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To cite this article: O. S. I. Fayomi *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **665** 012023

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Pillars of Effective and Efficient Energy Systems in Nigeria

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Abstract

Nigeria is posed with a myriad of challenges to achieving efficient energy systems; the colossal collective demand for sufficient electricity for approximately 200 million is a concern. Another challenge is the mismanagement of Nigeria's abundant resources, by individuals and by groups. It has withheld us, for decades, from making the bold and rapid progress which ought to have made for the energy system. This report explores the concept of an energy system in Nigeria perspective and progresses.

Keywords: energy, electricity, power, development, industrialization, privatization.

1. Introduction

Energy industries are paramount for any nation with a desire for sustainable economic growth [1]. For example, in Africa, Nigeria ranks first in oil exploration and production, which accounts for almost 70 % of the gross domestic product [2]. In retrospect, energy in the pre-industrial world was mostly provided by man and animals. These sources of energy inherently constrained the boundaries that could be explored by man [3-5]. The mining of coal in exploitable quantities propelled the industrial revolution. Steam engines, efficient transportation systems and mechanized production rapidly followed. A large portion of coal produces electricity which is the most premium form of energy. After the Second World War, oil replaced coal as the prime driver of industrial expansion [3-6]. In present times, natural gas has been linked to the reason for economic growth in some countries. From [7, 8] the quest by other nations to satisfy their ever-increasing energy demands has led to the utilization of non-environmental friendly energy sources and a global increase in the carbon dioxide emission. Nonetheless, a large amount of coal and natural gas generates electricity in many parts of the world. The reason being electricity is a final form for energy is usually transformed into useful energy such as heat energy, light energy, sound energy, etc. According to [8-10], energy is a prerequisite for industrialization, engineering and technological innovation and economic growth. The security of the subject matter of interest, energy is an important discussion among policymakers and the larger community in a nation especially people whose daily activities and economic remuneration depend on the availability of this energy [11-14]. Worldwide, energy demand is on the increase and developed countries gradually mitigating conventional methods of power generation and transitioning to energy sources such as solar photovoltaic cells, geothermal energy, etc. [15-20]. Nigeria is a country with high potential in generating power from both renewable sources and conventional sources. However, it holds the position of one of the lowest consumption per head in Africa, which is still very poor even when compared with the rest of the world [21-26]. The need to checkmate the trend and energy efficiency is crucial, and this study helps to validate that.

2. Energy systems and classification

For the focus of this study, energy systems are a series of subsystems working together designed to supply energy in its premium form (electricity) to end-users. It involves all the processes and systems involved in the conversion of primary energy to the transmission of final energy. These



processes and systems are benchmarked by three major processes classified as Energy generation, consumption and distribution, all of which have been privatized except for transmission. In Nigeria, presently, we have inadequate energy systems in place to cater to the present population nation [6]. Concerning [7], energy systems of the future should address concerns about affordability, environmental degradation and efficiency. Renewable energy systems which are sustainable, environmentally friendly and largely inexhaustible answer these concerns and their optimization will further help to decrease the carbon emission and counteract global warming. [8], reported that energy systems and models do not have any specific grouping methodology and can be regarded as vital parameters for determining the potential of energy systems in a particular location. Energy Systems can be classified based on various selections. Sources that are termed renewable are found to be non-exhaustible because they are replenished within the average life span of a human being. The term non-renewable refers to energy resources which are predominantly exhaustible in terms of human time dimensions. Capital energy refers to the energy on earth available to man for exploration. It includes fossil fuel, nuclear energy and geothermal and Income energy is simple energy available to man from outside the boundaries of the earth. Examples are particle energy radiated by planetary bodies, moon, etc. Conventional are found to be largely commercial, and they consist of fossil fuels, hydroelectric power generation and nuclear energy. Non-conventional sources are not yet commercialized on a large scale, although global interests and development are rapidly increasing in this area. They include wind energy, solar radiation, geothermal plants, etc. Most industrialized countries still rely greatly on coal and natural gas [27, 28].

