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REVIEW OF RECENT DEVELOPMENT ON SOLAR ENERGY SYSTEMS IN NIGERIA

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Abstract. ***Solar Energy is under utilized in Nigeria hence, the need for the review recent work in the sector to create more awareness and to educate toward better ways of improvement to enhance better use. More than 80 percent of energy consumption is made by petroleum. This consumption requirement is a serious concern for the country due to depletion of petroleum and negative impact on our environment such as pollution and increase in global warming. This work presents an intensive review of recent developments on solar energy systems in Nigeria in order to itself score card for decisive action. The work x-rays the present status of solar energy system in Nigeria and identifies solar energy as a critical factor for its economic development. The research captures application of solar energy systems and its contributions to the development of the various sectors of economy such as agricultural processing, rural electrification, engineering and medical services. It's also highlights and discusses factors militating against the use of solar energy systems in Nigeria in recent times. In addition, the research also shows sample solar energy system sizing calculation to illustrate load survey which determines the capacities of solar components and finally makes some useful recommendations to forestall the setbacks in embracing the photovoltaic technology. The work will inform a lay man with the needed guide as regard the best way of Solar Energy application in the country.***

Keywords— Electricity, Renewable energy, Solar energy, Photovoltaic, Global warming.

I. Introduction:

The effects of energy in any society cannot be over-emphasized as power has a direct relationship with the growth and development across the globe. To achieve the growing demand for energy in a safe environment is a crucial challenge for supporting economic, agricultural and social progress [1]. The need for affordable, pollution free, easily accessible and renewable energies is fundamental in life because of its importance in the industry, agriculture, transportation, and education sector. The sun as suggested by [2] may be one of the solutions to future energy crisis. [3] revealed that solar energy as the radiant heat and light from the sun is harnessed using a range of ever evolving technologies such as solar heating, photovoltaic, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis. Solar energy essential source of renewable energy since almost all energy sources originate directly or indirectly from the sun [4]. According [5] "Solar energy is the largest and impressive source of energy in life for every plant and animal in our world yet so little is used by mankind today".

However, despite huge effort by public and private agencies to promote the adoption of solar energy systems, capital intensive and other challenges hinder the complete utilization of this technology.

Some of these challenges include lack of awareness, component failure, government policies, vandalism, and etcetera, especially in rural area with little or no access to electricity. If power supply is constantly provided, all the setbacks to economic and social life would be forestalled [6][7] This work intends to create awareness and proffers the best ways to utilize solar energy technologies.

II. Review of related work

The use of solar energy has become necessary and fundamental in the society due to its growing role in today's clean energy economy. Light from sun was used with magnifying glass materials as a lightening source by the Greeks and Romans for domestic, industrial, official and religious gathering. In the late 1700s and 1800s scientist through research were able to use solar energy to power some electronic device such as ovens and also, to produce solar powered steamboats.

These achievements are evidence that years before solar panel era, the concept of using solar energy was a common practice [8]. So many researchers have made huge contribution on the invention of solar energy; especially Edmond Becquerel in 1839 whom made a tremendous effort in the invention of solar cell. Edmond Becquerel in 1839 observed that light from the sun produce electricity in a process he referred to as photoelectric effect. This observation made by Edmond Becquerel in 1839 later became obsolete when photovoltaic was produced from element selenium by Willoughby in 1873. Williams Grylls and Richard Evans in 1876 further researched on photovoltaic led to discovering3 that selenium when exposed to sunlight creates electricity. In 1883, Charles Fritts develops the first solar cell using a selenium wafers and was thus credited to as the first inventor of solar cells. Today, solar cells are made of silicon not selenium giving credit to the true inventors of solar cells like Daryl Chapin, Calvin Fuller and Gerald Person's work at Bell Laboratory in 1954, becoming the first time in history that solar technology would power electrical devices for hours at four percent (4%) efficiency less than a quarter of what solar cells produces today.

