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Review Article

Solar Energy in Nigeria: An Overview of Prospects and Challenges

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ABSTRACT

In the last few decades, solar energy has gained extra attention as a renewable and clean energy source. The photovoltaic (PV) cells are made to convert solar energy from the sunlight directly to electrical energy. This energy can be utilised in many different applications, like heating lighting, and many more. Over the years, solar photovoltaic power cells have managed to be the main component of harvesting solar power since they are not only sustainable but also harmless and free of pollution. Many of the costs of a solar power plant are relational to the area of the plant. A higher efficiency cell may reduce area and plant cost, even if the cells themselves are more costly. In any case, some photovoltaic projects implemented in different parts of the country cannot meet the average lifespan due to several factors. In this investigation, literature assessment of several works was carried out. Economic and government policy as well as security challenges were observed to the major factors bedevilling the industry. Technology improvement and management are vital ingredients for the sector to achieve desired outcomes.

1. INTRODUCTION

The sun is a major source of unlimited free energy globally and presently, new technologies are being engaged to produce electricity from harvested solar energy. The approaches have been established and are widely practiced throughout the world as renewable alternatives to conventional non-hydro technologies (Kabir et al., 2018). According to Chiechi (2013), solar energy is the most promising of the renewable energy sources because of its seeming boundless potential. More than a half of Nigerian communities are rural

inhabitants and are adapted to subsistence living. Therefore, the energy method deployed to them must be such that can be adapted for most of the Nigerian populace.

The primary working principle of a PV device is the transformation of solar irradiation into electricity. Although, there are numerous applications of this principle, most solar PV developments are intended for street light, water pumping and general stand-alone/mini-grid power supply (Sambo et al., 2014). Unfortunately, solar PV schemes installed in many parts of Nigeria fail to meet the minimum life-span due to several restrictive factors such as poor or inappropriateness of essential design, use of sub-standard components, and use of poor installation technique by inexperienced staff and bad construction or civil works (Kabir et al., 2018). Many started to feel averse to solar PV projects as the weighty investments in such projects do not seem to be proportionate with the performances and satisfactions derivable (Sambo, et al., 2014).

Photovoltaic cells, also called solar cells, are electronic device that converts natural light into energy. Perhaps the leading solar cell is an image that many people recognize: they are on the panels installed in homes and add machines. It was invented in 1954 in the Bell Phone Labs in the USA. Photovoltaic cells are one of the fastest-growing and most advanced sustainable energy sources and ready to do a great job later in a mix of the energy age around the world (Sambo, et al., 2014; Kabir et al., 2018). Solar photovoltaic systems can be integrated into corporate power-saving projects or divided into smaller micro-networks or individual use projects. The use of photovoltaic solar energy in small matrix arrays is a great way to give people who are not connected to the national grid access to energy, especially in developing countries with a large solar vitality (Jijingi, et al., 2016).

The cost of manufacturing solar modules has dropped dramatically over the past decade, making them both affordable and the most cost-effective types of energy. The average age of solar panels is 30 years (Mas'ud, et al., 2015). Depending on the type of materials used in the manufacture, different colours are available. Concentrated solar power or energy (CSP) focuses on sunlight using mirrors. The CSP usually contains a series of mirrors that deviate from the rays to a high and long peak. Solar PV panel manufacturing in Nigeria is experiencing a lot of challenges in the face of the excellent availability of solar radiation across the country. Thus, operation and maintenance problem, poor government policy and inactive quality control are some of the concerns facing the sector. As a result of this, the existence of manufacturing may be an important factor in encouraging innovation and industrialization.

This is also part of discuss about the challenges of manufacturing solar panel in Nigeria. Therefore, an overview of solar energy development and solar manufacturing in Nigeria was discussed and to see the barriers and possible way to local manufacturing to confront PV industry challenges in the country which virtually can be overcome when all hands are on desk. The advantage of implementing solar PV panel using a local resource improves economic and industrial growth, therefore something must be done to correct these challenges in order to improve PV project development.

A complete description of the local economic value created from each part of the PV supply requires further study, e.g., short of domestic manufacturing, support for the public financing of innovation possibly will become challenging, given the lack of apparent benefit. Likewise, the presence of manufacturing may be a critical factor in supporting innovation. Most of the solar PV panel manufacturing industries are not domiciled in Nigeria, virtually 85% of manufacturing operations in a different country that is just a spot assembling in Nigeria rather than manufacturing. However, in the last decade there are significant improvements in terms investments in the sector.

