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### **ABSTRACT**

*Every nation requires ceaseless, reasonable, environmentally friendly and clean energy as a prerequisite for economic growth and sustainable development. Photovoltaic solar energy is a renewable energy source that offers the necessary prerequisite applicable to commerce, industries, health, education, social, household, and agricultural segments of the nation's economy. Almost 70% of the nation's populace is without access to electricity. To achieve sustainable development, the government needs to improve energy access to its citizens by embracing and diversifying the modern energy source and generation techniques, such as photovoltaic solar energy, which can lead to a significant cost-saving reduction in energy waste and bills. Thus, this paper reviews the literature on Photovoltaic solar Energy and sustainable development in Nigeria. It highlights some of the benefits of applying photovoltaic solar energy for sustainable development, such as access to a free energy source, job creation, improved agricultural production and others. It also recommends the provision of proper and adequate solar initiative research, public awareness of the needs and advantages of photovoltaic solar energy, provision of standard grid set-up, and easy access to funds allocated to solar and other energy-related research as few feasible means of achieving sustainable development through photovoltaic solar Energy in Nigeria.*

**Keywords:** Photovoltaic (PV), Solar, Energy, Sustainable, Development, Renewable Energy.

### **INTRODUCTION**

For every nation's economic growth and sustainable development, ceaseless and affordable energy is vital; it contributes in diverse ways to a nation's Gross National Development (GNP) (Taiwo, 2022). Energy is required in industries for raw materials processing, preservation and irrigation in agriculture, to power vehicles, planes, trains and others in transportation; and for refrigeration, cooking, lighting, community/social services, productive activities (advertising/billboards), and heating in various households (Vincent, 2021). Photovoltaic solar energy is one of the vital, available and standard sources of renewable energy apart from wind, biogas, hydropower, and biomass, whose adaptation and application will not only aid the country in achieving sustainable development but also in the realization of an environmentally friendly society (Yusuf & Emodi, 2021).



In Nigeria, an average of about 6 hours per day of daily sunshine is estimated, and it ranges between 3.5 to 6.5 kWh/m<sup>2</sup> with a total solar photovoltaic potential of 1% area of certain states as 1,189,321.65MWh (Shehu, 2022). This is worth 26 times the overall country's fossil fuel annual resources and above 117,000 times the generated electric power; hence only about 4% of the nation's landed area is needed to accumulate the required solar energy equivalent to the nation's conventional energy reserve (Shaaban, 2021). The need for sustainable development has recently been the hunt for most developing nations because it aids significantly in improving the standard of living, sustainable economic growth and development, but only realizable when it corresponds to the nation's per capita energy consumption (Sambo, 2020). Hence, photovoltaic solar energy has been realized as a promising sustainable energy worthy of handling the energy requirements significant for improving the standard of living, efficient solution for electric power hitches and outages, sustainable economic growth and development, as well as sustainable development of Nigeria (Taiwo, 2021).

Being a country with a larger economy, the need and demand for electrical energy is very high. Regular power demand daily is projected at about 17,520 MW, but only 5,300 MW peak generation is delivered, which corresponds to 144.52 KWh per capita or even as low as 123KWh (Oyedepo, 2021). The need for electrical power is projected to grow very high in the next few years coming, as by 2025, a demand of 77,450 MW is estimated, and about 119,200 MW is projected by 2030; thus, a forecast of about 52% energy demand increased within the period (Oseni, 2021).

### **Conceptual Definitions**

- Photovoltaic – similarly referred to as PV, are free electrons from solar energy in a semiconductor field induced in an electrical circuit to power a national grid or electrical equipment (Okafor, 2021). It involves the direct transformation of electromagnetic radiation from sunlight to electrical energy. It is linked to using generated voltage from two contrary materials (two different semiconductors) exhibiting a photovoltaic effect due to radiant energy (Odukwe, 2020).
- Solar energy: is typically referred to as the radiation derived from the sun, which creates enough heat that causes chemical reactions which produce electrical energy, which can, in turn, be employed in photovoltaic, synthetic photosynthesis, thermal energy, solar heating and architecture, and salt power stations (Akinbami, 2021). It is energy produced through nuclear fusion within the sun's axis and explores the Earth at an average speed of 186,000 mph (miles/second) (Muhammad, 2022).
- Sustainable development: It is referred to as an advancement that aims at fulfilling the prerequisites of the populace without conceding the capability of impending generations to fulfilling their demands (Oyedepo, 2022). The prerequisite involves living in a free friendly planet or environment, having access to a reasonable, efficient education and health care schemes, living in comfort with basic amenities in various households, and feeding