The growth and use of photovoltaic solar energy system is dynamic and varies strongly by countries. In 2019, International Energy Agency (IEA) projected that by 2050, solar photovoltaic and concentrated solar power would contribute about 16 and 11 percent respectively of the worldwide electrical energy consumption and solar energy would be the largest source of electricity. Presently, the top installers are china with 176,100 MW (32.3 %,), followed by United States with 62,600 (11.5 %), Japan with 45,400MW (10.5%), Germany 45,400MW (8.3%) and India with 32,900MW (6.5%) for their respective domestic electrical consumption [9].

Albert Einstein was one of the earliest promoters of solar energy. He won a noble prize for some publications on photovoltaic effect [10][11]His discovery shows the scientific and usefulness of the solar energy. One important aspect of his researches was on space race.

William Cherry in 1956 developed photovoltaic technology by using a small array of panel to power vanguard 1 satellite radio. Solar cells and panel was made available to many industries and was used to powered navigation and warning light for offshore oil rigs. In 1957 and 1960, Hoffman electronics achieved so much in improving photovoltaic efficiency from 8% to14%. This achievement was later preceded by University of South Wale by enhancing the efficiency of the solar cell by about 20% from silicon in 1985. National Renewable Energy Laboratory and Spectro Laboratory Incorporation corroborated to create 33.3% efficient power cell in 1999 and was subsequently improved to 34.5% by 2016 [12].

The first solar power house was built in 1973 by the University of Delaware and named "Solar One". In 1981 Paul Macready built a solar challenger which was the first aircraft in history to run on solar power. Although several researches have been carried out on renewable energy, there are still needs for more innovation. Generally, modern solar cells has 15 to 20% efficiency raising hope that the future of solar energy may enhance a better design, affordability and cleaner sources of energy [13].

Africa often considered and referred to as the sun continent or the continent where the sun intensity is high. This makes the continent a good site to enhance solar energy especially in the dry areas that constitute Sahara and the Sahel region. South Africa leads in solar power with 1329MW installed in 2016 [14]. Kenya has planned to install a 50MW photovoltaic power plant in the city of Garissa, located at the equator and thus expected to produce approximately 76,473 MW yearly. Ghanaian government has also planned to install 155MW photovoltaic power plant to increase the growing need for solar in the country from 22.5MW in 2017 to about 300MW in 2030. There are also many small scale power installations that are mounted across the continent.

A. Status of Solar Energy System in Nigeria

Solar energy is a critical factor for economic development. It is virtually used in most sectors of our economic. For instance, it is used for provision of portable water, street lighting, household's appliances, agricultural services all required energy with attention shifting from a serious cost issues associated with non-renewable energy to one of significant potential. In the past three years, there has been an increase in lighting options, affordability, and commitment through research with some laudable innovation within Nigeria. This has been based on the development of affordable and robust LED lighting attachments, better battery options, along with the falls in the cost of solar energy components such as PV cells, battery, inverter and LED life spans measured in years most batteries now being 3–5-year lithium variations, and small portable solar panels smaller than a shoe.

In order to strengthen solar energy, entrepreneur embarking on solar energy project must have access to mandatory micro-credit facilities from banks and others financial institution. The government should show commitment to already established solar energy research centers in universities and polytechnics such as NCERD ,SERC to produce less expensive and energy saving component that is considered viable for investment setting standards on imported component through Standard Organization of Nigeria (SON) .Also, Renewable obligation order should be issued annually to encourage electricity generation from renewable source such as solar energy and mandating the review of national building code to enhance roof-top solar power technologies and setting aggressive solar national mission outlining specific approaches to new target beyond the initial status of 1,343MW generated target by 2020.

B. Peak- Sun Hour (PSH) in Nigeria

This is the hours of the day that the sunlight intensity reaches an average of 1000 Watt/Meter Square. It is a vital tool used to estimate the rating of PV cells. Peak-Sun Hours daily is approximately 5-6 hours in Nigeria and also ranges from 4 to 9 hours depending on the location (ECN-UNDP). It's a major factor or determinant for solar energy installation and varies from places to place. For instance, the Northern parts of Nigeria have more peak-sun hours because of the closeness of the region to the equator. In brief the peak-sun hour value for one part of building might be different from another depending on time of the day, season, weather and angle of inclination of the PV panel.