2. ENERGY SITUATION IN NIGERIA

2.1. Energy Problems in Nigeria

Nigerian energy needs are growing, and population growth is not fully reflected in the energy promotion program (Platzer 2012). The current city-level energy savings agreements are rewarding, as the cases of local

and sub-local energy supply and demand have not yet reached the inner phase of the national approach to improving energy efficiency (John and Wara, 2018). People in the geopolitical zones depend on the consumption of energy from wood and traditional biomass, which leads to extreme deforestation, ozone-depleting substances, and pollutants, and causes global temperature fluctuations and other environmental problems (Ikyo et al., 2019). The main task is to provide energy to urban and other industrialized areas, resulting in uneven energy supply in the socio-economic and political context of the country. The contrast between all available power plants and the current and growing population shows that Nigeria cannot meet the energy needs of the entire population, the residents and industries (Felix et al., 2018).

The second element of the Nigerian energy crisis is the indicator of blackouts. This retrogression has taken place despite Nigeria's great energy potential. State-owned power energy company, formerly known as national electricity power authority (NEPA), is a facility that provides the most satisfactory universal principles of energy management with stable quality, openness, and availability for up to 30 years (Edomah, 2019). The idea of such a poor recording of the power supply is evident in the transmission model and catastrophic mapping shown in Table 2 (appendix). The misery is five or more times higher than a well-functioning energy frame. The unusual condition of the accident and the serious unauthorized access to the open energy supply indicate a business emergency (Diouf and Avis, 2019). The Figure 1 shows an electricity crisis in Nigeria from 1970 to 2004.

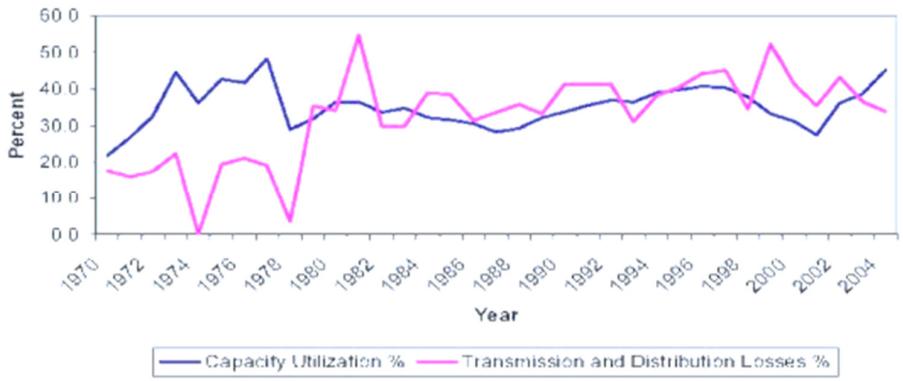

Figure 1: Indicators of the electricity crisis in Nigeria from 1970 to 2004 (Cota and Kumar, 2015)

There was a tremendous increase of major power outages at major installation companies between 2004 to 2005 of about 26%, leading to a dangerous increase of 43% between 2006 and 2007 (Cota and Kumar, 2015). The legitimacy of the number of trips in 2008 is very high. This inadequate management transfer provides an open source for the same number of customers who cannot afford the expense of sporadically poorly managed management, and gradually limits the negative impact on power generation disruption on productivity and replaces expensive supplier selection (Adeniyi et al., 2016; Xiao, 2018). Figure 2 depict the Projected electricity demands between 2005 to 2030. Whereas Figure 3 Graph showing the projected electricity demand between 2005 and 2030. Electricity is the most accepted and attractive type of dynamism worldwide. Table 1 shows the commercial primary energy consumption by type of the total. It is a prerequisite for national development, economic progress and a decent lifestyle. As people and the economy grow, so does the interest in electrical energy. If this interest is insufficient, there is no suggestion. This deficit can be based on emergencies and affect the achievement of sustainable energy progress. The demand for Nigeria's projected performance limit was around 3.5 times between 2010 and 2020 and 7.5 times between 2010 and 2020 (Adeniyi et al., 2016).

