Finnish renewable energy SMEs jointly coordinated by HAMK, Laurea and Lahti Universities of Applied sciences. Connect Project is for the co-creation of a network for market entry in developing countries comprising of Asia and Africa which Nigeria falls under.

Lagos state is in the southwestern part of Nigeria. Nigeria comprises six geo-political zones with a population of about 160 million people as reported in the last population census. In solar-powered projects, the capacity and performance of the batteries is a major challenge. This can be reduced by properly managing the batteries. Ensuring proper project management as a whole process is another key point to ensuring the minimizing of failures in solar powered projects.

Basically, secondary data was the main source of data analyzed in this research work and it was thoroughly analyzed by the author. It is therefore recommended for Finnish SME's that are interested in entering new markets in Africa in which Nigeria is one of the target countries.

**Keywords** Renewable energy, solar energy, Photovoltaic, PV systems.

**Pages** 43 pages.



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## 1 INTRODUCTION

Energy has a major impact on every aspect of our socio-economic life. It plays a vital role in the economic social and political development of our nation. There is restriction in socio-economic activities, economic growth limitations and the quality of life is adversely affected as a result of inadequate energy supply. (NEP 2003).

Location, days of the month, season, time of the day and several other environmental factors has a great effect on the intensity of solar energy radiation. Nevertheless, the usage of efficient storage devices in the conversion systems of solar energy will positively impact the availability of its radiation.

Solar energy is the third most important renewable energy in terms of installed capacity globally. It comes after the hydro and wind power. Solar systems begin with the solar module. These modules gather solar energy in the form of sunlight and it is converted into direct current (DC) electricity. The more the sunlight received, the more the electricity produced. These modules are the heart of solar systems. They are the power generators.

Nigeria lies within a high sunshine belt; within the country, solar radiation is fairly well distributed. The annual average of total solar radiation varies from about  $12.6 \text{ MJ/m}^2$  –day in the coastal latitudes to about  $25.2 \text{ MJ/m}^2$  in the far north. (NEP 2003).

Photovoltaic systems provide the energy necessary through the renewable and environmental friendly source- the sun.

This thesis work aimed at understudying the current solar energy powered projects in Lagos state, Nigeria, analyzing the failed projects in the state, understanding the reasons for the failure of these projects, improve the processes involved in manufacture, installations and the routine maintenance required to keeping every single solar energy powered projects working as expected.

Lagos state is located on a narrow coastal plain of the Bight of Benin. It lies approximately on Longitude 2.42 degrees east and 3.22 degrees East respectively and also on Latitude 6.22 degrees North and 6.20 degrees North respectively. (Boyo A.O).

Lagos state's dominant vegetation is swamp forest and it consists of the fresh water and the mangrove swamp forest. There are two climatic seasons in Lagos namely: the dry season (November-march) and the wet season (April-October). Lagos state has very good availability of solar radiation with  $4324 \text{ WH/M}^2/\text{Day}$  as the annual average of daily global irradiation measured on the horizontal surface in the state. Monthly, the average varies from  $5861 \text{ WH/M}^2/\text{Day}$  in February as the maximum to  $3231 \text{ WH/M}^2/\text{Day}$  in July as the minimum.

In Lagos state, there is an average annual rainfall of 111ml per annum with an average relative humidity of 82% and mean average temperature of 26.7°C. For sunlight, the state has a mean daily sunshine duration of approximately 5.0 hours per day.

The state is located in the southwestern part of Nigeria, created in 1967, with its capital situated at Ikeja. Of all the 36 states of the federation, Lagos state is the smallest in terms of area but it is the highest in terms of population as the state contains Nigeria's largest urban area. Lagos state can as well be referred to as the most economically important state in Nigeria and also the center of commerce for the country. It has 20 Local Government Areas (LGA's) that is further broken down into smaller units summing up to 56 Local council Development Areas (LCDA's).

In Figure 1 below, there is the Map of Nigeria showing Lagos state and the other 35 states of the federation. While Figure 2 is a location map of Lagos state showing some places in the state for better understanding of the above texts.



FIGURE 1: a map of Nigeria showing Lagos state and the other 35states. (Total Facts)

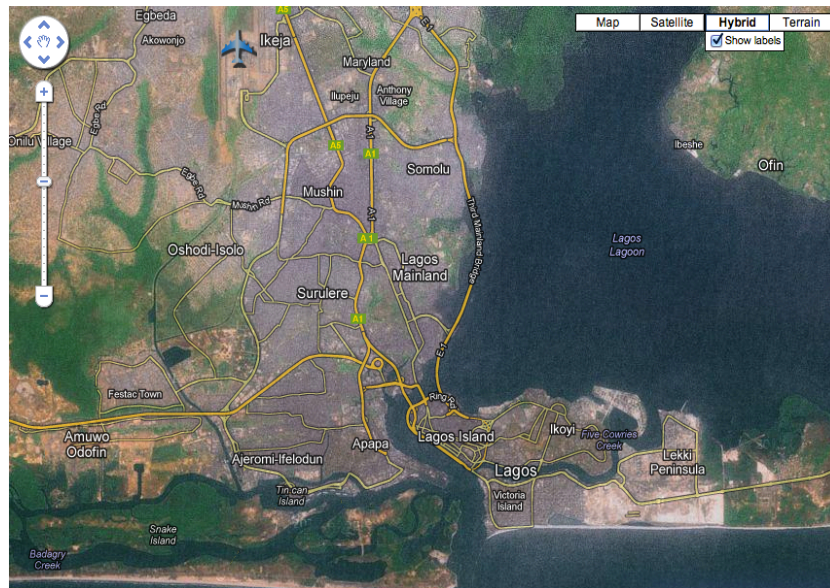


FIGURE 2: a map of Lagos showing locations (nations online)

## 1.1 Objectives and Research Questions

This research work is aimed at analyzing failed solar energy projects in Lagos state Nigeria, thereby identifying the causes of these failures. It is also aimed at suggesting solutions to minimize if not eradicating these challenges causing the identified failure.

In finding solutions to the identified challenges, the below research questions needs to be answered:

- What are the challenges facing solar energy projects in Nigeria?
- What are the impacts of these challenges?
- What can be done to minimize these challenges?
- Helps needed to minimize these challenges; where can they be sought?

## 1.2 Research Methodology

The analysis for this research work was based exclusively on secondary data for so many reasons. To start with, being a student with inadequate experience in this field, secondary data is better used in other to be able to achieve the desired result most especially when there is no enough resources for going to the filed for the sake of carrying out this research work. Furthermore, secondary research could be a better alternative to the primary research since it gave a better access to more and useful information that might be very difficult to get while using the primary research methodology, especially with the distance between the writer and the field of analysis.

As a result of the constraint in getting in touch with contacts in Nigeria, getting access to collecting the primary data was not a better option. Nev-

ertheless, assistance on where to get some useful data was rendered by a B9technology engineer. B9technologies Nigeria Limited is a Lagos based company that is into the market of Solar and wind renewable energy products.

While collecting primary data is often considered as the method to collecting information for analysis (Leskelä 2012), this might not be the best option in terms of economic and practical feasibility. Getting data from the Internet is mostly at zero cost and also from previously published journals, articles and publications related to this research work.

In this research work, both qualitative and quantitative data were used. Qualitative data being the form of data that focuses on the behavioural factors and it also answers questions related to “why” and “how”. Quantitative data on the other hand supports the qualitative data and it contains mathematical and statistical techniques in research (Leskelä 2012).

This research was basically based on the qualitative data while the quantitative data helped in throwing more light to this work.

### 1.3 Government Projects in Nigeria

Nigeria as a country operates a 3-tier form of government namely, the Executive, the Legislative and the Judiciary. This operates at the Federal, the state and the local governments levels of government in the country. The Legislatives make laws, the control public funds and as well are for checking and balancing of the activities of the executive arm of government. The Judiciary implement these laws.

Basically, Projects are being catered for by the executive arm of government, either at the federal level, the state level or the local government level.

The federal executive comprising of the president and his ministers see to the affairs of the country as a federal republic, the state executive that comprises of the state governor and his commissioners see to the affair of each of the state and an account is to be given to the presidency. At the Local executive level, we have the local government chairman and his cabinet as well, and they are under the control of the state government. See figure 3 below.



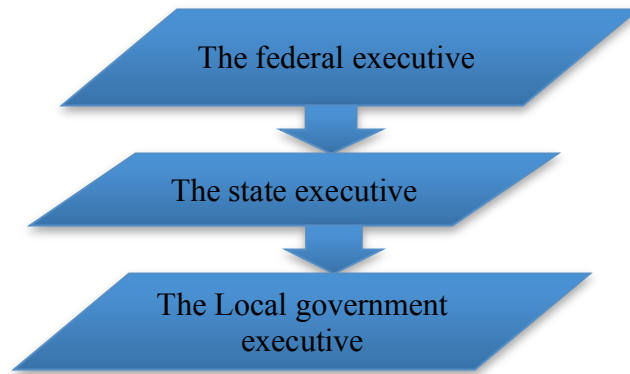


FIGURE 3. Nigerian forms of government in other of hierarchy (own design)

The Local government level is the closest to the people; they as well have the autonomy to execute some public projects for the use of their community so far it is what their budget can cover. In Several cases, the local government will have to get approval to embark on projects and the approval from the state government may means that the funding will be shared. It could be a project that the state government will be providing 60% funding and the rest will be funded by the Local government. Also there are some capital projects that the federal government projects, some are state owned projects and some also belonged to the local government. There are some projects that are shared within the three levels of government.