C. Application of Solar Energy Systems in Nigeria

For decades, solar energy has been constantly enjoying very high level of patronage due to its reliability, low cost and environmentally friendly in almost all areas of human existence. Solar energy do not required fuel of any kind for its operation and has low maintenance cost compared to several other energy source. It cannot be easily moved which help to prevent wear and tear and allow it last longer. PV panels are free from radiation, fume, noise or any environmental pollution. It requires limited space for its installation or can be mounted on existing structures such as roof-top pools. Its component can be recycled at the end of their useful life cycle. Due to its numerous advantages, usefulness and contribution to economy development, solar energy is applied several areas such as:

Agricultural Processing

A lot of effort has been made on solar energy application in Agriculture purposes including drying of agricultural products examples; it can be used to pump water for livestock and crops such as grains, cassava (tubers), yam flakes, fish, fruits, kernels. It can also be used for drying of manure, hides, skins, cooking and frying of agricultural products which cannot be preserved or sold raw. Solar water heater can provide hot water for cattle cleaning; other areas of solar energy utilizations include heating and lighting of animal pens, pumping of water and irrigation food storage among others.

Also, major percentage of agricultural produce spoilt when drying using traditional air method, using solar drying method can dry crops faster and offer protection from birds, insect and worm. Perishable crops are often difficult to dry and solar energy will enhance decrease on the percentage of spoilt crops and increase farmer's income.

Rural Electrification

Most citizens in Nigeria lack access to electricity considering the performance of national grids neither does they have access to alternative electricity like small scale solar energy system that can provide basic electricity to household, business, etcetera [15]. Solar energy has also found wide usage in places such as solar street lightings, solar refrigerators, solar cookers, solar-powered water pumps, and etcetera. It can be harnessed as mini grid to provide electricity to homes such example is the one set up by Schneider on behalf of the federal ministry of power, Works and Housing in Mpape, Abuja. Solar energy devices have been designed, built or adopted by research institutes and tertiary institutions across the country. Notable among the products in existence locally is the built 1000-litre capacity solar water heating system at the Usman Danfodiyo University Teaching Hospital, Sokoto in 1998 by the Sokoto Energy Research Centre (SERC), solar driers, solar chick brooders and solar absorption refrigerators developed at the National Centre for Energy Research and Development (NCERD), [16]. Others are scattered across the country by the government or any of its agency like the Energy Commission of Nigeria (ECN), Federal Ministry of Power (FMOP) and the Federal Ministry of Science and Technology (FMST), [17].

Engineering

Photovoltaic solar cells are becoming more popular in field of engineering. Gone at the days when they were only used in electronic calculators which needed no battery but today it is fast replacing other power sources such as in battery re-chargers, portable radios, emergency roadside telephones, and even homes [18]. Solar PV generators can power telecommunication stations; this has the potential for not only reduced road transport trips but fuel consumption in the transport sector, reduced carbon emission in our environment also improving the internal communication system. Another application in engineering includes heat pumps and solar furnaces.

Medical Sciences

In power generation, majority of the country's population dwells in the rural areas. Most of these people do not have access to electrical energy from the national grid. One of the most important amenities to be provided in rural areas is health care facilities. The most basic equipment to such a centre located in remote rural areas is the ability to meet requirements necessary for vaccines storage. Through research in solar technology has made available in the markets efficient and portable solar refrigerators that can be used for storage of medication, vaccine, samples, and etcetera. Solar powered refrigerators can also provide chilled and frozen storage for bulk meat, vegetable, and other products.

D. Problems Confronting Solar Energy Systems in Nigeria

To meet up with the energy demand by considering the population growth and socio-economic activities, the planned vision 2020 envisaged an increase in country power sector from 400MW that had been attained since 2007 to 35000MW [19][20]. The contribution target from renewable resources according to federal ministry of power (FMOP) for 2020 was 1000MW of capacity installed and expected mostly from large scale hydropower development. The rapidly growing demand for energy will create opportunities for solar energy development because conventional energy sources are inadequate to meet the need for ever increasing population and the expanding economic opportunities [21]. The rural area also required an aggressive deployment of renewable energy option, most especially solar energy system. This implies that prospect for solar energy demand and utilization is great in the near future if developed for domestic and industrial used.

