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The status of solar energy integration and policy in Nigeria

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ABSTRACT

The need to understand and proffer sustainable solutions to the persistent energy crises and energy starvation in Nigeria even in the face of abundant endowment of both renewable and fossil energy resources motivated this study. This study justified why solar energy should be accorded the highest priority as energy source in not only Nigeria but globally. A detailed review of the past, current and future status of solar integration in Nigeria is presented; it is seen that for grid-connected solar power integration the past status is nil, the current status is nil and future status may not be completely bleak as a number of Memoranda of Understanding have been signed. The existing supportive solar energy policies are highlighted and discussed; the chasm between the commendable Nigeria policy landscape and near-to-zero status of solar integration is blamed on poor implementation of the existing provisions by the Government. Recommendations were made on the basis of the existing policies and proposed policies. Additional provisions to some of existing laws of the Federation to accommodate support for solar energy integration are suggested. It is recommended that the poor and incipient status of solar integration in the vastly populated Nigeria should be viewed in a positive light by potential foreign investors as such status is a guarantee that solar power and thermal industry is a firsthand investment opportunity.

1. Introduction

Renewable energy sources are the energy resources that are environmentally friendly, readily available and infinite in extent or replenished (or can be replenished) with usage. The renewable energy resources include solar energy, biomass, wind, geothermal, hydro. They are used to generate various usable secondary (or final) energy forms or energy carriers (electricity, fuel bio-ethanol, biogas, biodiesel etc). Debates have favored RE energy in different fronts. Select countries of the world are endowed with fossil energy while all countries are endowed with RE; for example, every country receives solar energy. Therefore RE resources are less expected to become root of national and international conflicts as it is the case with fossil energy resources. RE is the solution to the problem of finite and depleting nature of fossil fuels and the harmful (to both the earth and its inhabitants) emissions and effluents associated with their (fossil fuels) utilization. It is known that world demand for electricity is increasing faster than total primary energy supply [1] and this is more so on sole reliance on fossil energy resources since this would mean progressively higher rate of utilization of a finite resource and thus hastened attainment of energy drought. These in essence mean that the energy for long-term sustainable development must majorly (if not entirely) come from RE resources.

Nigeria is a country in energy and economic crises and need for adoption of RE as a way out of the crises and out of the aforementioned problems of fossil fuels has been emphasized in a number of studies. A number of works such as [2–7] have focused on policy arguments to advocate increased utilization of renewable energy resources in Nigeria. Some other such works focused on specific primary renewable energy resource or group of related renewable energy carriers; for example [8], considered the potential for renewable distributed power generation in Nigeria from bioenergy resources while the works [9,10] have focused on policy promotions for adoption of biofuels (biodiesel, bioethanol and biogas) in Nigeria. Ohunakin et al. [11] focused on analysis of the drivers and barriers to solar energy applications and developments in Nigeria. In the current study, the RE policy items which are not found in the Nigeria RE policy but are important given the Nigerian energy consumption pattern and culture will be discussed and advocated for adoption with justifiable placement of emphasis on the solar energy. The current study is thus unique as it tries to: justify why solar energy should be given number one spot for development in Nigeria; Review in more detail the status (past, current and future) of solar integration in Nigeria; informatively highlight the existing policies together with recommendations of new policies that suit the Nigerian energy consumption environment and suggest additional provisions to some of existing laws of the Federation to accommodate support for solar energy integration.

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2. Motivations to rising global adoption of renewable energy

The oil crises of 1973 [12] - though a nightmare at the time of occurrence as a result of high fuel prizes - can today be considered blessing in disguise because it galvanized intense research effort on renewable energy (RE) [13]. RE today is no longer seen only as buffer to potential volatility in prices of fossil primary energy resources but also as the energy for sustainable development into the future that guarantees the following trends [14]; reducing health and environmental impacts of fossil energy use, boosting energy access and security and provision of secondary benefits like improved opportunities for education, job creation, rural economic development, poverty reduction, and gender equality. The UN Framework Convention on Climate Change signed in Rio de Janeiro in 1992 made sustainable development the principal determinant of composition of the energy future of the world to be significantly renewable [1]. This formed part of the impetus for rising trends in global renewable energy integration, investment and policy support. Renewable Energy Policy Network for the 21st Century (REN21) is an international organization that facilitates knowledge exchange, policy development and joint action towards a rapid global transition to renewable energy. REN21 arose in the world's first government-hosted international conference on renewable energy held in Bonn, Germany in June 2004 by delegates from 154 countries. The advent of REN21 has heralded a more-than-ambitious growth rate in renewable energy market when compared with what obtained before; for example, by the end of 2013, nearly 50% and 98% of all operational global PV capacity was installed since the beginning of 2012 and 2004 respectively [14]. Renewable energy resources met 13% of the world's primary energy demand in 2011 [15]. By the year 2012 fourteen percent of the of total world energy demand is supplied from renewable energy resources [13] while 19% of global final energy consumption was supplied from RE sources [14]. The above listed magnitudes of the renewable proportion of world energy is better appreciated quantitatively when put in perspective with the IEA estimate of the world energy consumption for the year 2012 as 13371 Mtoe or 560EJ [16]. The share of RE resources in the global electricity mix is 20% in 2011 and under the new policies scenario outlook, is expected to attain 31.3% [15]. Renewables made up an estimated 58.5% of net additions to global power capacity in 2014 and comprised an estimated 27.7% of the world's power generating capacity by year's end [17]. The European Union has policies and plans to obtain 20% of its energy needs from renewable energy resources by 2020 [1]. United nations targeted to increase RE usage by 50% and reduce conventional energy source by 50% in year 2013 [18].

