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Challenges of Solar Energy Applications and Development in Nigeria

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ABSTRACT

Nigeria is blessed with abundant amount of sunshine. In spite of this potential, solar energy is yet to find its foot in the country's total energy mixes even though the territory has good and viable potential for solar applications ranging from stand-alone pico units to large scale grid connected applications. Despite the abundant solar energy deposit in Nigeria, it was found that applications and utilization of the resource is majorly limited to small-scale and isolated applications. The aim of this work was therefore to discuss the possible motivations for the development of this resource together with the current obstacles to large-scale development of solar energy conversions systems (SECs) in Nigeria. As a way to extensively develop solar energy resources in Nigeria, good and enforceable policies with strong political will are necessary; hence, the study concluded that making available financial and subsidy incentive to individual, communities as well as private organizations to invest in solar energy development is necessary.

Keywords: Solar energy, Challenges, Applications, Policy, Development

INTRODUCTION

Nigeria is blessed with abundant amount of sunshine. The amount of solar energy reaching the Earth surface is about 100,000 TW [1]. The total global primary energy consumption in 2012 was 12,476.6 million tonnes of oil equivalent or 145,103 TWh [2]. From the BP Statistical Review of World Energy [2], it is very glaring that the global annual energy consumption can be supplied by solar energy in every 88 minutes or about 6000 times total annual energy consumption yearly. It is the world most abundant and permanent energy source that shows different appearances depending on the earth's surface topography [3]. In esssence, solar energy is expected to play a very significant role in the future global energy needs and most especially, in developing countries. Nigeria with her location on the equator is within a high sunshine belt where solar radiation is fairly well distributed [4]. It was estimated that the annual daily average of total solar radiation varies from about 12.6 MJ/m2/day (3.5 kWh/m2/day) in the coastal region to about 25.2 MJ/m2/day (7.0 kWh/m2/day) in the far north, thus making her to have an estimated 17,459,215.2 million MJ/day (17.439 TJ/day) of solar energy falling on its 923,768 km2 land area. Provided there is an estimated average of 18.9 MJ/m2/day (5.3 kWh/m2/day) over a whole year, an average of 6,372,613 PJ/year (E1770 thousand TWh/year) of solar energy is estimated to fall on the entire land area [4,5]. In spite of this potential, solar energy is yet to find its foot in the country's total energy mixes even though the territory has good and viable potential for solar applications ranging from stand-alone pico units to large scale grid connected applications. Despite the abundant solar energy deposit in Nigeria, it was found that applications and utilization of the resource is majorly limited to small-scale and isolated applications. The aim of this work is therefore to discuss the possible motivations for the development of this resource together with the current obstacles to large-scale development of solar energy conversions systems (SECs) in Nigeria

Solar Energy Development in Nigeria

Solar thermal has been constantly enjoying very high level utilization by rural dwellers for agricultural processing in purposes including drying of agricultural products such as grains, cassava (tubers or marsh), yam flakes, meat,

fish, fruits, kernels, drying of manure, hides and skins, cooking and frying of agricultural products which are not preserved or sold raw. Other areas of solar energy utilizations include heating and lighting of animal pens, pumping of water and irrigation, food and vaccine storage [6]. In addition to these, solar energy has also found wide usage in Nigeria viz: solar street lightings, solar refrigerators, solar cookers, solar-powered water pumps, etc; different applications exist in the form of solar thermal and solar PV. Solar energy devices (mainly solar thermal) have been designed, built or adapted 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). Solar PV found widespread usage in street lighting, but other pilot projects including water pumping, vaccine refrigerators, community lighting and few stand-alone mini grids installed and 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 (FMoST) also exist. However, synergy does not exist among all the major energy players (ECN, FMoP, FMoST, other private donors and state parastatals that are involved in energy projects), hence, no comprehensive project database exist for renewable projects in the country. Furthermore, all existing projects are either off-grid light applications of few kWp or stand-alone mini-grid at the moment; off-grid hybrid or grid connected solar projects do not exist across the country.