There are various problems confronting the acquisition, installation and development of solar energy system in Nigeria, which need to be addressed if appreciable progress has to be made. Solar application in Nigeria is actually experiencing a lot of challenges despite the: (i) good solar radiation availability across the country (peak sun-hours), which can easily be useful in remote areas, (ii) inherent applications and motivations such as rapid reduction in solar energy component such as PV cells and (iii) market opportunities created by many individual dwellings with limited or no access to electricity. These include:

Energy Demand

In Nigeria less than 20% of 170 million populations are connected to the national electricity grid showing that very small number of urban population and of rural population of Nigeria have access to the National Electricity Grid [22][23]. Going by that submission, it is clear that solar energy installation and utilization in Nigeria is at very low supply. This implies that prospect for solar energy demand and utilization is great in the near future since conventional energy sources is inadequate to meet the needs of rapidly increasing population flexibly especially in rural locations. The cause of problems encountered by Power Holding Company of Nigeria (PHCN) resulting in her inability to supply the required electricity to the Nigerian Nation is due to low generation capacity, outdated equipment, and other similar factors inclusive. These make the future of alternative (solar) energy very bright. The installed capacity for electricity generation, 98% owned by the Federal Government, increased by a factor of 6 over the period 1968 to1991 and by 1991 the figure stood at 58816MW. No further addition to generating capacity was experienced over the subsequent decade.

Geographical Location

One of the greatest assets that Nigeria has that can facilitate solar energy generation in Nigeria is its geographical location in the Globe, that is, in the equatorial region which is full of large amount of solar radiation. This can be solved by integrating the most relevant and important aspect of solar energy regarding installation, professionals in the field must consider this factor to enhance efficiency in solar energy systems. For example before solar cells are installed in a building, they must be positioned where it can receive maximum solar radiation, building roof-top must be designed to withstand wind in any direction, and a regular workshop must be held before installation.

Technology of Equipment and Fabrication

At present, the technology, equipment and fabrication are not available in Nigeria. This means that virtually all the solar equipment in the Nigerian market that is of commercial value are imported from other countries of the world such as china, etcetera. Hence, this makes spare parts, repair, and sometimes maintenance of broken down solar equipment difficult. It also creates time, incurs more expenditure between breakdown period and repairs, and in some cases repair of equipment is never possible. In the case of inverter, which is at present is widely used in solar hybrid energy supply; whenever it breaks down, it is always referred back to the manufacturers' repair laboratory due to lack of those laboratory in Nigeria [24]. Most of the solar energy equipment available in Nigeria is imported product by non-expert or companies that know little about solar technology. The result of this is that equipment which are technically suitable to Nigerian nation due to the peak-sun-hours could not be distinguished or certified by them when importation is carried out and most time substandard material are also imported at cheaper rate to maximize profits.

Environmental Problems and Climate Change

Presently, the world is seeking alternative energy supply to replace the conventional energy sources like hydro, thermal, gas/diesel generating set that are known for causing global warming and other environmental problems. This environmental problem can be remedied by planting more trees and to some extent by turning to renewable energies sources as alternatives sources of power, especially solar energy [25][26].

Government Policies

In Nigeria there is no clear policy, investment, and task in the areas of renewable energy unlike other energy generating sources such as hydro, thermal, nuclear and others. The people in government who are to make policy and the common man on the street are very much unaware of the existing capacity of solar energy. Many people in these areas assume that solar energy can power only small bulbs and at most television set. The media such as radio station, television station also has not produced enough awareness on the positive effect of solar energy systems.

It is evident, therefore that, the challenges of solar energy though huge can be resolved within short time especially if government gives more attention to research, development, commercialization, negative perception and installation of solar equipment through incentive, introduce subsidy in imported solar

energy component and good policy evolution [27]

Lack of Awareness of Existence

Solar energy as a source of power supply is still very low in Nigeria. To many Nigerians on the street, solar PV application seems more of science fiction than what can be obtains in practice. The few that are aware of it effect assumed that it could only powered small home, streets lightning, and at most television set. The conception is not true, solar energy can power homes, companies, hospitals, markets, churches, communities and even state and etcetera like any other source of electricity. The citizen is not aware of the fact that solar PV can be connected in series and parallel to achieve the desired power output. Awareness can be made through radio stations, television channels, magazines, online information and schools. This will enable people to have better understanding of solar energy and its systems like solar array, inverter battery and other components used. It has also been observed that solar energy awareness is very low in Nigeria and at the process resist the chance of new technology [28]. Energy research centres in Nsuka, Sokoto, Lagos, Ilorin, Bauchi and Port Harcourt are the roots to awareness and skills development for solar and other renewable energies in Nigeria [29].

