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Key Barriers to the Implementation of Solar Energy in Nigeria: A Critical Analysis

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Abstract: Nigeria, potentially, has abundant sunshine throughout the year, making it full thirst for solar energy generation. Even though, the country's solar energy projects have not realised a fair result over the years, due to many barriers associated with initiatives implementation. Therefore, the entire power sector remains incapacitated to generate, transmit and distribute a clean, affordable and sustainable energy to assist economic growth. The research integrated five African counterpart's solar energy initiatives, barriers, policies and strategies adopted as a lesson learned to Nigeria. Inadequate solar initiative's research, lack of technological know-how, short-term policies, lack of awareness and political instability are the major barriers that made the implementation of solar initiatives almost impossible in Nigeria. The shock of the barriers therefore, constitutes a major negative contribution to the crippling of the power sector in the state. Future research will concentrate on initiatives for mitigating solar and other renewable energy barriers.

1. Introduction

Solar energy contributes a tiny fraction of power generation in Nigeria, although, the country receives maximum sunlight exposure, potential for solar PV. Nigeria is in the solar belt, which heightens its solar potential but sadly, the opportunities for harnessing the renewable energies remained narrow and unpractical compare to the conventional electricity [1]

Traditionally, solar energy in the country has predominantly been used for various activities by employing the open to the sun method, mostly in the rural communities. Solar electricity generation, on the other hand, emerged approximately two decades ago and it has seen a steady growth [2]. The primary drivers for the solar power uptake in the country are attributed to research centres and energy institutions, initiatives apart from the huge electricity production deficits. Besides the learning and research institutions, government and international agencies' activities have led to the development of the largest solar-PV plants across the country [3]. The major aims for the various solar electricity generation initiatives include the enhancement of water supply and the maintenance of clinics and healthcare facilities in the rural areas [4]

2. Solar photovoltaic (PV)

Nigeria is blessed with the abundance of solar radiation throughout the year. However, according to [5] only the exact utilisable solar resource base, formerly available in the state is unknown despite the huge financial commitment towards ensuring sustainable electricity in the country. They further added that Nigeria lacks the proper equipment and infrastructure to conduct solar radiation measurement. At the moment, Nigeria operates about thirty (30) measuring stations which are managed by the Nigerian



Meteorological Agency (NMA). These are airport based and the data from these stations are used to calculate an estimate probability for solar radiation in the country [6]. They are little local research and development activities related to solar energy in Nigeria. According to surveys conducted by the Energy Commission of Nigeria (ECN) in 1999 and, it was gathered that there are about 44 companies and research centres responsible for the importation and installation of photovoltaic systems in Nigeria. Out of these, only one company (Exide Batteries Nigeria Limited) produces batteries that are used for photovoltaic solar systems [6].

3. Solar energy potential

Nigeria is located in the solar belt with an average sunshine of up to 9 hours per day, equivalent to 5.5 kWhm⁻² days⁻¹ degrees of solar radiation are seen almost throughout the year [1]; [7]. The availability of massive radiations combined with the developments in the photovoltaic technologies makes it clear that huge amounts of electricity can be generated and utilised to combat the country's electricity crises that has become an obstacle to economic development [8]. [8], argued that the solar PV prices have been in steady decline in the recent years, dropping to approximately 50% compared to when it was first introduced years ago. This phenomenon was attributed to ramping up of solar PV productions in China and the technological breakthroughs experienced in the field [2].

Given the large amounts of incident radiation, installing solar panels on at least one percent of the country's geography can easily generate enough electricity to outdo the amount currently produced in the country [9]. Annually, the state receives up to 115, 000 times its total energy production through solar energy. This fact highlights the immense amount of energy which the country can benefit from the solar energy, bearing in mind that currently, solar energy contributes less than one percent of the total power generation [7].

Solar energy is the most stable and reliable source of energy that can be harnessed for the benefit of domestic and commercial purposes [9]. They further argued that, in line with the objectives of cutting down global warming through limiting the use of carbon fossils, solar energy has emerged to be a strategic component for achieving the sustainable development goals. Not only it is environmentally friendly, but it is also free and available in Nigeria. Electricity is not only produced cheaply, but also environmentally friendly [10].

4. Policies adopted

The national energy policy of 2003 approved by the federal government of Nigeria was aimed at leveraging the latent potential in power generation [11]. The plan highlights the need to develop energy using sustainable and environmentally friendly sources. The policy emphasised on electricity generation with the use of solar power among other renewable energy sources [12]. Regarding stakeholder composition in the energy production, the policy is much oriented towards the integration of public private partnership (PPP). Essentially, the policy based on hope that the private sector will take up the production, acquisition and distribution of renewable energy sources in the country [3]. The broad objectives of the policy include the generation of electricity in the rural areas, the creation of employment opportunities, environmental protection and mitigation of climate change and the diversification of energy production in the country. Besides other objectives, is to develop the country's solar utilisation capabilities [1]; [13].