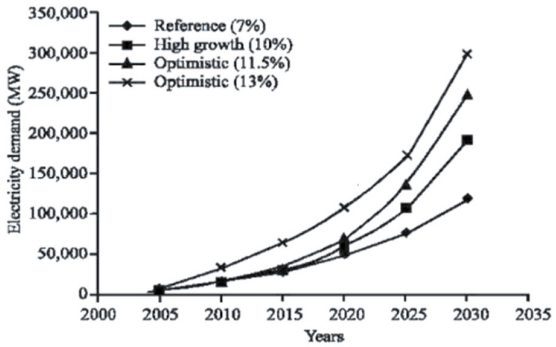

Figure 2: Projected electricity demands between 2005 to 2030 (Akorede et al., 2017)

Table 1: Commercial primary energy consumption by type average percentage of the total (Akorede et al., 2017)

Type	Consumption per year (%)						
	2002	2003	2004	2005	2006	2007	Average
Coal	0.03	0.03	0.03	0.03	0.05	0.05	0.04
Hydro	11.93	14.20	17.39	12.04	17.03	23.90	16.08
Natural gas	2.84	1.90	4.54	5.50	7.52	8.73	5.17
Petroleum products	85.20	83.87	78.04	82.45	75.44	67.32	78.71

2.2. Energy Policy in Nigeria

The Nigeria energy policy document came to effect in 2003 to assist as a road map to develop a national energy future. Additionally, based on the policy report, the renewable energy master plan (REMP) was established in 2005 by the combined efforts and determination of Energy Commission of Nigeria and United Nations Development Programme (ECN–UNDP), 2005). Working through the several policy reports on renewable energy (RE) development and consumption, there are specific problems which may be addressed to accelerate and further the development and also the development of renewable energy in Nigeria, but there are many policy challenges these policy issues when appropriately implemented could attract and draw investors into the country. Some of the hindrances to the policy implementation include the following:

- lack of economic inducements
- weak government motivation
- non-existent favourable customs
- frequent taxations and excise duty liability act to promote renewable energy technologies

Therefore, some of the laws that require an amendment to encourage renewable energy include the decree of environmental impact valuation, land use act, and the asset or investment laws of the Federation of Nigeria (Mills and Lee, 2002; Ozoegwu et al., 2017).

3. SOLAR ENERGY IN NIGERIA

3.1. Solar Energy Potential in Nigeria

Nigeria has excellent and sustainable potential for large scale solar photovoltaic (PV), particularly in the semi-arid region through the high solar radiation incident on the horizontal surface. According to Yohanna and Umogbai (2010), the solar radiation distribution in Nigeria from the map in is categorized into three different zones which is explained as I, II, III with each zone having different radiation levels that may be needed for a particular project selection (Figure 3).

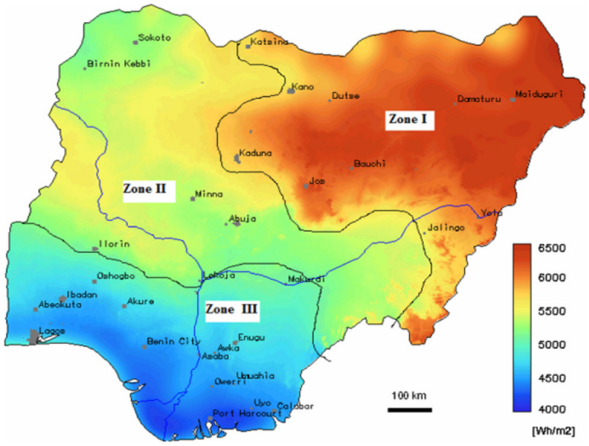

Figure 3: Map of solar radiation in Nigeria (Yohanna and Umogbai, 2010)

The zone I comprise of all the state in the North-east and part of the northwest geo-political zone with the highest solar radiation incident on the horizontal surface. Zone II consist of Northwest and central also have sustainable solar radiation that may be required for the most solar project, while the low potential of annual global solar radiation exist in zone III comprising all locations in southern regions can readily support decentralized solar energy projects.

3.2. Challenges of Developing Solar Energy in Nigeria

Some of the factors that are militating against the growth of the solar technology in Nigeria include:

- Absences or poor general National policy: every country needs organisation effective running policy to promote engagement; there was almost no comprehensive policy in Nigeria till of recent. Only sub-sectorial policies involving energy exist (Dias *et al.,* 2016).
- Technical incapacity: there is a large gap in technological skill in respect to the process of solar energy connection and its development in Nigeria; most modules have to be imported which further drives the investment cost higher.
- Financial restraint: a necessary barricade to the development of solar energy technology in Nigeria as emerging country lies in original high costs and long settlement times. Therefore when there is financial pressure it could create serious problem to the entire sector.
- Level of public awareness: The level of awareness or public understanding about the vast socio-economic and environmental benefits derivable from solar energy is actually near to the ground in Nigeria or virtually at the zero level.

