International Journal of Information, Engineering & Technology

Volume 11, Issue 2, PP 84-90, ISSN: 2360-9194, December, 2020
Double Blind Peer Reviewed International Research Journal
garcjournalssubmit@gmail.com
Journal Series: Global Academic Research Consortium (garc)

Reforms in the Nigeria Energy Sector with Solar Energy in Focus

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Abstract: *Nigeria having biggest growing economy among African countries, the sustainable and balanced growth is focused considering environmental and socio economic factors. This can be meet by development of renewable technologies and the initiatives by government. In this proposal, the potential of electricity supply through solar energy are presented considering its technical feasibility with available resources and integrating in to present energy infrastructure. Environmental impact and economic factors were also highlighted with the initiative by government for development of this technologies and also suitable policies for balance growth,*

Key words: *Energy, Solar, Reforms, & Renewable.*

INTRODUCTION

Generations of energy through renewable energy sources are the present focused for the world energy requirement. The energy demand is the key element for the socio economic development and nation's economic growth, which is very important for fastest growing country like Nigeria. The conventional resources of energy are diminishing with the increasing demand hence, increase its cost Mustapha (2019). The problems with environment unbalance due to emission of greenhouse gases with the use of conventional energy sources are the real challenge. Development of renewable energy can help in minimising the environmental impacts by lowering carbon emission, and energy security and balanced regional development.

Nigeria is the biggest economy in sub-Saharan Africa, however the country's growth is constrain as a result of the poor power sector. Nigeria is rich in oil, gas, hydro and solar resource that is capable of generating 12,522 megawatts (MW) however only 4,000 MW, is generated which is inadequate for maximum energy demand of the country (Tallapragada & Adebusuyi, 2008). The Nigerian government has taken steps to try and address the challenges faces across the power generation value chain. They include the introduction of a power regulatory body the Nigerian Electricity Regulatory Commission (NERC) in 2005 - the unbundling of power assets and the implementation of the National Integrated Power Project (NIPP) formed to address issues of insufficient electricity generation. In 2018, Meter Assets Provider (MAP) was introduced by NERC to encourage the development of independent and competitive meter services and eliminate estimated billing practices. Finally, the Electricity Theft and Prohibition Bill was submitted to the

Senate committee in an effort to tackle the 35% energy losses due to theft and sabotage. This report reviews the performance of the power sector since 2018 and maintains that power must be realistically priced in order to attract the investments required to provide electricity to parts of the nation without power. With about 60% of the country's population without access to electricity supply, the enforcement of a cost-reflective tariff system could offer an opportunity to reach more customers and provide a more sustainable solution to the distribution problems currently affecting the industry. In addition, policies that promote the adoption of alternative sources of power must be properly implemented so as to meet the rising electricity demand (Adebowale *et al*, 2017).

Table.7 Nigeria's energy mix

Energy ource	Percent of generation
Fossil	81.72
Wind	0.01
Solar	0.08
Hydro	18.19
Nuclear	0
Geothermal	0

Source: Global petrolprice.com

ROLE OF RENEWABLEENERGY SOURCES

The persistent depletion of fossil fuel sources and the quest to combat greenhouse emissions and its environmental impact has led to exploration of other renewable energy sources (Mekontso *et al*., 2019). In 2018, transition to renewable energy in the power sector, a significant impact was achieved on Carbon Dioxide (CO_2) emission, by evading 215 Mt of emissions (International Energy Agency, 2018). This success story from renewable was driven by China and Europe, together contributing 66% to the worldwide aggregate. Without this change to low-carbon energy sources in 2018, emission could have hit 50% higher. Power generation from sustainable sources expanded 7% in 2018, infusing an extra 450 TWh into worldwide power systems (International Energy Agency, 2018) . The power sector has seen significant transition lately regardless of growth in emissions. Today it is estimated that electricity generation contribute 475g CO_2/kWh, a 10% enhancement in reduction from the 2010 intensity records. Without this, worldwide CO_2 emissions would have been 1.5 Gt higher, or 11% of current power sector emissions. This success over the year has been achieved as a result of huge investment in Photovoltaic (PV) plant, Wind, Bioenergy, Geothermal, and other renewables sources. Residential households including commercial building consumes about 40% of world's total energy contributing one-third of the greenhouse emissions globally(Isa *et al*., 2018).