For the purpose of this study, focus was laid on solar energy powered projects embarked on by the Lagos state government and the 56 LCDAs existing in the state.

## 2 RENEWABLE ENERGY

Renewable energy is that form of energy sourced through the harnessing of natural energy flows. These natural energy flows could be sunlight, wind, waves, falling water, ocean currents, and tides). It can also refer to that energy gotten from the tapping of natural stocks of energy with their replenishment rate comparable to that rate of human use. Renewable energy can be gotten from several sources like Hydro, Solar, Biomass and wind.

Brief discussions will cover other sources of renewable energy but more emphasis will be laid on the Solar to achieve the purpose of this research work.

### 2.1 Hydro Power Systems

Basically, hydropower systems are mainly dependent on the potential energy difference that occurs in the water level in the water dams, lakes reservoirs and their tail water levels downstream.

The water turbines which convert the potential energy of water to shaft rotation are coupled to suitable generators (Sambo, A.S 2005).

Nigeria has a very high potential in hydropower with about 29% of the country's total electrical power supply being gotten currently from hydro generated power.

In Nigeria, there are several hydropower supply stations with Kainji on the river Niger being the first. The installed capacity was 836MW with plans and arrangements to expanding by 320MW. Also on the river Niger, there is another hydro power plant at Jebba with the installed capacity of 540MW. On Rivers Kaduna, Benue and Cross River, where there is Shiro-ro, Markurdi and Ikom power plants respectively, there is an estimated total capacity of about 4650MW. (Sambo, A.S 2005).

On Mambila Plateau, the rivers where the hydropower generating plants were present were estimated to be 2330MW capacity. In total, Nigeria is estimated to have about 11,000MW excess of potentially exploitable hydropower resources. Inserted in Figure 4 below is a photo showing a water dam for a power generation plant in Nigeria.



FIGURE 4: A water dam for hydropower generation plant (business day online)

## 2.2 Biomass

Biomass can be defined as that material that is derived either from a living or recently living organisms. They can also be called organic non-fossil material of biological origin. They are composed of organic molecules with carbon being the base; then hydrogen; they usually contain atoms of oxygen as well as nitrogen and other atoms in smaller quantities. These could include alkali metals, alkaline earth metals and heavy metals. Biomass energy refers to that energy gotten from biological systems like wood and wastes. Biomass can also be formed from by-products and waste from livestock farming, their food processing and preparation, domestic organic wastes can be included. (Biomass Energy Centre)

Fossil fuels being derivatives from biological materials, offer high energy density as fuels with the oxidation of carbon, to carbon dioxide and the hydrogen to vapour (water) while burning the fuel to making use of the energy. See figure 5 below.

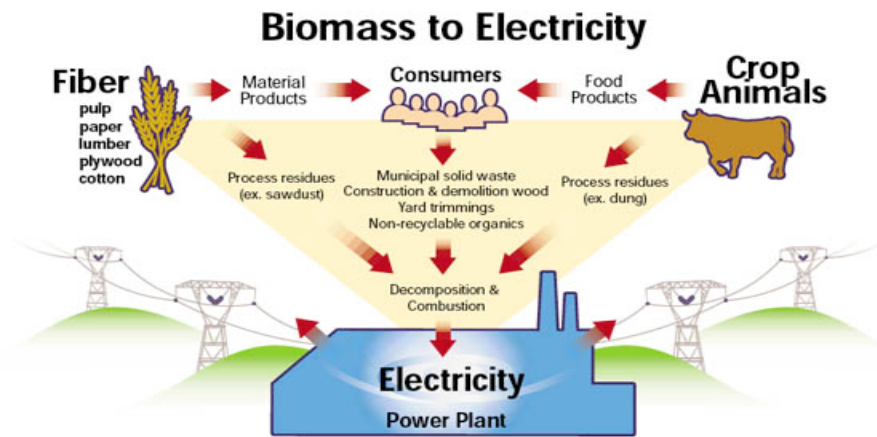


FIGURE 5: A diagrammatic representation of Biomass conversion to electricity (California energy commission)

### 2.3 Wind Energy

Wind is a natural phenomenon related to the movement of air masses caused primarily by the differential solar heating of the earth's surface. (Sambo, A.S 2005).

The strength and the direction of wind can be affected by the seasonal and locational variations in the energy received from the sun. Wind energy can be converted to mechanical and electrical energies and can be used for various purposes. It has being used for milling grains and pumping water. The average speed of wind annually varies from about 2m/s to 4m/s from the coastal areas to the far north.

There are other renewable energy sources, although they are not commonly used across the globe, but they are worthy of notice. They are energy gotten from ocean waves, tidal energy, ocean thermal gradients, and geothermal energy. For the purpose of this research work, more emphasis is laid on solar energy as a form of renewable energy. Figure 6 below is showing a windfarm where there are collections of wind turbines in the same location for electricity generation.



FIGURE 6: A collection of wind turbines in the same location for electricity generation. (The SPPI blog)

## 2.4 Solar Energy

Solar Power systems convert sunshine into useful power. Solar energy has a limitless potential, and this makes it the most promising of all the renewable sources. Energy radiation from the sun is at about  $3.8 \times 10^{23}$  kW/sec. Most of this energy transmission is in the form of electromagnetic radiation and it is found at the boundary of the atmosphere at about  $1.5\text{kW}/\text{m}^2$ . Solar energy has been confirmed to be viable for practical use as it was revealed that Nigeria receives approximately  $5.08 \times 10^{12}$  kWh of energy from the sun on a daily basis. It is worthy of note that this energy from the sun is available only for about 26% of the day.

Nigeria is as well characterised with some cold and dusty atmosphere in the Harmattan period. Especially in the northern part of the country it lasted between November and February of every year with accumulation of dusts virtually everywhere with a much windy situation. This dust could have an attenuating effect on the intensity of the solar energy radiation. Further studies revealed that with solar energy appliances having 5% efficiency covering like 1% of Nigeria's surface area, approximately  $2.54 \times 10^6$  MWh of electrical energy would be produced.

Nigeria being a country on the equatorial region impacts  $1500 \times 10^9$  MWh of solar energy annually on her surface with total land area of 923,768 km<sup>2</sup>. This equatorial position has allowed for this abundance of solar radiation. It was discovered that with a full exploitation of solar energy in Nigeria, there is the capability to produce about 120,000 times of energy as will be produced by the power holding company of Nigeria (PHCN); the electricity generation company in the country.

The technology behind processing solar energy can either be solar-thermal or solar photovoltaic. Solar thermal applications converts solar energy as electromagnetic waves to heat energy which is either directly as heat or transformed to cold, electrical or mechanical forms of energy. These can basically be found in drying, heating distillation, cooking, heating, cooling and refrigeration or even in electricity generation in thermal power plants.

A typical example of solar-thermal energy is the concentrated solar power technologies (CSP) which uses mirrors to reflect sunlight onto receivers that now collect the solar energy, convert it to heat. This converted heat energy is used to produce electricity through a steam turbine/heat engine that drives a generator.

The basis of this study will not emphasis more on this technology but rather focus more on the Solar photovoltaic.

#### 2.4.1 solar photovoltaic (Solar PV)

A systematic and well organised method of electricity generation as a result of the direct conversion of solar radiation into a direct current electricity through semiconductors of photovoltaic effect.



FIGURE 7. Panels tracking the sun in one axis (Nellis Solar power plant at NellisAirforcebase.USA)

It also can refer to the complete system by which electricity is generated from the sun. See Figure 7 above as panels were arranged in one axis to track the sun.

Photovoltaic as a system can be seen as an attractive alternative to fossils and nuclear fuels for electricity generation. It is worthy of note that sunlight is free and it does not involve using up of irreplaceable resources, and also the process of converting sunlight to electricity is non-polluting. These are some basic facts that make Photovoltaic useful almost where power lines from utility grids are not possible or not even in existence.

These can be outer space or remote areas or even nonurban locations.

Sunlight can be converted into electricity using PV cells through the light conversion process. This light conversion process is referred to as the PV effect.

#### 2.4.2 Photovoltaic effect (PV effect)

When two different materials come closely to each other, get stricken by light or other forms of radiant energy, thereby producing an electrical voltage, the process can be referred to as a photovoltaic effect.