Building Compliance

Recently, most solar power generating capacity available in Nigeria is limited since most of the buildings in Nigeria are not designed for solar energy the few that are available occur by accident and not by design. Civil engineers should ensure building compliance in recent building so as to support solar energy installation. If there is no design available space around the building can complement the challenge of building compliance and fence round with nets to keep children aware from sudden dangers from the system such as electric shock, fire outbreaks.

Component Failure

In Nigeria, Component failure happens in almost all fully installed project operational device. Since the process of solar is a new development in this part of the country, users get turned off especially if it does not perform up to the years of guarantee which the equipment is rated. Equipment and component failure occurred mostly with such devices that do not come with manufacturer's address, date, poor sizing and designs [30]. Inexperience personnel during installation can cause component failure because a professional consider all the factors before setting up a project such as building design, component to used, cost of installation, peak-sun-hours, building compliance and others. Most users believed that a good number of the components are sub-standard especially the china made quality this prevents the adoption of solar energy system in general [31].

Cost of Generation

At a moment, comparing equipment and installation cost of solar energy with other energy supply sources is discouraging, solar energy is higher in the short run but it is however cheaper in the long run [32]. The result shows that the solar energy systems source is more expensive up to 4 years of installation and is mostly imported from other countries like china except the cables and few accessories can be obtained in Nigeria. Higher percentage of the population in Nigerian is low income earners and cannot afford the cost of installation of solar energy. While high income earners have access to other energy sources like petrol/diesel, generator set. Furthermore, it is not easily come by for an average individual to invest in solar energy project except a mortgage system impacts to raise a huge amount of capital like loan, free grant.

Research and Development:

In Nigeria, not much research and development has been carried out on solar energy and its associated devices in recent times [33][34]. Since the technology is new scientist taking steps to have sustainable energy free from pollution global warming, reliable and renewable source of energy because energy is the bed rock for growth, development and wellbeing of any economy. Solar energy devices are yet to become common household commodities in Nigeria. Their uses are only scantily seen in universities and research centres [35]. Hence availability in Nigerian market of made in Nigeria brand name solar energy components such as PV, battery, charge controller and other solar generating equipment and accessories is still not possible till date. This shows that Nigeria needs a lot researches in the area of solar energy development, deployment and device production to enhance economic and social development. Research centres should be built in all the Universities, Polytechnics so that realities about solar energy can easily be discovered.

Energy Wastage

Presently in Nigeria, there is unhealthy attitude of energy wastage by electricity consumers. For instance, it is very common with some households to install 500W halogen security light at the four corners of the premises. This is further complicated by the installations of numerous energy consuming inefficient equipment's inside the rooms of the same premises. Considering proper standalone solar energy installation, 500W solar power supply will be enough to power a domestic home when energy saving equipment such as the energy saving bulb is employed [36][37]. Wastages can also be minimized by not using welding machine and not more than one electric iron at a time. Most industries in Nigeria make use of electric motors, compressors and boilers which are huge energy consumers.

Theft and Vandalisation

Theft and Vandalisation is one of the principal problems facing solar energy utilization especially components that are expensive such as panels, inverters, batteries and others. Vandalisation is not prominent in Nigeria because of the level of awareness and utilization which is still very low; however few cases have been repotted [38][39].Unlike other African countries a practical way of preventing theft is by putting concrete cement on the frame of the solar panels when mounting or during installation. This prevents whosoever wants to vandalize the solar panel illegally to end up losing the solar panels completely. On the other hand, designing with a building give best result or installing solar energy close to your house may help prevent theft and making a save box for those components such as batteries, inverter.