Propellers of Solar Power Development

Apart from the advantage of good solar radiation and its abundance across the country, several other factors propelling solar energy development in Nigeria are discussed below:

Power sector reforms law

The enactment of the Electric Power Sector Reform Act (EPSRA) Cap E7 LFN 2004 in March 2005, made provision by law for an individual to construct, own or operate an undertaking for generating electricity not exceeding 1000 k W in aggregate at a site without a license and/or own or operate an undertaking for distribution of electricity with a capacity not exceeding 100 kW in aggregate at a site without a license [7-8]. This exemption to holding a license favours energy generation from renewable resources. This law empowers individual or group of individuals to invest in stand-alone or off-grid power generating systems [8]. The legislation also made way for the establishment of the REA whose major objectives are to: (i) extend the national grid (ii) facilitate independent off-grid systems (iii) generate renewable energy power and (iv) coordinate renewable electricity activities among the state and federal agencies.

Reduction of CO_2 footprint

Climate protection is one of the major propellers for solar energy development in Nigeria. Nigeria has a coastline that is 800 km long, sea level rise of about 0.2 m will inundate approximately 3400 km sq. of the coastline; several kilometers of arable lands have also been found to be lost annually to desert encroachments. Rise in sea level and desertification are consequences of changing climate as propelled by rapid greenhouse emissions. Solar applications produce no emission thus meeting or exceeding emission standards around the world. Energy generation through various solar applications will thus reduce the industry's carbon footprint and will also be an excellent means of reducing carbon dioxide (CO_2) emission thereby mitigating climate change across the country. The lowering of the water table in the North through desertification will continue to also make solar water pumps a relevant choice in water supply.

Energy demand

Population growth is a major driver of energy demand while its most important determinant is the level of economic activity measured by the total GDP alongside with its shares by the various sectors and sub- sectors of the economy [9]. The rapidly growing demand for energy will create opportunities for solar energy development because conventional energy sources will not be enough to meet the need of the ever increasing population in a flexible manner. Furthermore, the expanding economic opportunities in the rural areas will also demand an aggressive deployment of renewable energy options (most especially the vast solar resources) due to grid non-availability needed to evacuate generated conventional power to the respective primitive locations [8].

Increasing demand for local added value

Solar technologies will support the needs of developing countries like Nigeria through added local values. Only about 30% of the entire Nigerian population is connected to the national grid and the majority (mostly rural dwellers) is left to the use of biomass and fuel wood for their energy needs. Most of solar applications can be developed locally by the rural dwellers for energy in various forms (solar cookers, solar chicken brooders etc). Majority of solar based applications belong to technologies with a high potential for local added value; some have a little fraction of high-

tech components substituted with other parts that easily subject themselves to local fabrication. This will promote socio-economic stability, skill acquisitions and employment generation.

Barriers

Solar energy development also faces many obstacles in Nigeria. Some of these obstacles are presented below:

Variability and intermittency of radiation

Solar energy is a variable resource and its availability as an energy source fluctuates. Sunshine duration in Nigeria ranges from a minimum 4 h in the South to 9 h/day in the Northern part of the country [8]. As a result, electricity output from solar power plants across the country will vary accordingly while its demand does not follow similar pattern. Grid connected and hybrid solar electricity can only be realizable in the North where solar insolation is highest whereas off-grid solar applications (solar lantern, solar battery charger etc) can be a viable option in the Southern part of the country. However, this shortcoming can be overcome by the development of appropriate solar energy storage technologies for storage purposes when solar energy is available, and then re-use when the energy is not available.

Lack of awareness and information

The level of awareness about the immense socio-economic and environmental benefits derivable from solar energy among the citizens and decision-makers at different political and administrative levels is very low in Nigeria. The current flow of information about the development, various applications, dissemination and diffusion of solar energy resources and technologies are also inadequate. There is inadequate and insufficient education of consumer/solar applications users. Solar projects (mainly solar street lights) across the different states of the country had been executed by inexperienced technicians/practitioners using sub- standard solar products; most of the facilities are therefore no longer functional. This has established poor confidence of the technology among the public, private and financing sectors on the adoption of SECs in the country.

High initial investment cost

A basic barrier to the development of solar energy technology in Nigeria as a developing country lies in the high initial costs, including high installation costs with long payback times. High initial costs may also reflect high-risk perceptions of investors and a general lack of financing instruments as well as fragmented or underdeveloped financial sectors [10]. There is also lack of incentives on import or local manufacturing of solar devices in the country. Import duties are not allowed on solar PV in Nigeria; when the PV to be imported into the country forms a part of the complete solar device including battery storage, it attracts a 21% import duty. This has forced the initial investment cost of solar devices to tower high above other conventional energy sources (such as diesel generators whose duties are stable, regular, and the products readily available when needed).This challenge further becomes more pronounced in the country because of the high transaction costs since most solar projects are decentralized and within the small scale range. The solar energy projects thus become too costly in the long-run for local banks in Nigeria to consider for financing.