The irradiance level and duration of sunshine in most West African countries makes harnessing of solar as the main source of her future energy.

In Nigeria, electricity access rate was nearly 60% in 2015 (according to the World Bank), with 86% of urban areas and 41% of rural areas with access, while access to non-solid fuels reached only

4%. Nigeria has huge sun oriented energy potential, with genuinely conveyed sun based radiation averaging 19.8 MJm2/day and normal daylight long periods of 6h/day. The expected potential for concentrated sunlight based power and photovoltaic age is around 427,000 MW.

Moreover, it is essential to harness energy that are sustainable, economical and are less risky to nature while simultaneously fulfils the rising need for power (Isa *et al*., 2018). This need has driven the idea of inexhaustible and sustainable energy to the first of ecological maintainability discuss. In target to use the sustainable source to satisfy the power need, sun oriented photovoltaic power has been seen as the best accessible alternative that can bolster this strategic in enormous capacity to create power. Photovoltaic technology has several benefit including small size of sun powered plant that can take points of interest of unused space available on top of household and existing buildings. The PV modules are quiet and clean since they operate on incidence radiation emitted from the sun other than traditional fossil fuel (Isa *et al*., 2018). Many rural communities in these subregions are small and far away from the national grid or transmission infrastructure, supplying electricity via the traditional infrastructure will not be cost-effective (Shenawy *et al*., 2017). The deplorable nature of road networks linking this long-distance communities makes it impossible to install generator and transport fuel to produce electricity in such environs.

The optimization results over the years show that the use of batteries in conjunction with the renewable sources is economic and ecological friendly(Isa *et al*., 2018). In addition, a power supply system consisting of the aforementioned technologies are capable meeting the maximum power demand in rural communities or the installation they supply. Telecommunication networks or media transmission systems base stations are regularly provided with regards to standalone energy systems since they are every now and again installed at remote areas without simple access to the distribution system (Merei *et al*., 2013). Off - grid PV system is eventually considered as the future of the world's energy sector and has significant role of electricity generation. Off grid PV energy system usually includes energy storage battery system. The idea of Stand-alone PV system is well established for both distributed and centralized systems in Nigeria and major part of the world. Photovoltaic systems can be considered as the most far-reaching arrangement with huge edges of progress while guaranteeing the age of energy with low ecological effect (Askarzadeh & Askarzadeh, 2017).

However there are assortment of optimization issues that are non-direct and non-arched in nature such as uncertainties associated with the renewable power sources, load demand and the non- linear attributes of certain parts.

Optimization algorithms are significant methodologies for resolving complex optimization issues. optimization is characterized as the strategy of revelation that gives the base or most extreme estimation of a function *f(x)* [8]. There are numerous reasons that make these problems hard to unravel. To start with, we cannot play out a complete inquiry if the domain space is excessively enormous. Secondly,the evaluation function is uproarious or shifts with time, producing a progression of arrangements rather than a solitary arrangement. Thirdly, in some cases the imperatives forestall landing at a potential arrangement with the end goal that the optimization approach is the main outcome.

The complex nature of optimization problems is due to nonlinearities and the implicit nature of PV modules, critical computational exertion is required to get everyone of the parameters, consequently, in this setting distinctive metaheuristic algorithms has been proposed and used over the years. This is because of the improved precision and diminished execution time of this artificial intelligence techniques. Besides, the capacity of metaheuristic algorithms, for example, Genetic

Algorithms (GA) particle swarm optimization (PSO), artificial bee colony, firefly algorithm (FL) to adapt up to missing meteorological information, is a noteworthy advantage.

