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Existing and recommended renewable and sustainable energy development in Nigeria based on autonomous energy and microgrid technologies

Y.S. Mohammed^{a,*}, M.W. Mustafa^a, N. Bashir^b, I.S. Ibrahim^a

^a Department of Electrical Power Engineering, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor Bahru, Malaysia

^b Institute of High Voltage and High Current, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, UTM Johor Bahru, 81310, Johor, Malaysia

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ABSTRACT

Deployments of renewable energy technologies in the current century represent a critical approach to sustainable development. Renewable energy can be generated from sources with the backdrop to restock themselves based on timescale. The most important sources of renewable energy include solar photovoltaic conversion technologies, biomass and biofuel energy systems, wind energy turbines, geothermal energy technologies and hydroelectric power systems. Considerable investment in renewable energy in a country can lower the nation's dependency on imported fuels and purchase of energy from foreign market. It also drives technological innovation and generate employment scheme while enhancing clean development mechanism. Consequently, this paper presents the existing renewable energy technologies in the Nigeria and as well makes some critical recommendations to further induce development of renewable and sustainable energy systems based on autonomous energy systems and microgrid (μ grid) technologies. The recommendations are made based on varieties of energy technologies for solar power generation, biomass and bioenergy, wind energy, hydropower generation and the combined generation systems using hybrid energy mechanism. The structure of the study is concluded based on suggestions on how to pursue some impending socio-political, technological, investment policy and legislative issues for effective renewable energy development in the country.

1. Introduction

Electricity generation by means of any sustainable approach in the 21st century is typically an inevitable prospect for socio-economic progression in the context of sustainable development. This is based on the fact that every independent country must realize the need to promote enthusiasm for greater sustainable development, self-sufficiency and increase economic globalization. Currently, existing predominant energy generation systems in the world largely utilize fossil fuels to generate electricity. The energy systems utilizing fossil fuels could be cheap and more reliable in terms of efficiency and continuity of power supply but some critical environmentally inconvenient scenarios have been linked to fossil fuels combustion. Documented evidences had established that the potential threat of global climate change has increased in recent time and combustion of fossil fuels has contributed the greatest percentage to greenhouse gas emissions [1]. In the context of sustainable development, there must be a productive approach to clean development mechanism (CDM) so that cleaner production could be sustained. The global desire for sustainable development has fostered the emergence of different technologies

having different degrees of development as shown in Fig. 1. The deployments of these technologies are expected to encourage cleaner production of energy. Though the technologies are in different phases of research, demonstration, ready for deployment, development and mature stages. It is quite obvious that there are multitudes of technologies required for effective exploitation of sustainable energy development but a number of policy actions and appropriate investment strategies are required to fully adopt the systems for purposeful socio-economic development. Beside the environmental problems orchestrating from fossil fuel consumptions for power generation, there is also a critical problem of depletion of the global reserve of fossil fuels. The negative consequences of these challenges strongly approve the imperative needs for the exploitation of renewable energy in order to deal with the current state of increasing demand for energy.

Over the years, the global energy market has increased as shown in Fig. 2. A great deal of the world's energy is currently produced and consumed in ways that could not be sustained if technology were to remain stagnant and if overall quantities were to increase substantially [4]. Scores of recent research publications in the field of energy studies increasingly focus on the development of alternative energy systems to

* Correspondence to: Department of Electrical/Electronic Engineering, Federal Polytechnic Nasarawa, Nigeria.
E-mail address: engryek88@yahoo.com (Y.S. Mohammed).

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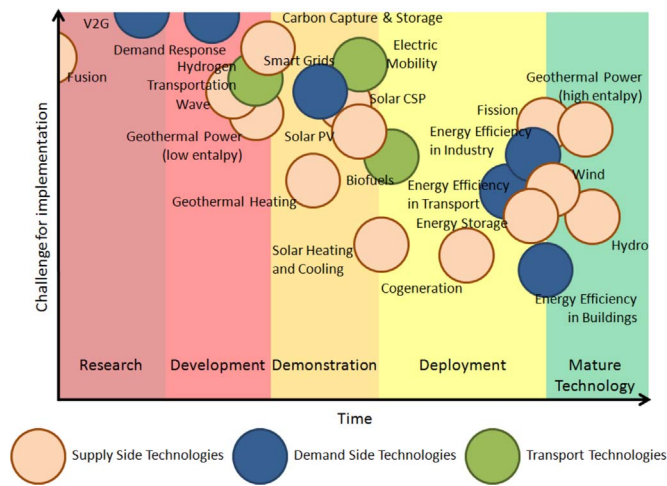


Fig. 1. State of development of technologies for Sustainable Energy Systems in terms of development stages and challenge for implementation [2,3].