In Photovoltaic effects of solar cells, the electron is at ground state at the initial stage, but when energy is consumed from the incoming light, it moves to the next stage referred to, as the excited stage. It is worthy of note that at this excited state, there is an available energy to be dissipated. When such energy is dissipated, the electrons in the solar cells go back to the ground state and the whole energy generation process can begin again.

In 1954, it was found out that silicon has the capability of creating an electric charge when exposed to sunlight. Silicon being an element found in the sand of every beach was discovered by the scientists at the bell telephone to have this property.

When Semiconductors are laid into thin flat sandwiches of three layers, a PV cell is constructed. In this thin-layered sandwich, the uppermost consists of an n-typed silicon, which releases negatively charged particles called electrons when stimulated by light. The Lower layer comprises of a p-typed silicon that develops a positively charged particle called proton when stricken by light.

The medium for the flow of electrons is the middle layer, which can also be called the junction layer. See figure 8 below for the diagrammatic representation of the PV effect.

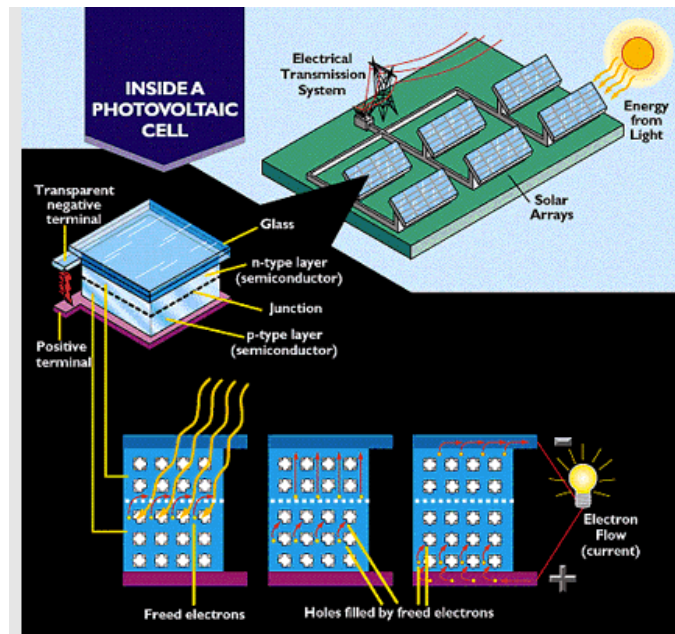


FIGURE 8. Diagram showing the PV effect: courtesy U.S department of energy. (Encyclobeamia)

### 2.4.3 Photovoltaic Module (PV Module)

A PV module refers to a laminated package of PV cells, (environmentally-sealed). It is usually connected in series for the production of a usable voltage. Most commonly, a PV module usually contains between 35-40 cells in series connection, and it generates an open-circuit voltage of about 22volts direct current. See figure 9.

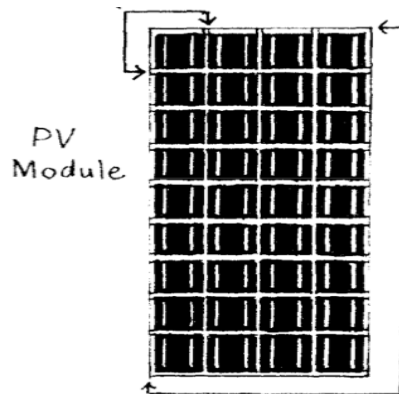


FIGURE 9: A PV module (Working safely with a photovoltaic system)

In situations where there are a number of PV modules in series connection for the generation of the required voltage needed to operate a load, such configuration is called a source circuit. It can also be called a string as it is shown in figure 10 below.



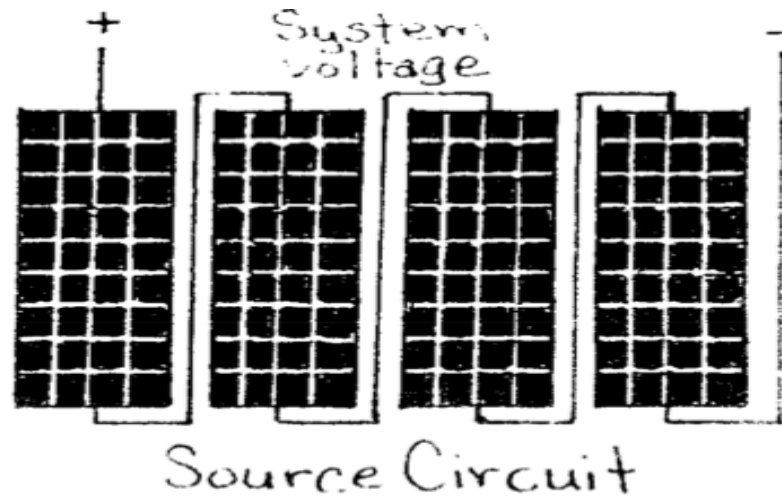


FIGURE 10: A source circuit. (Working safely with Photovoltaic systems)

#### 2.4.4 A photovoltaic Array (PV array)

Photovoltaic array consists of parallel-connected source circuits that generate the current required to meet the power demands of the load. (Working safely with a Photovoltaic system).

A PV array comprises PV modules individually framed, which are connected electrically for the production of the required current and voltage for operating the load. In an opened circuit PV module, there is a production of about 22 volts direct current (dc) when exposed to sunlight and also about 15volts when operating at the maximum power output. This is shown in figure 11 below. See figure 12 for a recap of what a PV array is from the PV cell.

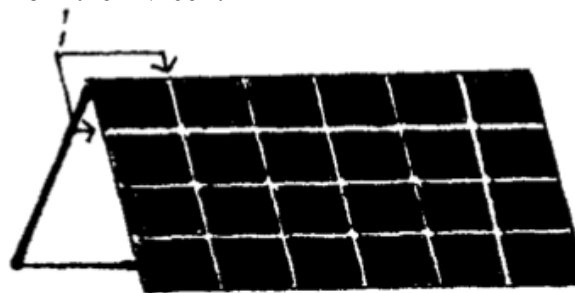


FIGURE 11: a PV array. (Working safely with Photovoltaic systems)

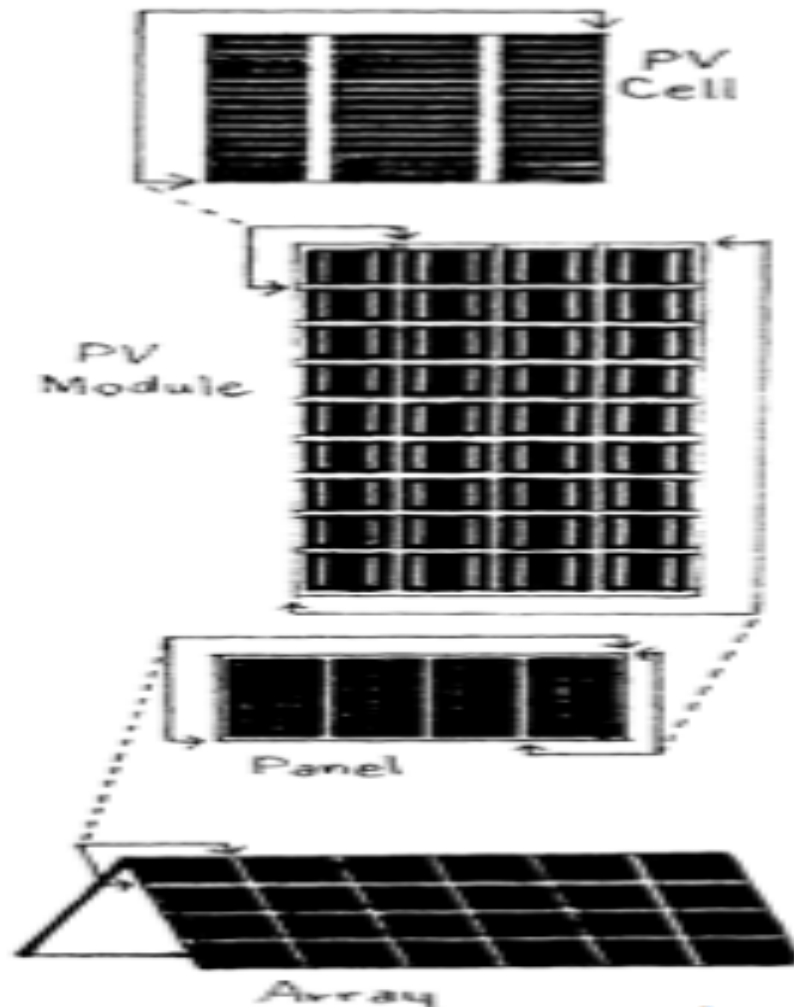


FIGURE 12: a PV array from the least level, which is the PV cell. (Working safely with Photovoltaic systems)

## 2.5 Photovoltaic Systems (PV Systems)

PV systems refer to a system that is made up of more than one PV panels, a DC/AC power converter (also known as an inverter), a racking system holding the solar panels, electrical interconnections and mounting for other components using the solar panels to convert sunlight to electricity. ([http://en.wikipedia.org/wiki/photovoltaic\\_system](http://en.wikipedia.org/wiki/photovoltaic_system)).