Lack of Users Training

Most people in Nigeria are familiar with the used of petrol or diesel generator, kerosene lamp and even candle lighting and new to solar energy technology. It is necessary that user of solar energy system should be train on how to use the system especially on how to save energy using energy saving devices such as bulb, fan and others. It corrects errors that do occur in the application of the devices by users.

Poor Component Sizing

Why most solar energy project fails in Nigeria is due to lack of awareness on component sizing. Knowing the amount of energy needed, the required hours and what other device will tap from the source is very important. This information and details will help prevents such project from failing and also enhance proper functioning of the solar energy system all-round the year. It is advisable that sizing should be done when there is lesser availability of solar radiation.

III. SIMPLE SOLAR ENERGY SYSTEM SIZING

A Basic Component of Solar Energy System

There are multiple components that make up solar energy systems. Each type is chosen based on the unique advantages it can offer.

Photovoltaic panel

This is the component that generates electricity by converting sunlight into electric energy. It often connected in series and sealed from environmental degradation. It ranges in size from 5Wp to 300Wp and it must be in line with standard testing condition (flash test) irrespective of the manufacturer. Commercially available PV is the crystalline silicon produce using monocrystalline or polycrystalline silicon. Maximum power can be track using some intelligent methods [40][41][42].

Figure 3.1: Solar panel (PV modules)

Inverter

Most of our home appliances use an alternating current (AC) to operate. Direct Current is not too good for our appliances it can damage the electronic hence need to be converted. Therefore, an inverter converts DC from the PV panel to AC that is safer for electronic. They are classified into sine wave, modified sine wave and square wave inverter.

Figure 3.2: An Inverter. (www.inveter.com)

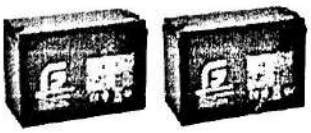
3.1.3 Batteries

Solar-powered systems work on the electricity produce in the day time depending on the peak-sun-hours daily, and the solar energy are stored in the battery to be used when there is no sunlight at night or on a very cloudy day when the peak-sun-hours is minimum. It is otherwise called energy serving bank and are of different types such as lead-acid, flooded and tubular batteries as shown in figure3.3.

Figure 3.3: Batteries (www.leadingedgepower.com)

Charge Controller

A charge controller otherwise known as circuit



breaker is a devise in solar energy systems that regulate the output voltage from the solar panels and prevent over-charging and overvoltage of the batteries. Therefore, they are used as safety measure to protect batteries from deep discharge and protect reverse current from the battery to the solar panel. A typical charge controller is shown in figure 3.4 below.

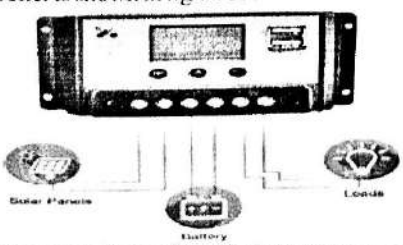


Figure 3.4: Charge Controller(www.amazon.com)

Interconnection Wires

They are used to link current from one point to another in the

systems. They are made of copper, leads, aluminum etcetera depending on the choice.

Figure 3.4: Charge Controller(www.juikaikacable.com)

Mounting Structures

These are made of metals, concrete, poles, ground, roofs, rails that help solar energy systems to withstand wind, erosion, theft, and vandalism that will make it last longer. They are mounted in four different ways such as roof (it provide a better access to sunlight, save space, causing leakage in the roof is a major disadvantage), ground (suitable for all types of PV, easily installed), and top-of-pole (such as in street light, traffic lighting and building integrated). Figure1.4 shows the mounting structure

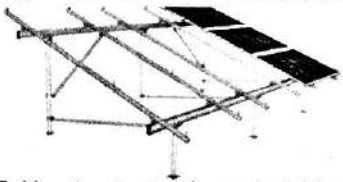


Figure 3.7: Mounting structure (www.solarbuildermag.com)

B. Case Study of Simply Solar Energy Systems

Example One

Table: 3.2 Energy consumption table

S/N	Appliances	Qty	Unit Watt	Total Watt	Hrs	Total Watt (hrs)
1.	Laptop	3	60	180	5	900
2.	Standing Fan	3	55	165	4	825
3.	Printer	1	400	400	2	800
4.	Water dispenser	1	300	300	3	900
5.	Lighting Point	4	26	104	8	832
6.	Miscellaneous	102	500	500	3	1500
	Total			1,649		5,757