nutritiously, among others (Boo et al., 2021). In meeting these prerequisites, access to and availability of sustainable energy is paramount and is worthy of the advancement of the industrial and socioeconomic development of a country (Oyedepo, 2020).

- **Renewable Energy:** This unpolluted energy is obtained from natural processes or sources, such as solar, wind, water power, tidal energy, wave and geothermal Energy (Igwiwo & Chinelu, 2022). Renewable energy plays a vital role in achieving sufficient energy in developing nations, and it also aids in reducing gases emission that generates the greenhouse effect obtained in energy consumption or generation (Atiku & Yahaya, 2021).

### **PV Solar Energy in Nigeria**

Photovoltaic solar energy is deemed significant and more appropriate in the development of the energy sector of the country in that solar radiation is so abundant and affordable (Sambo, 2020). This makes it more optional than other sources of renewable energy. About 7.0KWh/m<sup>2</sup> daily (25.2MJ/m<sup>2</sup> daily) of solar radiation is received in the far northern region of the country, and also an average of 3.5KWh/m<sup>2</sup> daily (12.6MJ/m<sup>2</sup> daily) in the coastal region (Shaaban, 2021). Periodic occurrences of system downtime or national grid collapse could be forestalled if solar radiation opportunities have been taken advantage of (Vincent, 2021).

Nigeria's first solar power plant was inaugurated in 2016 in Ibadan by President Muhammadu Buhari, and almost about \$20 million had been invested by the government in several solar projects across the nation as of December 2017 alone (Taiwo, 2022). It was also in its effort to actualize stable energy for the nation that by 30<sup>th</sup> January 2023, the president commissioned the 10MW Challawa Industrial Estate (kano) solar power plant grid, the largest in the country (Muhammad, 2022). Similarly, Nigeria's renewable energy master plan has tended to upsurge renewable energy supply from 14% of overall electricity generation in 2015 to 24% in 2025 and 38% by 2030; this will amount to about 10% of the country's overall electric energy consumption (Shehu, 2022).

Recent studies have indicated the country's CSP (concentrated solar power) potential at about 427 0000 Mega Watts (MW); hence, the country seeks to have over 30% of its electric energy supply from solar and other renewables by 2030.

### **Advantages of Photovoltaic Solar Energy**

The advantages and benefits of photovoltaic solar energy, as highlighted by Oyedepo (2022), include the following:

- Sustainable, available and inexhaustible
- Pollution free
- Reasonably accessible
- Continuously and cheaply reaped
- Improve agricultural production

- Create employment
- Favour system transference
- Independent of the national grid
- Provides indefinite, sustainable and reliable energy supply
- Offers economic remunerations to minor remote populaces
- Reduces greenhouse gas emissions, hence minimizing global warming

Studies have also indicated that all small-scale and medium enterprises in Nigeria that incorporate photovoltaic solar energy as their source of power in their business activities have noticed an increase of about 25 to 45% in their operating hours; and also a reduction in fire and other related accidents due to utmost usage of electrical generators (Akinbami, 2021).

### **Photovoltaic Solar Energy Applications**

Photovoltaic solar energy applies to residential and industrial applications, thus aiding commercial activities, life enhancement, and sustainable development (Okafor, 2021). Taiwo (2022) indicates some practical applications of photovoltaic solar energy, among others, include:

- ✓ Lighting
- ✓ Drying of manure
- ✓ Production of poultry
- ✓ Cooking
- ✓ Pumping of water
- ✓ Refrigeration of diary
- ✓ Production of fish
- ✓ Incubation of eggs
- ✓ Charging of phones, tablets, and laptops
- ✓ Crops drying, and
- ✓ Preservation of vaccines

### **Photovoltaic Solar Energy for Sustainable Development**

Studies and research have indicated that photovoltaic solar energy services are vital for sustainable development because energy is essential in all nations' sustainable development and economic drives (Yusuf & Emodi, 2021). Energy services delivery in a sustainable mode which is delivered to people in a manner and technique adequate to deliver reasonable, basic needs, not harmful to the environs and also suitable to individuals and societies currently and in the future, is referred to as sustainable energy; hence a factor of production and in sustainable economic growth and development (Taiwo, 2021).