A Photovoltaic component consists of a PV generator, the battery, the controller unit and these components are joined together by cables (Osei, K. 2003).

## 2.6 Types of PV systems

PV systems are basically divided on the basis of their functional operational requirements, components configurations and how the equipment is connected to other power sources and electrical loads. On these bases, PV systems are rather classified as grid-connected/utility-interactive systems and the stand-alone systems.

### 2.6.1 The Grid-connected System

This is also referred to as the utility interactive PV system. It is designed such that its operation is in parallel with the electric utility grid and it is also interconnected with it. It has its primary component as the inverter or the PCU (Power conditioning Unit). When Power is being produced by the PV array, (DC Power) is converted into AC power by the PCU, and the power is in consistence with the utility grid voltage and power quality requirements. When there is no more energy in the utility grid, the PCU automatically stops supplying power to the grid. When there is a system output that is greater than the on-site load demand on the PV system, the grid will need to be back-fed.

Basically, a bi-directional interface is required between the PV system AC output circuits and the electric utility network. Example of this utility network is a typical on-site distribution panel or service entrance. The essence of the bi-directional interface is for the power produced (AC Power) to be able to supply the on-site electrical loads, or the back feeding if necessary. Also, when there is a case of greater electrical load than the system output, mainly at night, the required power balance is received from the electric utility. This is a safety measure and it is required for all grid-connected PV systems.

It is worthy of note that grid-connected PV systems should not operate, or there should be no feed back process into the utility grid whenever the grid is down for repair work or any kind of service/maintenance. See figure 13A and 13B.

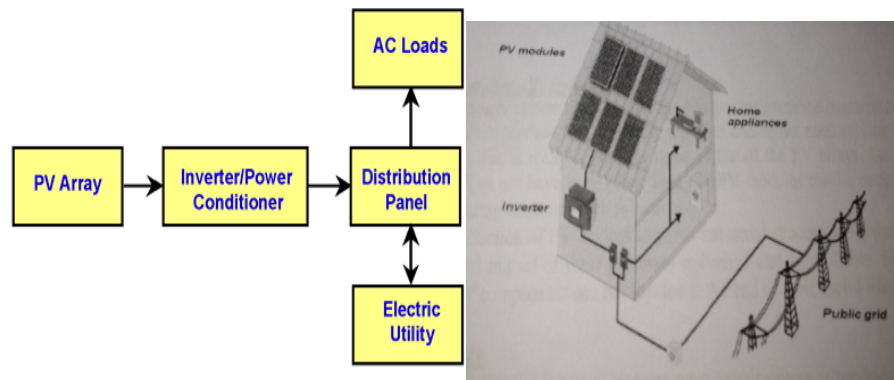


FIGURE 13A. Diagram showing a grid-connected PV system (Florida solar energy center)

FIGURE 13B. The energy produced is distributed within the AC loads and the remaining energy is moved to public grid. (Charge regulator for PV systems)

### 2.6.2 The Stand-Alone PV Systems.

Stand-alone systems as the name implies does not require the electric grid. This makes them autonomous because they are not connected to the electric grid. Some types of Stand-alone systems do not require energy storage, therefore there is no need for batteries and for this reason it can only function when there is sunlight. This system is designed such that it operates without the electric utility grid. There design is basically to supply a DC and/or AC electrical loads.

Direct-coupled system is a type of stand-alone system. It is the simplest type with the DC output of a PV module array directly connected to a DC load. (See fig. 14 below). In this system, the load only operates during sunlight hours because there is no form of electrical energy storage (Batteries) in DC system. Direct-couple systems can also be called the stand-alone PV systems without battery.

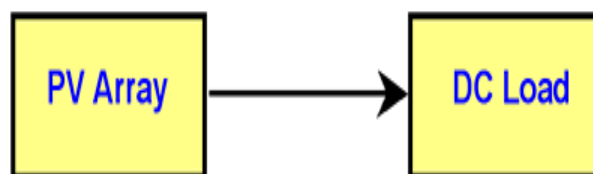


FIGURE 14. Diagram showing a Stand-alone PV system without battery (Florida solar energy center)

Stand-alone PV systems with battery are the most common types of PV systems. The PV array powers the load and a battery is charged during the

day. At night or times with little or no sunlight, the battery can power the load as shown in figure 15.

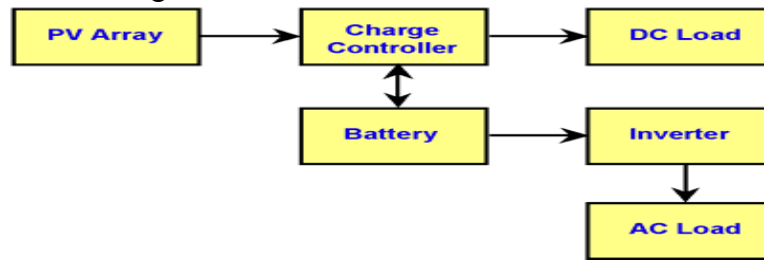


FIGURE 15. Diagram showing a PV system with battery (Florida solar energy center)

### Stand-alone Hybrid PV system

In this hybrid system, there is the need for an auxiliary power source to augment the energy produced by the array. In certain situations when there is a larger variation in the average load and the output, by which the output of the PV array is greater, this auxiliary power source makes up this difference. See figure 16.

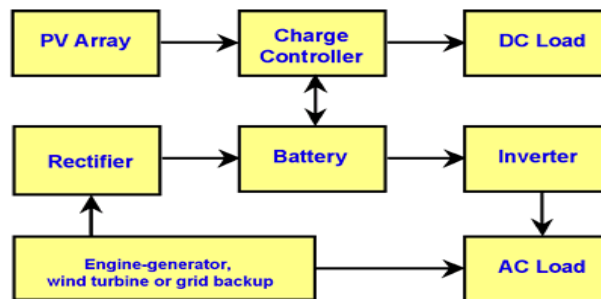


FIGURE 16. Diagram showing a stand-alone PV hybrid system (Florida solar energy center)

### 2.6.3 The Concentrator PV Systems (CPV)

This is a PV system designed such that the PV module has a concentrating optics as part of its structure. In this type of PV systems, direct beam solar irradiance is the only means of solar radiation that is allowed. This type of PV system requires a lesser number of solar cell materials when compared to all other types. It is this solar cell or PV cell that is the most expensive material in a PV system. Metal housings, plastic lenses are examples of inexpensive materials that can be used in capturing the solar energy as it is shining on a large area and this energy is focused on the solar cell. It is worthy of notice to focus on the effectiveness of this system through the measurement of how much concentration of the energy the cell is receiving, i.e. the concentration ratio. It is also a point to note that CPV systems mostly do not work during cloudy days.

Concentrator PV systems reduces the size or number of the needed cells and it allows certain designs to use more expensive semiconductor materials that would otherwise be cost prohibitive. Also the efficiency of the solar cells increases when light is concentrated.

This increase in efficiency depends mainly on the design and the kind of material used for making this solar cell. Smaller individual cells are more effective and efficient and such sizes are still very perfect for concentrators. The benefit of making a concentrator of smaller individual cells is that in the course of production, it is more difficult to make solar cells of larger surface area that will be highly efficient and effective, whereas making such cells of smaller surface area is easier.

CPV systems also experience challenges such as a highly exorbitant concentrating optics and most concentrators will have to track sunlight for a very long time. It will rather have to capture sunlight all through the days of the year before it can be fully effective.

#### 2.6.4 Fixed-Tilt PV systems

When a PV array with modules has a fixed tilt angle and orientation, such PV systems is to be referred to as a Fixed-tilt PV system. Such array can be mounted on a pole, it can be on the ground and it can as well be mounted on the top of a roof.

#### 2.6.5 Flat-Plate PV systems

A flat-plate PV system has its modules flat in geometry and uses a natural un-concentrated solar irradiance. Flat-plate uses both the direct beam and the diffuse solar irradiance. By diffuse, it means scattered in this context.

When there is no clear weather, there is still power generation. The fact that flat-plate PV systems use both a direct beam and diffuse solar irradiance brings about the word total global irradiance, which refers to the sum of the direct beam and the diffuse solar irradiance.

Flat-plates are relatively lightweight, needs no extra equipment and also lack moving parts. For these properties, flat-plate PV systems are suitable for several locations. Example of a perfect location for such PV systems is the top of residential roofs.

#### 2.6.6 PV systems design

PV systems play a very crucial role in the reduction of  $CO_2$  as it also brings about good business sense. Even in the European Photovoltaic Industry Association (EIPA), there was a forecast for PV growth of up to

32% in the PV sector by 2013. This forecast has been driven by new governmental promotional schemes that have been introduced in many countries. Its construction and operation is now integrated into the standards under IEC 60364-7-712. PV systems compliance with this standard is an assurance of its safe construction and operation.