3.3. Solar Panel Manufacturing Technology

According to Platzer (2012), the technology to produce solar panels in common use today is the crystalline silicon photovoltaic identified to account for about 80% to 85% global PV production capacity. The production of a crystalline silicon system involves several stages. The first stage is the polysilicon manufacturing. Polycrystalline silicon based on sand is the material used to make the semiconductors which converts sunlight into electricity. This is followed by wafer manufacturing which unutilized traditional semiconductor manufacturing equipment, wafer manufacturers, shape polysilicon into slabs and then slices the slabs into thin wafers which are then cut, cleaned, and coated according to the specifications of the system manufacturers. Solar cells shown in Figure 4 are the fundamental structure of PV system and are made by cutting wafers into sizes normally not exceeding 5x5 or 6x6 inches and round, square, or long and narrow in shapes. Copper leads are linked so the cell could be connected to other cells and but minimizes the area

covered by these leads is a key issue in cell design. Because, the lead blocks the sunshine from getting to some parts of the cell surface, therefore decreasing potential energy output (Platzer, 2012).

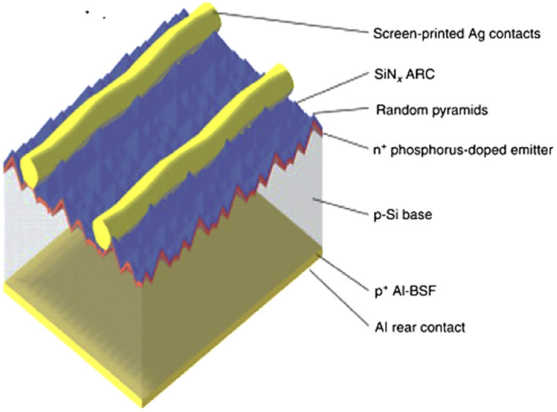

Figure 4: A classical structure of aluminium back surface field solar cell (Sharma 2015)

The last stage of the process is the module manufacturing which is created by mounting 60 to 72 cells on a plastic backing within a frame, usually made of aluminium. The module is covered by solar glass to protect against the elements and to maximize the effectiveness with which the component modifies sunlight to power. Production of solar glass is highly capital-intensive and around 60% of the international market is monopolized by four manufacturers (Platzer, 2015). Figure 5 shows the contact and interconnection cell made of ribbon and solder which connects cells to increase voltage and power output productivity (Lior, 2008; Ogbomo et al., 2017).

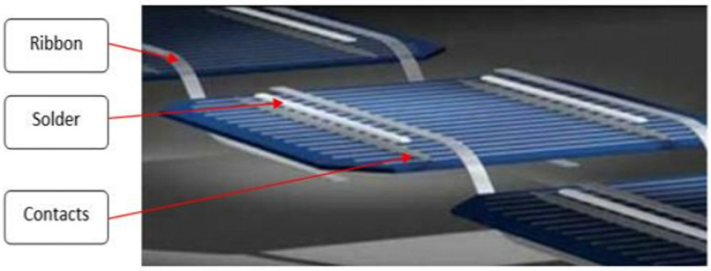

Figure 5: Contact and interconnection cell (Ogbomo et al., 2017)

3.4. Challenges Associated with the use of Solar Systems

The application of solar technology just like any other technology is associated with certain advantages and disadvantages. Researchers have argued that there are inevitable problems that accompanied the advent of this desirable technology (Mekhilef et al., 2012). Dias *et al.* (2016) reported that the lifetime of solar panels is short and will finally be swapped with new ones for efficient performance. Consequently, huge quantities of solar modules will be abandoned as waste electronics in the future. The same authors argued that recycling of the solar panels may be necessary in order to recover vital raw materials and thus decreasing the cost of production and adverse environmental effects. Wang (2019) warned that stakeholders should not be carried away by the fact that there is no pollution during generation of electricity. The life cycle of solar panel will increase the emissions of greenhouse gases. This life-cycle continues all the way from generation to dumping or recycling of the solar panels, including manufacturing, materials conveyance, setting up and dismantlement (John and Wara, 2018). It further reported that challenges associated with solar panel include the use of harmful heavy metals such as Cd, Cr are harmful to the human body and contribute to the drinking water contamination and land use problem (Wang 2019).

4. CONCLUSION

The investigation on a case-study involving solar panel manufacturing companies in Nigeria were conducted. The literature assessments of several works were carried out to assess this sector of economy. It was revealed that production have occurred in these industries at various level of different geopolitical zones, but it was observed that products were either be imported in parts or assembled locally or are imported fully assembled in some cases. Findings also revealed that the technology in use by both manufacturers needs to be updated to provide competitive prices bearing in mind the economic reality and demand. The marketing challenges faced by significant numbers of industries are majorly due to the government policies and security challenges. These findings can significantly enhance the literary body of knowledge and will set a path for further studies in a view to finding a lasting solution to the nation current energy predicament.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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