The electric power sector reform Act of 2005 is the second policy formulated with aims to overcome the historic energy crisis in Nigeria [14]. The plan's principal objective was the liberalisation of the electricity generation industry to allow private investors to take part in energy generation, transmission and distribution [15]. The country's planners envision that by 2020 the country will be the 20th largest economy in the world. Bearing in mind the fact that power generation comes second to political goodwill in a country's development, the planners had to align energy production to their vision. Solar energy was therefore slated to be the major boost to the country's developments [16].

5. Impact of the policies

The policies highlighted above have a huge impact as far as solar energy generation in Nigeria is concerned. For instance, the Power Reform Act of 2005 has allowed private investors to get involved

in the power generation exercises [17]. This measure has enabled the country to achieve some of its short-term energy objectives with rural areas being the primary beneficiaries [16]. The aligning of solar power generation with the country's Vision 2020 has also ensured that the program features in most government plans. For example, in parliamentary procedure to bring down the cost of the new textiles, the Nigerian government has removed duty on solar modules being imported into the country [13]

6. Lessons from five African countries

Apart from Nigeria, the other countries in Africa which have successfully adopted solar PV Panels include Morocco, South Africa, Ghana, Chad, and Kenya. Morocco so far has one of the most ambitious solar projects in the world [18] The Moroccan government sets some policies to direct their energy industry: The National plan of priority actions (PNAP) and the National Energy Strategy (NES). The NES major objective is to ensure that 20% of the country's energy needs is met through renewable energies [19]. Similarly, other related goal was to ensure that the country attains an energy efficiency of 20% by 2020 and a further 15 % by the dawn of 2030 [20] The PNAP policy on the other hand aimed at diversifying the fuel varieties and their sources. Subsequently, other policy, is the provision of energy in all sectors and at relatively competitive prices. The renewable promotion was another major objective aimed at heightening energy efficiency [20]. Finally, a policy was also aimed at integrating markets from the euro-Mediterranean region.

Morocco is on track towards the achievement of its energy objectives with the generation of 500MW of solar electricity having been initiated. The beginning stage of the project amounting to 160MW was completed in February 2016 with the other phases being scheduled to be finalised in 2018 [21].

South Africa, on the other hand, has also developed some policies to direct its renewable energy generating sector. South Africa's most important energy policy is the integrated resource plan [22] The plan outlines the country's aims to develop up to 9600 MW of solar power by the dawn of 2030. Resultantly, the solar electricity generation in the country has moved from nil to a point where it has provided a significant contribution to the national grid [23]. Furthermore, the rapid developments in the industry can be imputed to the friendly policies which contributed to the liberalisation of the sector. In combination with the relatively affordable Solar PVs, the industry has witnessed tremendous growth [23].

Ghana has also made strides towards the development of its solar energy generation capacity. The government's resolution is captured in its policies which include the national energy policy of 2010, aimed at introducing public-private partnership in the development of infrastructure [24]. The other policy was the Ghana sustainable energy for all action plan 2012 and was aimed at the development of renewable energy technologies. The government also developed a strategic national energy plan for 2006 to 2020 [24]. The plan as the title insinuates, was to outline the role of renewables in the national grid. The various policies set by the government have had a positive impact on the development of renewable in the country and specifically solar power generation. For instance, the country could add 20MW of solar energy to its national grid [25].

To achieve the SDGs, Chad initiated a myriad of measures towards the generation of power. One important renewable energy policy formulated by the country's government is the system of renewable [26]. The policy is aimed at providing the necessary framework for developing renewable energy schemes. There has been a great success as far as the attainment of renewable energy goals is concerned. For instance, recently, the country benefited from a sustainable energy fund for Africa loan aimed at the development of a 40MW solar plant in the country [27].

Kenya is optimally located along the equator to access maximum sunlight throughout the year. According to [28], the country experiences up to 300 days of sunlight within a year this highlighting the potential that it has regard to the generation of solar energy. The government has put in place some policies to ensure the seamless development of the renewable energy industry [28]. The policies include scaling up renewable energy program put into effects the elimination of import duties and value added tax (VAT) on all renewable energy-related imports. The government has also introduced a feed-in tariff to help the uptake of the energy produced from renewable sources such as solar power. The measures taken by the government have generated positive results as attributed to the proliferation

of solar firms in the country [29]. Despite the potential of renewable energy, especially solar PV, in Africa, particularly Nigeria, the implementation suffers from various challenges which is further discussed.