One of the most common and cost-effective applications of PV is the stand-alone system. This is because it basically employs a PV array to charge a battery. During the dark period or in a cloudy sky situation, the battery supplies power to be used. The system basically includes a charge controller saddled with the responsibility of regulating the battery operations, and if need be, it includes an inverter for the purpose of converting the direct current electricity from the battery to an Alternating current electricity for the systems and applications that requires it for their operations.

PV-battery stand-alone systems are pulling more attention towards its side on the basis of some features they possess that appears advantageous to the end users. Especially in the cold-climatic region where they experiences winter periods.

PV-battery stand-alone systems provide an independence from the grid connection and as well can function effectively in situations where grid connection would be entirely costly as an option. The technology is also very highly reliable. The operation is automatic and does not really require human intervention during the normal operation period. Monitoring this system is quite on the easier side and issues and operational disturbances can be easily detected at a very early stage.

## 2.7 Net Metering

Net metering is a process by which extra power or unused power is being sent to the grid in exchange for banked energy credit, which can be useful whenever it is needed. The main difference between a grid-connected system and a stand-alone system is that inverters (connected to the main electrical service) must have an inherent line frequency synchronisation capability to deliver the excess power to the grid. (José Maria 2008).

Energy produced through photovoltaic effects, has several advantages when compared to other energy gotten from the conventional methods and other sources. Some of the advantages are below listed:

### 2.7.1 Reliability:

In PV modules, there are no parts that are movable. For this reason, there is no cause for wear and tear or worn out parts. This results in last longer PV modules. Hence, they are said to be highly reliable.

#### 2.7.2 Environmental Friendliness:

PV power systems do not require fuel of any kind before it can effectively and efficiently perform its functions. The maintenance requirements can be regarded as very low compared to several other systems. They do not emit any radiation, produces no fumes, noise or any other form of environmental pollution. There is no need for cooling-water before they can function effectively. All is required is a small space for the PV arrays to be installed.

The other good part of this is that it can even be integrated into existing structures like roofs of buildings etc. Also in the course of producing these components, the industrial processes involved are such that their impact on the environment are controllable and as well limited. Another environmental point of friendliness is that these components are recyclable at the end of their useful life.

#### 2.7.3 Risk Level:

PV systems usually have relatively stable energy outputs and this energy output can be predicted as well. The level of risk associated with a well-installed PV system is very Low.

#### 2.7.4 Low operating and maintenance costs:

PV systems are capital intensive and could be expensive to purchase, but they have a low maintenance and operating cost when compared to other conventional sources.

#### 2.7.5 Modularity:

PV systems are used in applications with very small energy requirements or those with large amounts of energy. A number of the same building blocks, and the PV module can be used acquire the needed power and voltage when they are interconnected. It is worthy of notice that when the power output of an existing plant is to be increased, modules can be added based on the power output required.

#### 2.7.6 Rapid Progress:

PV systems has actually being experiencing rapid and consistent progress in the area of its technology, the chemistry of its batteries, materials for its semiconductors and several other areas. This is because its existence is getting more noticeable and researchers are growing by the day across the



globe to find new and better ways of improving these systems. Hence the entire system is progressing rapidly.

## 2.8 Projects at a glimpse

A project can either be an individual or a collaborative enterprise that must be carefully planned to achieve a particular aim. The aim or objective of every project is to be successful and hitch free from the planning to the initiation, organisation, monitoring, and execution and to the point of delivery. It is also the aim of every project to have a longer Life span such that it will be functioning perfectly, thereby being useful for the intended purpose.

Nevertheless, all projects run the risk of getting into trouble along the way. The possibility of such risks could be as a result of several pitfalls. When these pitfalls are identified, they can be avoided. Below listed are some pitfalls that can expose projects into trouble along the way:

### 2.8.1 Let's do it all now:

Projects are meant to be planned and reviewed. The possibility of delivering every stages of a project in one go is null. The best of a project can be seen in situations where there is a stepwise approach that runs through from the beginning to the end. Reviewing the stages and situations at hand. Looking for better ways of handling and fixing situations that arouse suddenly whether planned or unplanned.

When projects are reviewed in real-life situations, either with the customers, end users or experienced personnel in the field boosts morale and gives confidence and reassurance that the right thing is being done. Not doing it all now also shows a high level of prudence, increases the possibilities of becoming champions of the project as it increases the chances of getting support during the later stages of the project that might appear complex and cumbersome.

### 2.8.2 Let's break it down:

When projects are broken down into bits or stages, it looks very good. But, when these are coupled together again, will they be the same as what was broken down? The risk in this case is that the project wont actually fit in to be the same as it was split initially. By so doing, problems begin to arise. Issues like rework, inability to realise benefits effectively, teams becoming separated or team members working on the same integration exercise, a whole unit that is eventually lesser than the parts combined, different standards, or approaches for individual elements, successful unit testing but unsuccessful integration testing thereby resulting in extension due to

searching and fixing of errors, increase in costs and finally confusion at the handover stage of the project.

The confusion may be as a result of which one is which when it comes to methods and ways of operation as compared to a standard approach.

If integration of components- whether they are software of elements or smaller parts of a large programme of business change- are not designed with fitting together in mind, chances are they will not fit. (Project Management tips).

### 2.8.3 Let's fix the scope:

For every project, there should be a view of what is to be achieved. Despite this fact, a project scope should be dynamic and is not to be fixed till eternity. Since projects are meant to be in phases or stages, the best is to determine scope stage by stage. This means that the entire project scope is not permanently fixed, as it is being made stage by stage.

It is worthy of note that the only constant thing is change. Business do need change, the environment, the economy also needs change. This is what brings about a strategic analysis that is very useful in planning. This analysis tool is referred to as The PESTLE analysis.

Despite the fact that change is constant, in Projects, there should be a procedure to be followed when making these changes and at every point in time. Sometimes there will be a recommendation for a change, but when it is critically analysed, it will not be necessary. For every change to be effected, there should be a change control process and methods to be followed. (Project management tips)

## 2.9 PESTLE ANALYSIS

A pestle analysis is that analytical method used for reviewing the macro environment (external forces that impact a company's ability to plan). (Alan 2011).

It is an acronym that can be further interpreted thus:

P-Political

E-Economic

S-Sociological

T-Technological

L-Legal

E-Environmental

These above mentioned forces that formed the acronym PESTLE have an impact on the success of any task, project or future plans if they are properly considered and included in all the planning at the initiation stage

and every other stages involved. These factors are in most cases out of the organisational control, but are very useful in all projects. See figure 17.

If PESTLE analysis is properly included in project plans, it can always change the project direction for the better and build contingencies and it is very useful in the identification of new opportunities. While making strategic decisions, involving PESTLE ANALYSIS could be very important.

Here below, is a figure showing the diagrammatic interpretation of the pestle analysis. The centre point representing the organisation can have it replaced with a particular project with which this analysis is to be used. In the case of this research work, the centre point named Organisation can be replaced with solar energy powered project. See figure 18 below.

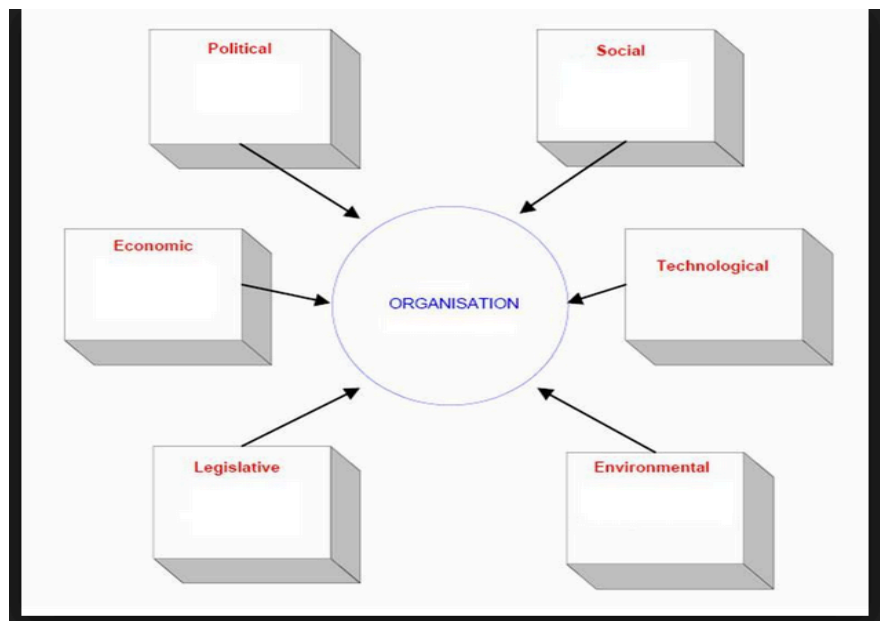


FIGURE 17: A diagrammatic representation of PESTLE Analysis (ignitestrategicsolutions)