It was also observed that fast-developing economies are those that substituted animal and human labor with proficient sources of technology and energy, which supports the environmental, social and economic pillars of sustainable development upon which photovoltaic solar energy is

deemed applicable (Boo et al., 2021). Recently, adequate access to and provision of energy is essential for any country to materially advanced, alleviate and reduce poverty (Odejobi et al., 2022).

Photovoltaic solar energy can serve as an essential factor in boosting the growth of a nation's economy because of its efficiency, consistency and reliability, and this promotes the attraction of foreign investors to a nation (Odukwe, 2020). Okafor (2021) highlighted that manufacturing/processing companies and other allied marketers, whose contribution to the nation's economy promotes sustainable development, have indicated that voltage fluctuations and power breakdowns hinder their economic activities and hence slackening down effort in their quota influences towards sustainable development.

Photovoltaic solar energy is an excellent example of sustainability. It generates an enthusiastic influence on the environment when adopted other than other energy sources, which negatively affect the environment (Oseni, 2021). When citing examples of sustainable development such as efficient water fixtures, crop rotation, wind energy, sustainable forest, green space, and sustainable construction, the ensuing one is photovoltaic solar Energy (Oyedepo, 2021). This signifies that it is a sustainable resource in aiding environmental, social, economic, and human sustainability, which are termed the four pillars of sustainability in the global features of sustainable development of nations (Sambo, 2020).

Photovoltaic solar energy plays a fundamental part in the efforts to attain sustainable development, by harmonizing environmental safety and social and economic growth and by promoting industrial advancements, through communications and transport, thus making international trades and fairs accessible (Yusuf & Emodi, 2021).

Shortage and fluctuations in electric power services to the significant sector of the Nigerian populace, institutions, organizations and industries have been viewed by Vincent (2021) as a factual task to the nation and is termed as negligence on the part of the government, and can thus deprive this country and any nation the virtues and pluses of economic and sustainable development. This research and studies have proven and shown that photovoltaic solar energy resources and technology are vital factors for accomplishing the sustainable development of any nation (Muhammad, 2022).

### **Challenges Facing Utilization of Solar PV in Nigeria**

Even though photovoltaic solar energy holds a promising future in the energy sector, specific challenges must be addressed. As described in his write-up, Taiwo (2022) states that some challenges facing the utilization of photovoltaic solar energy include the following:

- Political instability
- Lack of technological know-how
- Lack of awareness
- Inadequate solar initiative research, and
- Short term policies



Other examples of the challenges, as addressed by Shehu (2022), to be among the foremost obstacles that made the application of solar inventiveness almost awkward in the country include:

- ✓ The insight of photovoltaic solar energy as an expensive investment
- ✓ Insufficient grid setup
- ✓ Limited access to funding, and
- ✓ Regulatory impediments

## **CONCLUSION**

Energy prominence in sustainable development achievement is very vital. It cannot be over-accentuated, as its availability has been identified as a significant factor contributing to a nation's sustainable and socioeconomic development. It is also closely related to climate change, public health and security, which ensure a nation's long-term economic advancement. Thus, photovoltaic solar energy has been established and identified as more naturally sustainable and a form of renewable energy that can provide the needed energy demand for sustainable development. It is eco-friendly, affordable, accessible, and can provide an everlasting and uninterrupted power supply.

## **RECOMMENDATIONS**

Below are a few recommendations deemed worthy of achieving sustainable development through the application of photovoltaic solar energy in the country:

- Public awareness of the needs and advantages of photovoltaic solar energy.
- Government should provide a standard grid setup.
- Easy access to funds allocated to solar and other renewable energy-related research.
- Ensuring efficient policies and political stability.
- Provision of proper and adequate avenues for solar initiative research in tertiary institutions.

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