SOLAR ENERGY POTENTIAL IN NIGERIA

Solar power is developed its huge potential in the last decades with total installed capacity of 12,493 MW. The Renewable Energy Master Plan (REMP) seeks to increase the supply of renewable electricity from 13% of total electricity generation in 2015 to 23% in 2025 and 36% by 2030. Renewable electricity would then account for 10% of Nigerian total energy consumption by 2025.The mission has accelerated the development in this sector considering grid satisfaction and stand competition in market with an targeted vale of 12,493 MW of grid and 3,904 MW of off grid connected plants (Cecily *et al*, 2019).

AVAILABILITY OF ENERGY THROUGH SUN

Solar energy is a very clean sour of energy resources available freely an in abundant. Nigeria is blessed with abundant solar energy. The country has an annual average sunshine of about 6.25 h, ranging from 3.5 h at the coastal regions to 9.0 h at the north. Similarly, the mean daily solar radiation is about 5.25 kWh/m 2 /day, ranging from 3.5 kW/m 2 /day at coastal zones to 7.0 kWh/m 2 /day at the north. This extra ordinary local put Nigeria in very good advantages. It divides the country into two half due to which almost 300 sunny days are available annually because of location advantage. The average available solar irradiance is of 4-7KWh per sq. Thus, a day which can produce 5000 trillion kilowatts of energy.it is also estimated that potential of energy can be harnessed on 12.5% of the land mass. Also scope of adoption of building integrated approach helps in enhancing capacity. In addition the scope of distributed generation with mini and micro grids can solve the problem of rural figure 1 and figure 2.

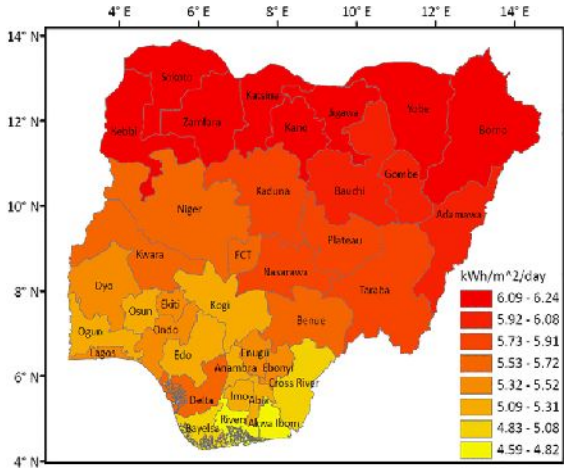

Figure1: Map of Nigeria showing global solar Irradiation (kWh/m 2 /day, from 1985 to 2004) on optimally inclined plane at the various locations (Cecily *et al*, 2018)

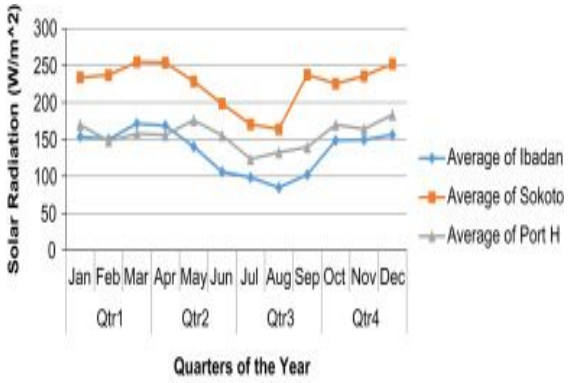

Figure 2: Exploration of solar radiation data from three geo-political zones in Nigeria (Cecily *et al*, 2018)