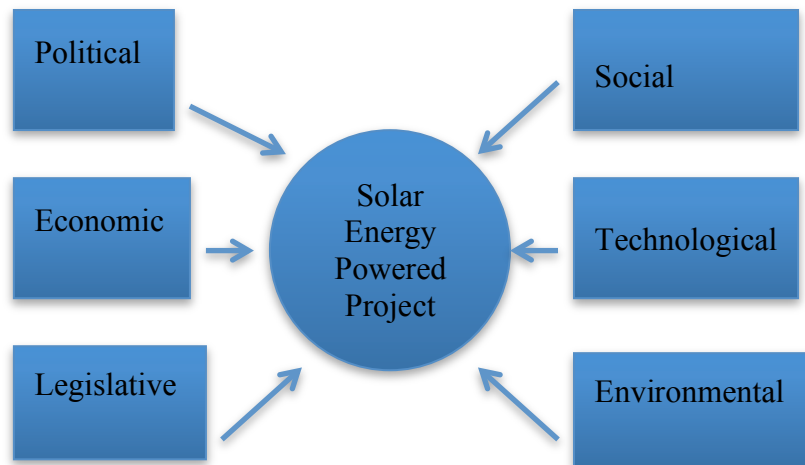


FIGURE 18: A diagrammatic representation of PESTLE Analysis making it suitable for solar energy Powered Project Planning. (Own design)

### 3 SOLAR ENERGY PROJECTS

There are several projects in Nigeria being powered by solar energy and in Lagos state and its metropolis, there are several solar energy powered projects. This chapter will discuss some of these solar powered projects and their category either as domestic or community based projects.

In Lagos state Nigeria, based on the population and the nations epileptic power supply, solar energy powered projects has become the choice of many homes and even some of the state based community projects are being powered by solar systems.

#### 3.1 Domestic Appliances (Solar energy Powered Appliances).

Domestic appliances refer to those appliances meant for home use. They are such appliances purposely built to serve in homes. They are built and designed having the capacity to supporting home functions. Examples of solar energy powered domestic appliances can be consumer electronic devices such as calculators, watches, radios, lanterns and small battery-charging applications. Also a PV power system for residential use is another example of this.

#### 3.2 Community Based Projects. (Solar Powered Appliances)

Community based projects are those projects constructed for the use of the majority residing in an area or the entire community. Government projects either federal, state or Local government projects are constructed for the use of the entire citizenry, either those residing there permanently, temporarily or passers-by. Solar powered community based projects are mega projects in other to cater for a larger number of people, or to render continuous services for a longer period of time.

Examples of Community based projects found in Lagos state of Nigeria are solar powered public water systems/water pumps, solar powered streetlights, and fish drier. Precisely there was a solar electrification project Launched by the Lagos state government in the Onisowo village of bishop kodji.

The electrification project was to power streetlamps, water pumps and fish driers. Also in the Bishop village area also in the Lagos harbour, a segment of the Lagos lagoon, solar lighting project was erected for powering the community-based school, a mosque, a church and a maternity centre. It was also to power water pump for supplying water to the village people. These two villages are in the Amuwo-odofin local government area of the state. There will be further discussion on these projects in the next chapter.

### 3.3 Essence of Proper Project Management and its impact on Solar Powered Projects in Lagos State.

Project management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements. Knowing that Project itself refers to a temporary endeavour undertaken to create a unique product, service or result. The temporary nature of projects indicates a definite beginning and end. The end is reached when the objectives of the projects have been achieved or when the project is terminated as a result of the inability to meet up with its stated objectives. (PMI 99-001-2008).

For a project to be successful, it requires proper management. This is where a good project manager is required.

A Project manager is the person assigned by the performing organisation to achieve the project objectives (PMI 99-001-2008). It is worthy of note that project managers differ from functional managers and as well as from Operational managers. Functional managers are saddled with the responsibilities of providing management oversights for specific functions or an administrative area, while operations managers are in charge of certain facets of the core business.

Projects managers are expected to possess the following characteristics:

- Knowledge. A solar energy project manager is expected to have basic ideas of solar systems, PVs and how things work. With this, he should be able to give insight to maintenance functions and also be able to proffer solutions urgently at least during the course of the project work.
- Performance. Project managers in this field must be up and doing. He must be able to accomplish several task and responsibilities in a timely manner. He must be able to break barriers that might hinder the success of his projects. Especially looking at the environmental circumstances surrounding the state. A capable project manager in this field must be able to meet up with strict deadlines.
- Personal. He must set examples. He must behave properly when handling project works and several other activities. He must have a very good leadership quality, personal effectiveness. He must lay good examples with the ability to properly guide the project teams and as well ensure that the project objectives are met thereby balancing project constraints.

The essence of proper project management is to ensure that good materials are used, proper project planning, initiation, execution, organisation, and monitoring. The conclusion or delivery stage must not be left out as well. These stages require proper management, and milestones must be set to

review results and for decisions to be taken on weather to move forward or to revisit some steps for modification.

Solar energy projects might look small, but adequate management is required from its planning to delivery. The impact of proper project planning on solar energy projects in Lagos state will be for a successful last longing project that will be able to meet up with the set objectives for a longer period of time. The negative side of not properly managing projects will be failures, and uncompleted project works.

## 4 CHALLENGES FACING SOLAR ENERGY PROJECTS

The level of awareness of solar energy and its projects is increasing by the day in the country and especially in Lagos state. This is as a result of the erratic power supply being experienced nationwide. This increasing level of awareness has been a result of some major failures in the solar powered projects.

These failures and the reason for these are further analysed below.

### 4.1 Why Projects fail?

Many solar projects fail after just a short time, whereas it is not a must that this kind of situation must happen at all time. This is because solar technology is actually a simple and highly suitable technology for a long-term usage. (Harald, S)

From the understanding of project and its management as earlier discussed in this research work, understanding a better way to putting projects together with the aim of being successful plus a very good, vibrant and hardworking project manager, projects are meant to be successful. Basically on solar energy, successful solar powered projects can be achieved if the below tips are considered:

- **Analysis of need:** Basic analysis should be done on the need to embark on certain projects. In this case, how great the electrical need is, where, why and for what purpose are they needed for, how many hours light will be needed, space, what time and number of days, what other appliances will tap power supply from this same source, for how long will these other appliances expect this supply?

With this rigorous analysis, plan should be in place for like 30% buffer for growing demand. Most especially, in making a solar powered project intent for the use of the community or to power public facilities, a precise and detailed analysis of the need and demand is a must to avert such projects from failing. Hence this is seen as a primary requirement.

- **Sizing:** In solar powered projects, sizing is another key factor to be considered. Solar radiation situation during the raining period should be considered. The setting of the dimensions of the power unit must be considered especially for the wet season so as to ensure perfect functionality and efficiency all round the year. The solar insolation values during the raining season can be as much as between 30-40% lower than the average recorded in the other season of the year.

Note that the oxford dictionary defines insolation as the amount of solar radiation reaching a given area while Wikipedia defined it to be the measure of solar radiation energy received on a given surface area and recorded during a given time. It is expressed as hourly irradiation.



For these reasons, it is advisable for solar engineers to size-up the battery and modules for projects in other times of the year rather than doing such in the peak sun availability period. While basing their calculations, it is preferable to do such during the periods of lesser availability.

Another point to note here is the battery capacity and its calculation. It should be calculated such that it can store charges for giving the required output for electricity supply for at least 3-4 full days for an assurance of electricity supply during high demand period cum bad weather. Also it is important to do these proper planning and include electricity reserve for crucial equipment like in the health sector, refrigeration is important for medication.

- **Required of the installation firm:** As a project awarding institution, your goal must go in line with the plan presented by the installation firm. To making this a reality, price must not be the key determinant but rather the quality of the employed components (generator, module, lamps, batteries etc.). The fact that setting up a solar power technology is expensive is not enough a reason to balance it up using cheap products.

For solar power technology projects to be successful and lasts longer, extreme climatic conditions must be seen as a major rule thereby making the technology and components to be used to meet up with the highest demands in terms of stability and robustness. With this, there will be minimum operating and maintenance costs for years. Careful attention must be paid to maintenance and services rendered by the installation firm. Closeness of the service station/workshop is another important thing in this regard.

This will save costs in the long run as numerous projects have failed as a result of enormous costs in the area of maintenance because the service station is at a very distant location. It is useful to gather several offers and consult rural electrification experts independently.

- **User training:** In Nigeria and in Lagos state to be precise, people are highly skilled in the areas of using petrol or diesel generators, kerosene lamps and even candle lightning. In the area of solar power technology, an entirely new technology, it is a must to prepare the people meant to use this technology with trainings and made them familiar with the technology.