Inverter Sizing

1,649x1.25, with 25% Power Loss

Power factor = 0.65 = (2,061.25/0.65) = 3, 171.15kw, therefore, the inverter size is approximately 3,200kw

Panel Sizing

Note: PSH = 5hrsand Total Watt Hour = 5,757x1.25 = 7, 196.25

Panel Capacity = (7,196.25 / 5) = 1, 439.25, approximately 1.4kw

Battery Sizing

1. Calculate total Watt-Hour (WH) of appliance
2. Divide Watt-Hour (WH) by 0.85 (Pf)
3. Divide the answer by 0.5 for depth of discharge (DOD)
4. Divide the answer by normal battery voltage
5. Multiply the answer with Days of Autonomy.

Battery Capacity (Ah) = (Total Wh per day used by appliances x DOA) / (0.85 x 0.5 x normal voltage) = (5757 x 3) / (0.85 x 0.5 x 24) = 17271 / 10.2 = 1,693.24Ah

For DOA = 1

Battery Capacity = 564.4Ah

C. Protective Measure

Safety is very important in any solar energy system installation because poor protective measures can cause disaster or even dead [43]. Solar energy systems during operation are liable to electric shock, burns, and damages of component, etcetera. Therefore precautionary measures must be taken. Such precautionary measures include: using hand gloves, boots, first aid kits, fire extinguisher, and eye protection especially when working with lead-acid batteries. Falling on slippery floor could also cause injuries hence should be avoided for safety. It has been observed that most injuries occur as a result of lack of concentration, unsafe tools (ladder), unsafe working environment and procedures.

D. Simple Diagram of Solar Energy Systems (Off-Grid)

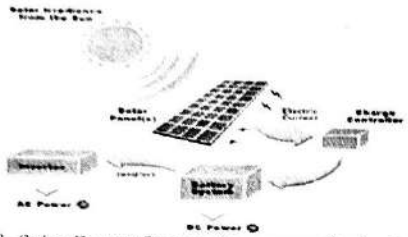


Figure 3.8: Solar Energy Systems (www.neosoltechnologies.com)

V Conclusion

This work presents a review of recent developments on solar energy systems in Nigeria. Secondary method of data collection which includes sourcing of information from books, journals, magazines was adopted. The research work reveals that energy is the key to national development hence its challenges can hampered the entire growth of our economy, be it agricultural, health, educational, social, or other sectors. As a matter of facts, the challenges confronting the acquisition, installation and development of solar energy system in Nigeria can lead to project failures, waste of money, time, cause hardship and waste of other resources. As part of a way forward, It is also worthy of note that, if awareness is created, proper system sizing is done, regular routine check with an adequate security measures is taken, good and proper monitoring of the project work from planning to initiation, organization, financing and execution are ensured then, Nigeria can used solar energy as alternatives to compliment and achieve its quest for energy sufficiency and safe environment. More so, this research work also made it clear that, since solar energy project at a moment is capital intensive, the governments giving support through loan, incentive, subsidies for solar energy project could also improve the situations.

VI. Recommendation

Despite the slow start for solar energy development in Nigeria, there are needs to be optimistic about it potentials. Based on the findings from this research the following recommendations are hereby presented.

- ü Proper planning of the entire projects from the planning to execution state is important.
- ü Sizing of solar components of the load survey is vital for installation and long-life span of the solar energy system.
- ü Materials used should be taking into consideration, substandard materials should not be an opportunity to save cost or minimize cost to make more profit.
- ü Continuous emphasis on awareness on solar energy system is important as the entire citizen will embrace it thereby solving the likely occurrence of vandalisation.
- ü Apart from public awareness, general training should be introduced to the entire region in Nigeria especially in the universities, colleges and polytechnics and agencies.
- ü The government should see routine maintenance to capable firms and engineers as a mandatory practice.
- ü A regulatory body is required in Regional, National and International that will focus on the improvement of solar energy technology and its systems.

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