TECHNICAL CHARACTERISTICS OF SOLAR ENERGY

In Nigeria the global solar insolation is between 4 to 5.5. Electricity generated by solar cells is proportional to the area exposed and the intensity of global insolation received. Its conversion efficiency is defined by= Po/Pi where Po is the maximum power output and Pi is the power input at Standard Test Conditions (STC) of 1000 W/m2global insolation, 25 ◦C module temperature and 1.5 air–mass (AM). Solar cell, the change in efficiency with temperature is found to be±0.5% ◦C−1.For long term power generation; this inverse variation of efficiency with temperature is more or less compensated by season's changes. Solar based power generation depends on component selection, global insolation, seasonal variation, elevation angle, and temperature and battery capacity. The output of solar generation is maximum at noon and again it reduces to zero at night. For Nigeria, the Solar based system may able to give 67% efficiency without battery backup if the sky is clear.

INTEGRATION OF ELECTRICITY THROUGH SOLAR ENERGY IN SUPPLY SYSTEM

Nigeria's off-grid market has huge potential, especially in the areas such as rural electrification, power irrigation pump sets, back-up power generation for the expanding network of cellular towers across the country, captive power generation, urban applications, highway lighting etc. In addition to the government's initiatives such as Feed-in-Tariffs/Generation Based Incentive(GBI) as part of the NSM, the incentives under the semiconductor policy, and other expected incentives for the industry make the long-term prospects for this industry much brighter (Dada *et al*, 2017; Adenji *et al*, 2019). These targets and plans have potential to attract a variety of businesses in Nigeria, belonging to diverse segments - manufacturing, installation, operation and maintenance, training and engineering, procurement & construction (EPC) businesses, and more. The Nigeria energy resource master plan proposal (2020-2025) for new and renewable energy to rationalizes strategies for the development and Deployment of these sources. Thus, going forward, the market for photovoltaics in Nigeria is likely to be shaped by the following priorities

- Grid interactive solar power projects:
- Remote village solar lighting program:
- Retailing of solar energy products:

ECONMICS

The main object of Renewable Energy Association of Nigeria (REAN) and other agencies is to make a global leader in solar energy by boosting development into sector with appropriate policy conditions. The strategy is administered through

Nigeria Energies with Nigerian government, Energy development agencies in the various States for generation based incentives for grid connected solar plants with an extended scheme for central /state/ public / private PV power projects (Aondoyila *et al*, 2019) .

Nigeria's solar PV market is growing with tremendous rate. Currently, the Nigeria Solar PV manufacturing sector is export-led, and is much larger than the country's total installed capacity. In addition, the National Solar Mission's target to achieve 20 GW by 2030, of which 50% will be solar PV, and its plan to produce modules and cells domestically increases module production capacity. Many states in Nigeria are also devising the ambitious policies for solar PV power generation. Thus, there exists a huge manufacturing opportunity not only for the export market but also to fulfil the Nigeria federation and state targets.

CONCLUSIONS

Nigeria is a fastest developing country in which, its economic growth is measured with the power consumption. Various renewable technologies are contributing for supplying demand power and solar energy is promising technology measured considering geographical location of country with abundant energy sources. Solar technology is most dominating player in renewable energy scenarios with its advance in technology and support to grid with highest generation capacity which is most suitable. Considering scopes, initiatives and resources it quite feasible to be explored. Moreover, solar is also growing at faster rate for grid contribution and support wit with development of technology and reduction of cost. Solar energy has played a vital role in the overall electrification of rural areas and various off grids installations and applications, Hence currently powering as a major contributor in some agriculture sectors and in near feature with various policy and initiatives by government.

The authors believe that beginning to tackle our renewable energy issues by taking pragmatic steps towards implementing developed plans such as the one presented in this paper will take Nigeria out of the circle of a consuming economy to a creating one.

Development of Nigerian energy sector which will contribute to the Nations GDP. Since these energy could be exported for foreign exchange that will revamp the Nigeria's economy. Providing electricity would not only solve rural urban migration but would also ensure good educational outcomes in the rural communities where children find it difficult to learn in the evening.

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