The fact that this technology is new, it should be made user-friendly and presented to the users practically. In making the user training, the followings should not be left out:

- Saving the energy: solar energy is valuable and should not be wasted despite the fact that it is free.
- The correct usage of the solar power system.
- The consequence of incorrect usage

- Errors that can be repaired by the users and those that needs the hands of experts
- To whom should help, problems or questions be addressed?

In general, for community-based projects, either in public buildings or in the entire community, it is definitely not going to be the best idea to try to make every individual user aware of their responsibility. Rather, strict rules are required regarding enforcement of these rules.

Without these, there is the possibility of these solar projects working for a very short time. To set these clear rules, it is necessary to have precise knowledge of the system and as well a clearer understanding of local conditions. What are structures like on site? Which people are to be included in the project-planning phase?

Another important thing is the question; who is the actual owner of the project work? Setting the user training could be simpler for domestic appliances or appliances for individual usage as compared to the community-based projects.

- **Plant management:** In Nigeria as a whole with Lagos state included, many solar projects end up with inauguration celebrations with project installation firms, users, financiers are all overwhelmed with joy. They are filled with joy over the newly installed project. This joy eventually makes those involved to overlook the fact that the greatest challenge is yet to come. Effective and efficient permanent plant management is required to ensure the functionality of solar powered projects for a minimum of twenty-five years. Plant management rests on three main pillars viz: Organisation, technology and financing.
  - **Organisation:** This refers to those saddled with the responsibility of monitoring the entire plant, ensuring that the facilities are not misused. For community based projects like those used in schools, health stations etc., at every point in time, a particular person should be responsible for the organisation. There should be a clear formulation and communication of responsibilities to every particular person involved in the organisation of the solar power plant. It is good to put such in a written agreement. How to handle growing demand should be anticipated and planned for because with the first functioning solar power system, new ideas will surface new demands and new desires will come up sooner than expected.
  - **Technology:** Technology here refers to the responsible for the routine control of the facility. It includes the tasks of the installation firm, the storage of the spare parts and the access to the spare parts its replenishment and replacement

and also the ways to handle and who is passing information to the servicing firm.

- Financial: This refers to the means of settling the bills accumulated from repairs and maintenance work, the responsible for the payments of exchange of old batteries with new ones, and how will these required funds be raised. Who is in-charge of keeping the money, and whose consent must be sought before any spending can be incurred?

A careful understanding of these points in the course of solar energy powered projects will not only please the inauguration, but will also avert unnecessary failures thereby making the project a long lasting one.

#### 4.2 The Solar powered Electrification project at the Bishop Kodji near Onisowo Village, Lagos state Nigeria.

Bishop Kodji is located in the onisowo lands on an island in the Lagos lagoon. Onisowo is about 15 minutes west by water from the prestigious Ikoyi boat club, and 10 minutes east of the private beaches ilashe and ibeshe. The description of this village showed that it is less than one mile from the Tin can Island port in Lagos.

Tin can Island port is a popular place where the federal government is earning tens of millions of dollars on a daily basis from exporting petroleum and every other general importation and exportation activities. Cargo ships filled with goods enters and exits the port on a regular basis and still bishop kodji was not found on the energy grid of the state. See figure 19 for the tin can island Location.

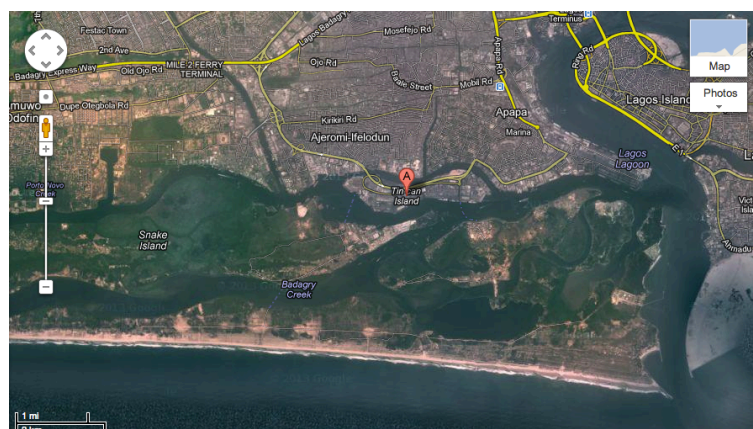


FIGURE 19: A location map showing the location of the tin can island port in description of its closeness to the bishop kodji village in Lagos state. (Google maps)

This solar energy project was built for the community such that it can power the water pumps for easier water supply for the entire villagers, power the street lamps for lamination and security and also to power the

fish driers. Bishop Kodji being surrounded by water has majority of the residents to be fishermen. So the essence of the fish drier is to boost and strengthen the fishing economy of this area. See the inserted photo in figure 20 for the solar powered project.

By the year 2011, this electrification project was five years old and it was recorded that things does not eventually work as planned. A traditional leader in person of Azime Anthony said; “It only worked for about three months, and then it stopped. All the places where we are supposed to have light are dark and they never came back to try to fix any of it.” (Omisore 2011, National Geographic News 2.11.2011.)



FIGURE 20: The Lagos state-sponsored solar powered Project at Onisowo village of Bishop kodji. (National geographic news)

### Project Analysis

Going by the Azime Anthony’s statement as quoted above, after the inauguration and launching of the project, everybody was happy and with the hope that the project will last longer, there was no maintenance culture in place. No plans for servicing either by the installation firm or getting a servicing company to monitor this. It was also glaring that there was no proper planning the power plant management, Organisation, technology and financial. There was no proper planning for adequate funding for maintenance, and sustainability of the project for the long-term.

Bishop Kodji as a village is economically depressed as a result of the lack of power supply as the residents do not even have enough let alone affording to pay for services.

Failure on this project was also as a result of the poor maintenance by the residents and actions termed as jealousy from the neighbouring villages.

Bishop Kodji residents claimed that the moment the news of the new technology spread across, neighbours from nearby communities came in and sabotaged the solar units.

Although, the initial success of this project work in Bishop kodji brought about the introduction of such projects in nine other communities in the state. The question here is, what has happened to the other projects as well? Are they functioning well at the moment, or they are also short-lived without any one paying attention to fixing these issues, a field research work in this regard will definitely give a lasting solution to this question.

#### 4.3 The Solar powered project in Bishop Village of the Amuwo-odofin LGA of Lagos state.

Bishop Village is another remote area located in the Amuwo-odofin L.G.A of Lagos state Nigeria. It is a neighbouring village to the bishop kodji village that was discussed above. Both villages are on the onisowo lands in the Lagos lagoon. See figure 21 below.

Onisowo lands is an island that falls in the Lagos Harbor, which is a segment on the Lagos lagoon. Lagos lagoon consists of two other segments namely; the Epe division segment and the Metropolitan Lagos Area.

The project in bishop village was an electrification project using the PV to convert solar energy radiation to electricity. The village was electrified, and the water-pumping machine was also installed in the village well to give the entire villagers easier access to water. This project was from the Lagos state ministry of science and technology, a ministry under the Lagos state government.



FIGURE 21: The bishop village in Amuwo-odofin LGA of Lagos state. (Development of Solar energy in Lagos state, Nigeria)

### Project Analysis

The PV panels used to power this project were mounted on the roof of the buildings of the mosque, the church and the community school. Actually the report of this project as written by the director of science and technology of the state, the project was a success and it was still functioning well as planned.

#### 4.4 The Challenges facing solar energy projects in Lagos state.

Despite the potentials of solar energy in Lagos state, the number of solar energy projects in Lagos state is still minimal because of several issues that really require much attention. Some of these issues are listed thus:

**Security Risk:** Lagos state being a state with the population of about 7 million people has a high risk of theft and even vandalism of such systems as a result of crisis.

**Poor Understanding of the consumption rate/local needs:** In Lagos state and its environs, a better understanding of the economic, social and cultural needs is a very important factor that is lacking in the planning of solar energy projects in the state. For domestic appliances, housewives could be of tremendous help as they usually have deeper understanding of energy needs and consumption.

This idea can also be factored into planning for the expected consumption rate when planning community projects as well. Lack of careful planning can lead to the usage of wrong materials or even batteries of lesser capacity.

**Maintenance:** There is lack of skills or the skills to operate and maintain solar energy systems are inadequate. Most times, men are trained to do these tasks, whereas men are not often around to monitor these situations sometimes because of tight schedule. It is a better idea to train housewives some basic at least to be able to handle such systems effectively in the case of any mis-happening.

**Technical problems:** Technical problems are seen as one main part of the cause of failure in solar energy projects in Lagos state. Problems like overcharging of batteries, broken inverter etc. occurs and the lack of technical know-how might delay the ability to notice such failures and it can thereby stay for long thereby making the project a failure.

**Price and economic sustainability:** Most times, solar energy products are expensive. "Lagosians" as Lagos people are fondly called will definitely prefer cheap solar products than quality items. For this reason, Lagos state

people might not even embrace solar powered projects so easily as it is not the cheapest power option for them.