Operation and maintenance costs

Solar technologies have been viewed as the energy supply option for the remote and rural poor areas in the country. At the moment, the operation and maintenance costs are appreciably high in the country, due largely to lack of technically skilled personnel. Hence, potential users of the technologies (occupying largely the remote locations) may be prevented from the adoption of SECs due to fear of failure in the absence of technical supports.

Ineffective quality control of products

Absence of national technical standards and effective quality control units in the country were identified as a major institutional challenge to the adoption of renewable energy in households. This absence is due to lack of appropriate training and personnel. Most of the solar products are imported from China through various nations' borders into the market. There are no existing standards and specifications regulating these products; products are also without trademark certificates and certificates of analysis from manufacturers (most of the products in the market have no brand name). These led to the influx of large quantities of substandard solar components; systems and services are also poorly installed by technicians with inadequate expertise. Confidence reposed on the technology has thus been undermined since the high initial cost of investment into these products cannot be justified.

Insecurity of solar plant infrastructure

Most locations that are very suitable for the development of solar energy system in the country had played hosts to militant insurgency in the past. Insecurity has affected power plants constructions and other infrastructures through kidnaps and killing of workers in various parts of the country. General insecurity of solar infrastructures especially in the northern region of the country where there are abundant solar insolation can be a potential threat that will stall future investment in large scale grid-connected solar infrastructure.

Policies to Overcome Barriers to Solar Energy Development

Mitigate political and regulatory investment risk

The development of essential reform processes in political, economic and societal structures that will be needed to manage corruption, establish standards of transparency in public administration and enforcing established laws are essential in reducing the fundamental barriers of the political and regulatory risk of the country. There is also need for political will and determination to address security related issues.

Cost reduction measures

Solar energy development is economically viable in Nigeria but project finance is not readily available. Financial institutions can be encouraged to offer loans to retailers of solar technologies at rates that are more favorable than commercial terms. Retailers will thus have access to capital needed for procurements of SECs (e.g. solar PV) in bulk. It may also be essential to provide soft loans with low interest rates for solar energy projects. In addition, micro-lending schemes adopted by micro finance institutions should be encouraged and promoted. Micro-credit linked to micro-enterprise has proven highly successful in promoting renewable energy and reducing poverty in some countries [11].

Favorable government policy

Favorable policies are fundamental to long-term sustainability of solar energy development. The lifetime and crediting period of large scale solar projects will exceed the democratic duration of any government in Nigeria. Ensuring that laws are stable and enforced is very vital as potential investors will need reasonable certainty that key legislative provisions put in place for solar activities will remain stable, unambiguous and enforced, thus allowing the continuity of investment into the future. In addition, the current electricity tariff is low; the tariff is not market reflective for profitable investment in power generation even with the existing fossil fuel energy sources and hence will not encourage any transactions into solar applications by any potential investor. However, increasing the tariff regime may be counter-productive considering the fact that larger portion of the population belong to the low-income level.

Consistent awareness creation

Large scale implementation of renewable energy applications can only be undertaken successfully with the understanding and support of the public [12-13]. Hence, increased awareness into the benefits and opportunities associated with the development of SECs and the inherent advantage for climate change mitigation is vital to rapidly and significantly improve the desire and interest among the public across the country. Awareness is also found to be an important ingredient needed to help in specific solar project identification and will also assists in tackling the problem associated with insecurity of solar plant infrastructures. Awareness can be accomplished through various promotions and dedicated communication efforts primarily through workshops and media (television and advertisement) and community meetings/forums.

Establish and enforce quality standards for solar energy equipment

A lot of setbacks due to poor-quality solar systems had been suffered with some solar energy projects in this country. [13] The Standard Organization of Nigeria (SON) and other government agencies such as ECN need to establish suitable manufacturing standards and specifications and to strictly enforce them. Policy instruments and incentives could be introduced to encourage local production of solar devices. The failure of solar energy equipment and associated appliances are due to poor sizing and designs, resulting from lack of quality solar and other meteorological data.

CONCLUSION/RECOMMENDATION

As a way to extensively develop solar energy resources in Nigeria, good and enforceable policies with strong political will are necessary; hence, making available financial and subsidy incentive to individual, communities as well as private organizations to invest in solar energy development is necessary. In like manner, financial compensation and training for individual and communities whose land are acquired by government and/or investors for the development of the solar energy project is recommended.

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