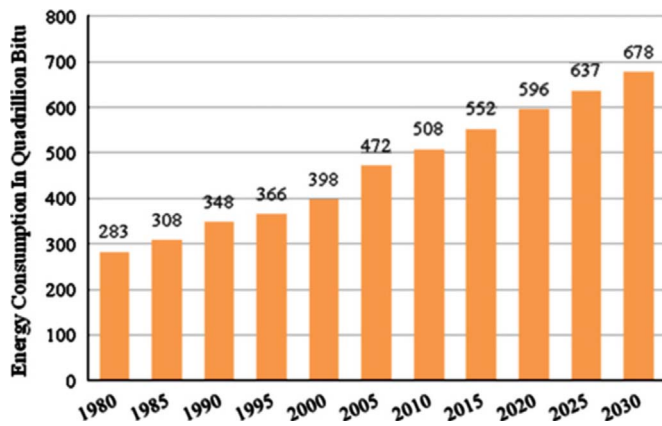


Fig. 2. World marketed energy consumption 1980–2030 [5,6].

bridge the gap of demand and supply of energy especially among the developing nations where there are cases of energy crisis. Despite the challenge of intermittency associated with renewable energy systems, the application of energy sources is to some extent becoming important in the quest to propagate socio-economic demand.

In Nigeria, electricity supply to the consumers is exceedingly by grid extension. However, extending power grid to rural locations is not usually economically sustainable especially in localities with rough terrains and long distance from the grid infrastructure. There is high cost of capital investment, installation and distribution of rural energy supplied by grid extension. Other identified challenges are poor voltage regulation and low load factor. In Nigeria, about than 100 million people live in rural areas with contracted access to grid network electricity [7] based on the inherent problems of location and economy [8]. Consequently, this paper presents an overview of the existing and recommended renewable and sustainable energy systems in the context of autonomous renewable energy systems and hybrid µgrid energy technologies. Consequently, the framework of this study is concluded on discussions pertaining to imminent socio-political, technological, investment policy and legislative issues towards realizing renewable energy development in the country.

2. Scenarios of energy delivery in Nigeria

A sustainable, reliable and affordable energy supply is a backbone and indispensable precondition for economic development in a country. Substantial access to modern energy can help foster economic growth and reduce poverty. A consensus also exist among the energy

scientists and supporters of community development that energy is a catalyst for socio-economic transformation at all levels of human society [9]. It was widely deliberated that energy relationships have been established with all the objectives of millennium development goals (MDGs) [10,11]. Currently, it is no doubt that energy is an index for modern development because a country cannot develop unless there is opportunity to foster reasonable access to energy for all or a greater percentage of the populace. Under a progressive economy, there must be sustainable development which must be entrenched in efficient application of decentralized energy economy based on the locally available clean energy sources. Nigeria is naturally endowed with abundant energy resources from renewable and non-renewable sources but it is quite unfortunate that the country’s energy generation mix is not adequately diverse to its fullest advantage. Energy generation in Nigeria is subject to multi-faceted challenges because as much as the 50% of the nation’s power sector installed capacity is usually unavailable and a major challenge is inefficient utilization of energy resources available in the country [12]. In reality, energy consumption in Nigeria has actually increased in needs for diversification [13] but the country has not taken the full advantages of the emerging global energy technological innovations to satisfy her energy demand. The condition of energy utilization in the country is such that combustible bioenergy sources such as firewood are excessively utilized as illustrated in Fig. 3.

Even with the fact that Nigeria has substantial renewable and sustainable energy resources, electricity consumption accounts for insignificant percentage compare to other sources. This problem has compelled the majority of households in Nigeria into energy crisis condition so much that only about 40% of the households in the country have connection access to grid electricity [15] with only 45% access to electricity available for consumption [16]. In most rural and urban communities private individuals use household based electric power generators to provide electricity to compensate for sporadic power failure from the grid. Barely 2% of the rural households in Nigeria have access to electricity from the grid and rural electrification programmes in the country critically rely on grid extension approach initiated by government [17].

As a result of lack of effective performance, the Nigerian power sector was restructured in 2005 in what was tagged as power sector reform Act. The fundamental objective is to reform the existing power policy in the country for better service delivery. The formation of the National Electricity Regulatory Commission (NERC) was part of the reform agenda. NERC was based on the quest for national economic reform in the country via the Electric Power sector Reform Act, 2005. NERC was established as an independent regulatory agency with the mandate to regulate the electric power sector of the country. Another integral objective of the reform is the review of the electricity tariffs and promotion of effective policy actions with sustainable energy subsidies promoting different mix of energy resources including renewable power generation for environmental sustainability. The low tariff situation in the power sector has been criticized by many investors based on the fact that is generally below the cost of electricity generation. Through NERC the federal government has increased the

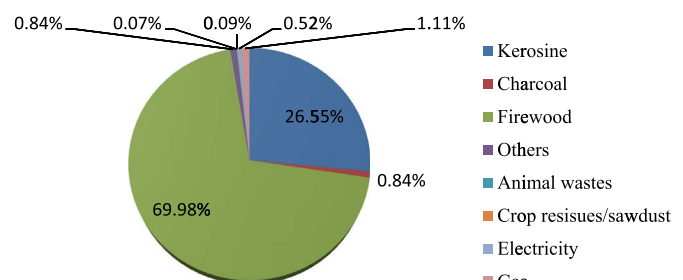


Fig. 3. Shares of energy consumption by source in Nigeria [14].

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