Juan Leandro reported that batteries life span runs through 1-4 years. This means that when a battery's lifetime ends, it must be replaced for the project to continue working and this will definitely involve money. If not, such projects will be reported as a failed project.

**Little Awareness:** In Lagos state Nigeria, Solar energy projects is much needed in the rural areas, areas that are off the electricity supply grid of the nation, where electricity through solar power is the cheapest option. These are areas where solar energy needs to be marketed. But the solar energy companies are not even familiar with these environments, let alone marketing to those areas to improve the awareness of the citizens in order to embrace the improved technology.

**Communication challenge:** The official Language in Lagos state and Nigeria as a whole is English Language, but reaching a common level of understanding is difficult most times. This in addendum to cultural issues is also a great challenge for such projects in the states. Moreover the inhabitants of the rural areas where solar energy can really be useful at the moment might not be ready to embrace change as they are already used to the traditional ways of life. For example, a 50 year woman in bishop kodji will prefer to cook by firewood, rather than a solar powered cooker that she might need to start learning the manual written in a language she does not understand before a full operation of such system.

**Poor Quality Local products:** The majority of the solar PV technologies in the state are of very poor quality as a result of cheaper importation. Virtually all markets are filled with the Chinese products as popularly called "chinko" in Lagos state or even the "Ibo made" as a popular term for items of inferior quality. With this situation, few people that are even using to use the technology at home will experience such products not lasting longer and they will definitely be discouraged. A cheap product of inferior quality is expensive to maintain in the long run since it will need to be replaced or service when it damages regularly.

The first solar energy products that first entered the Lagos market have really done a great havoc to the peoples orientation in the state and the country at large.

There is little or no political motivation, trained manpower, full governmental support in creating awareness for this technology and even the commercial activities for this PV technology is very low. These are also challenges that solar energy projects need to overcome before it can really come to limelight fully in Lagos state and Nigeria as a whole.

## 5 SUMMARY, RECOMMENDATION AND CONCLUSION

This section summarised this research work, with useful suggestions as recommendations to reducing the challenges facing the solar powered projects in the state and a formal conclusion of this work.

### 5.1 Summary

In Summary, this research work has analysed some of the solar energy powered projects in Lagos state using secondary data and have come to the following findings.

The Major challenges facing solar energy projects in Lagos state, which appeared to be the cause of the major failures, are listed thus:

- Technical know-how in the area of technology involved in the solar systems
- Inferior materials and unavailability of the raw materials
- Lack of proper planning in the areas of  
Project planning and management,  
Maintenance culture by the user and the installation firm/service company,  
Monitoring and routine inspections.

Also, this research work eventually showed that these challenges has nothing good to offer other than to lead to a short-termed life span for projects which eventually will now be a waste of money, time and bad reputation for either the government in charge of the projects, the installation firm and those involved in the project from a to z.

These challenges which in turn has led to various project failures has brought hardship to the citizenry that are suppose to be the beneficiary of these project works if it were to be a long lasting one.

It is also worthy of note that if adequate planning is made, with proper monitoring of the project work from planning to initiation, organisation, financing and till execution. Also after execution, if there is proper routine check from time to time with an adequate security measures, then there is a very greater chance of improving these project work in Lagos state and its environment. Moreso, neighbouring states can bench mark this thereby making the solar technology a widespread system in the country as a whole.

This research work also made it known that with the governments giving the full support from the start, there being involved from the start, awarding such projects to capable firms with proven results, given adequate instructions with proper documentation, ensuring proper monitoring from the beginning to the end, putting things in order with the rules and its enforcements. The failure encountered in the area of solar powered projects will reduce drastically and can be eradicated in the nearest future completely.



Also, help is needed from the individual users and the entire community to improve in their ownership. Seeing all these equipment as their own projects and ensuring that hands are joined together with the other quarters to ensure that things are working as planned and according to the initial objectives of these projects.

The installation firms should always be ready to give their unflinching support at every time it is needed in terms of advise, maintenance and monitoring. Also, the use of quality materials from the start of the work should be a major priority to the installation firms. This will make good reputation for such firm and will in turn bring more projects to them thereby giving them more money in the long run.

## 5.2 Recommendations

This research work has been done thoroughly using the available secondary data, and the below recommendations are as a basis of the results gotten from this research analysis.

Proper planning of the entire projects from the planning to execution state is important. Review stages or milestones should be set. At these milestones, good notes should be made of the status of the project work, emphasising on the next steps for progress. Materials used should be taking into consideration. Inferior material materials should not be an opportunity to save cost.

Moreover, I am recommending that the state should emphasise on publicising solar energy and its advantages. By doing this, the awareness will increase and the entire citizenry will embrace it thereby solving the likely occurrence of vandalism in case of crises.

Apart from public awareness, general trainings should be introduced region by region in the state. When a general training is made available voluntarily either through the local governments, the understanding of what a PV system is and how to operate it will become a possibility to all and sundry. This then helps everyone in the state to be able to operate such projects even when such projects are within the state. Moreover, when such projects are then erected within the state, the level of operations would have moved out of zero level, and operating manuals and refresher trainings will be a useful tool then.

Routine maintenance and regular Quality checks using any of the basic quality tools: Lagos state government should see routine maintenance by capable firms and engineers a mandatory practice. With this, issues are like going to be captured earlier, and they can be fixed immediately or scheduled for the next planned maintenance. Also, the use of the fish bone analysis helps see to the root-cause of issues and fixing such issues will be a permanent fix rather than gambling on what could be the problems and not fixing it permanently. Scatter diagrams, the Pareto analysis or any of the rest of the basic quality tools is a plus to understanding the issues that

can make the life span of solar energy powered projects in Lagos state a short-termed one as compared to being a long-termed project.

Planning for the energy required and testing the batteries intended for use in any of these projects to be erected in Lagos state during the weather period that there is lesser amount of sunlight. This provides the opportunity to see and plan for actual energy required to sustain the projects even at times when there is not going to be the availability of sunlight at its peak.

Also, the use of energy saving bulbs is a must in areas where there is the need for bulbs. This will consume lesser amount of energy and will make the energy stored last a bit longer.

A regulatory body is required or a standard organisation such as the ISO (International standard Organisation) that will focus on the improvement of solar energy technology and its systems. Focusing on the assurance of systems of high quality and standards in general.

It is also recommended that Lagos state should see to the way solar energy projects are being approached in the developed countries. Countries like the United States, Finland, Germany to mention but few and understand their approach to how things were done. They should bench mark from all these nations and reapply all the processes to the projects back home. Knowing fully well that Countries like Finland and Germany do not even have sunlight the same way it is in Lagos state Nigeria and still, the solar projects are flourishing well in these nations.

To strengthen the result of this research work, it is pertinent to make a field research using capable engineers or thesis students to go on the field and gather raw data (primary data), analyse them as that will also be of tremendous help as Lagos state and Nigeria as a whole need to fix all these challenges facing solar energy projects in other to be able to change the status of these projects from a short-lived projects to a long-lived projects.

By doing this, the entire residents of Lagos state will have a rest of mind as to having an alternate means of generating electricity as the PHCN has not being able to satisfy them with their epileptic power supply.

This can even be helpful to migrate all the domestic usage of electricity on to the solar renewable energy source, and the PHCN can focus more on supplying the industrial sector with electricity thereby boosting the industrial processes and production and in turn improves the economy of the state.

### 5.3 Conclusions

This research work analysed the challenges facing solar energy projects in Lagos state Nigeria, thereby suggesting likely solutions to the challenges so as to having a Long-termed solar powered projects in the state.

Conclusively solar energy projects must be seen and embraced as a better alternative to fixing energy issues and the epileptic supply of power for the use of the citizens of the state. When this is seen as an alternative and user and environmentally friendly, then the challenges making the projects a mirage should be tackled and at least minimised to a very large extent if not permanently fixed.

Seeing to the above recommendations as suggested by the author, the reader should carefully read through this research work and bring out useful facts from every aspect of the write up, as it will definitely widen the knowledge of the reader and thereby giving clues on a better approach to how the challenges facing the solar energy powered projects in Lagos state should be handled and thereby minimised.

It will be a useful document for the Finnish SMEs looking forward to expanding their businesses by penetrating into African new markets with Nigeria being one of their target countries.

Also, a further research work with the use of primary data as can be gathered through fieldwork will also shed more light on how to fix these highlighted challenges, and as more challenges can also be found and solutions to fixing them can be proffered.

It is my conclusion that when all these challenges are fixed, Solar energy powered projects will serve for decades and every one in the state will be happy from the usage of stable electricity supply to access to other basic amenities and will also be able to do other day to day activities happily thereby boosting the economy of the state in the long run. With this, other states can benchmark from Lagos state and will also reapply the technology and the entire system used to manage it in their own states.

There is a greater hope for Nigeria as a country to move from being a developing nation to a developed nation someday. The country can join the rest of the stable nations across the globe enjoying peace and systems that works.

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