7. Key barriers to solar initiatives in Nigeria

Despite the many benefits that can be accrued from the use of solar energy potential and uses is still very low. The major impediment to the technology adoption are series of barriers which makes it hard to implement.

Table 1: Barriers to Solar energy implementation in Nigeria

Barriers category	Barriers	Remarks	Sources
Technical Barriers	Lack of skilled personnel, lack of code of standard, lack of maintenance and operation, lack of training facilities and entrepreneur's development mechanism, lack of Reliability.	The barriers lead to poor plans, poor standard, constraints of the competitive market, inadequate knowledge to know-how about the technology and risk acceptance. All these barriers resulted in technology locked -up.	[1]; [30]; [31]
Social; Cultural Behaviour	Lack of consumer awareness about the product, lack of understanding of benefit of solar PV and public resistance to chance for new technology.	The barrier, affect the market projection negatively, cultural and religious faith controversies towards economic development and sustainability.	[32]; [33]; [34]
Economic/ Financial Barriers	Lack of access to capital, credit to consumers and financial instrument. Lack of support to R & D, high interest rate, import duties subsidies to support local manufacturing.	At the early stage, solar projects need incentives to encourage entrepreneurs. The barriers make it difficult to adopt and sustain due to financial constraints.	[13]; [17]; [35]
Institution al/ Legal barriers	Institutional barriers, legal framework, regulatory issues, non-integration of energy mix, non-participation of private sector, poor R & D culture and stakeholder's non-interference.	The barriers cause risk of uncertainty in support of solar energy, lobbies against RET, poor communication mechanism to reach the institutional policy makers for improvement and negative perception about the technology.	[7]; [36]
Political/ Policies Issues	Lack of long term policies, lack of political will to diversify into clean energy, constantly changing of government and re-shuffling of institutions.	These barriers serve as a deterrent to future planning for solar and other renewable energy adoption and sustainability. There is the fear of uncertainty in government.	[1]; [3]; [30]
Market Distortions Issues	Trade barrier for new product, energy sector controlled, lack of access to diversified technology, lack of facilities and backup technology, non-market oriented research for solar energy technology and application.	The barriers cause hindrance to market penetration and hence new technology failed at some point.	[3] [37]

Apart from awareness, the workforce to support and technical know-how to install the solar panels is still lacking. The necessary expertise to assemble and manage the solar facilities in existence has further composed the issue. Currently, Nigeria relies on experts from other developed countries to run its solar generation plants. This lack of capacity increases the maintenance cost of the projects. This fact impedes the technology's uptake even in cases where the end users are aware of its adverse effect. Despite the major reduction in the price of solar PVs, the lack of financial and fiscal incentives present a challenge to the stakeholders. Essentially, the development of a solar firm requires massive amounts of money which may not be easily available in Nigerian situation [16].

Solar generation also suffers from the insufficient institutional framework. Apparently, the country's energy regulation Commission (NERC), is also mandated to oversee the licensing of electricity plants that generate at least 1MW. Incidentally, renewable energy plants which produce less than 1MW are not adequately regulated. The intermittent nature of resources leaves the stakeholders with operational challenges. Renewable energy sources are cyclic in character, with seasons of high supply and others of low supply. Therefore, the lack of storage makes the operation of solar systems, complex [17].

8. Findings

It is evident that Africa in general and Nigeria to be precise have huge potentials as far as the generation of clean energy is concerned. It is, however, disappointing to note that solar power which is the most efficient and readily available resource is least utilised with most countries covered having below one percent solar power generation. The major impediments to the uptake include the lack of sufficient finance, technical know-how and general awareness [38].

9. Recommendations

As far as the improvement of solar energy production in Nigeria is concerned, creating awareness concerning its advantages will go a long way towards its adoption. The Nigerian government should, therefore, put in place a policy that encourages the sensitisation and awareness initiatives. Besides creating awareness, the government should also introduce in the country's learning institutions, courses on the handling of solar panels. Such a policy will aid in the development of the necessary workforce capacity. A special fund should also be put in place to subsidise the raw materials needed for the installation and production of solar panels [39]. Future work of this research will proffer a framework to mitigate challenges for solar energy initiatives in Nigeria.

10. Conclusion

Nigeria has not taken advantage of its potential in the renewable energy generation. Given the large amounts of incident radiation, the country can greatly benefit if the necessary resources are committed towards subsidised opportunity for socioeconomic development. It is, therefore, imperative upon the stakeholders to put in place policies that will create an enabling environment for solar energy production. The stakeholders for energies, especially solar, can learn from other African countries such as South Africa, Kenya and Morocco who to some extent have yielded positive result. The Nigerian government needs to address the challenges also by integrating research recommendations from various research more especially the institutional and technical barriers.

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