3. The supreme competitiveness of solar energy in the long-term

Competiveness of solar radiation relative to other primary energy resources becomes supreme when its universal availability together with its almost zero environmental impact on utilization is noted. This is hardly the case for other primary energy resources. The absolute enormity of solar as the mother primary energy resource has been quantified in [1] as follows: the solar energy reaching the earth from the sun is so enormous that more than four times of the total world's capacity of 5000 GW in electricity generation will be harnessed even if only 0.1% of this energy could be converted at an efficiency of 10%; in other words, the total yearly solar radiation falling on the earth is more than 7500 times the world's total annual primary energy consumption of 450 EJ. The annual average solar resource is uniform enough throughout almost all human-inhabited regions of the world that the supreme competiveness applies all round. Supply infrastructures of most of other energy resources; for example, gas and oil pipelines or vehicular and other mechanical conveyor systems are vulnerable to adverse weather conditions, natural disasters and human vandalism but there are no such risks in solar energy supply. The basic disadvantage associated with solar power technology is hinged on less economic competitiveness compared to conventional technologies and renewable power technologies like wind and hydro. Mgbemene [19] considers the fear about cost and level of maturity of RE technologies as misconceptions. The viewpoint of less economic competitiveness is based on economic analysis that has been judged as unfair against solar - by Timilsina et al. [20] - on the bases that accurate cost of negative externalities of conventional technologies and benefit of solar in terms of unrestricted potential for distributed power generation (unlike wind, hydro, geothermal and ocean energy with potential restricted by natural endowment) are not taken into consideration. Construction of dams for hydropower - just like wars - displaces aboriginal populations of riverside communities and floods farms and forests in the process of filling requisite large reservoirs. The cost analyses which place hydro power above solar do not normally take into consideration the cost of such massive human displacement, greenhouse-gas emissions from decaying flooded organic matter, pressure on ecosystems of the not-flooded adjoining areas and the cost to agriculture and fishing downstream of the dam. These problems do not respect international borders thus dams are not free from becoming source of international tensions. A typical example is the continual tension between Nigeria and Cameroon over the latter's routine release of water from the hydro power Lagdo dam. The tension is because the arising flood sweeps through some states in Nigeria damaging lives and properties. The scale of the damages in 2012 is always a case to fear as calls thereafter for preparedness are high whenever there is an impending release [21]. It is stated earlier that hydro power capacity is restricted by natural endowment meaning that developing all feasible sites will not be sufficient to meet the long-term energy needs of many nations. Wind turbines perform best when located in prominent areas like hill-tops thus angers locals by creating significant visual impairment and potential risks to property values in nearby areas [22]. This is in addition to problems of intermittency which limits deployment of wind turbines as large-scale electricity utilities.

The supreme competiveness of solar energy is not in any way meant to dilute the advocacy for RE supply from waste biomass especially municipal solid and liquid wastes as their utilization in this manner - in addition to clean energy supply and stabilization of wastes - protects the environment from negative externalities like green house Landfill gas (in the case of municipal solid wastes) emission and pollution. Landfill gas which is a mixture of 45–60% methane, 40–55% carbon dioxide and trace components is a product of complex chemical and biological decomposition processes on the organic component of municipal solid wastes. Landfills of municipal solid wastes alone account for about 8% of global methane emission and in addition wastewater accounts for about 17% of the global major sources of methane [23]. Thus Landfill gas must be captured for RE energy application to forestall further accelerated climate change. But the advocacy for solar energy would overshadow the advocacy for RE supply from energy crops because of the not-yet-resolved stigma of competition for land with food and feed crops, timber and fiber producing plants, human residential expansion, and nature conservation and climate protection forests. More analyses on the debates for and against bio-energy crops can be found the work of Popp et al. [24]. According to Bradford [22] industrial geothermal energy sources are not as environmentally friendly as they might look since they emit significant amounts of unfriendly gases like hydrogen sulfide and carbon dioxide. Moreover the potential worldwide geothermal market is no more than 6.5% of all electricity generation thus the future is clearly limited.

Though available in enormous quantity on earth, solar energy has low-density and intermittent nature that makes research effort imperative for its efficient interception, conversion to final forms (thermal and electric) and storage. Though intermittent, the average variation of solar energy over a day somewhat follows the human electricity demand trend. The research effort has over the decades led to more