3. Nigeria's Energy Sector

Energy advancement in Nigeria started in Lagos with the age of power in 1896 [11]. Progress proceeded in 1926 with the formation of the main utility in the Nation called the Nigerian Electrical Company [12]. In the north, production of electricity began in 1929 with the making of the Nigeria Electricity Supply Company (NESCO) which was a service organization that developed a hydroelectric power station in Kurra near Jos. Advancement in the energy sector prompted the creation of the Electricity Corporation of Nigeria (ECN) in 1951 to oversee the conveyance of power in the Nation [11]. The Niger Dams Authority (NDA) was then created in 1962 to control the use of hydropower in the Nation. This was then trailed by the development of the initial 132 KV line which connected the Ijora and Ibadan Power Stations. The NDA handled the production of electricity while the ECN regulated the dispersion and sales of the power created. These two organizations were converged in 1972 as a focal body would be better responsible and capable in the production, distribution, and supply of electricity, the organization, was named the National Electric Power Authority (NEPA). NEPA a state-owned organization that had an imposing business model over the Nation's energy sector was responsible for the circulation and production of electricity. However, power has been accessible in the Nation for quite a while the energy sector has not been developed at the rate it should. As observed by Sambo (2008a), the power segment of the Nation has not had critical advancement as new plants were not commissioned and old ones were not appropriately kept up. More than 20 years of low ventures and lack of foresight have prompted the power division not having the ability to meet the electricity demand of the country [13]. The organization, since its creation could not satisfy the power needs of the Nation, amusingly as the power request in the Nation expanded the transmission and circulation of electricity diminished. Investigators [14] have identified that there was a huge investment in the generation of power yet this was not reflected in the transmission and dispersion stages other reasons, the inadequacy of the body in charge of energy, and poor investments. These factors led to the demise of companies that relied on electricity for the production of their goods and services. In spite of the Nation having a rich wellspring of natural resources, the energy sector has yet to benefit from these resources. This is all the more shocking as the country is said to be the biggest oil producer in Africa [17]. The power sector has been confronting difficulties, for example, the high losses both from the technical and commercial aspects of the business, the equipment utilized in the production of electricity being obsolete, and poor financing and management. The serious power deficiencies around the Nation forced the legislature to begin changes to prevent a breakdown in the country's economy. This prompted the drafting of the National Energy Policy (NEP) in 2003. The approach had the accompanying goals [18].

The stringent policy will only attain the significant improvement of electric power to make it accessible to 75% of the populace by 2020. The Electric Power Sector Reform Act (ESPR) of 2005 was passed in the power sector of the Nation which prompted the unbundling of NEPA and to its renaming to Power Holding Company of Nigeria (PHCN). This demonstration additionally enabled private speculators to take a section in the power division of the Nation. The Nigerian Electricity Regulatory Commission (NERC) was additionally founded to direct and decide the tariff in the sector. Its obligations incorporate [18].

- Licensing and guideline of the division
- Determination of taxes
- Enforcement of execution measures and purchaser rights

The privatization of the energy sector prompted the creation of various organizations in the power segment which can be ordered into [19]: (1) Generating Companies (GENCOs) for example, Kainji Power Plc. (2) Transmission Companies (TRANSCOs) for example, Transmission Company of Nigeria (3) Distribution Companies (DISCOs) for example, Eko Electricity Distribution Co. Plc., Ikeja Electricity Distribution Co. Plc.

3.1. Constraints, Ineffective and Effective Energy Systems

Any country that has a deficiency in power supply slows down its economic growth rate. The lack of power affects all aspects of the economy, and its citizens suffer its effects. This has been the case with Nigeria since the founding of NEPA. Despite its expansion every year. Most of the Nigerian citizens have no means to a constant electricity supply, and some have no access to electricity at all [20]. Power production in Nigeria goes as from 1896. The supply for electricity is far less than the demand even though electricity has been in use in Nigeria for more than hundred years and this has greatly affected the country's technological and socio-economic development [21]. Nigeria has not been able to provide sufficient and constant electricity despite its importance in an economy due to bad culture of maintenance, lack of sufficient funding and ageing of power plants. In 2005, 3959MW out of 6500MW of electricity was provided due to the above [11]. One of the major problems we have is the excessive reliance on the power production sector on crude oil products has reduced the speed of the development of other ways of producing energy. Diversification in power manufacturing methods would help Nigeria go far in providing efficient and adequate electricity for her citizens [23]. Nigeria has been endowed with numerous alternative energy sources such as Wind, Biomass, Hydro-electric and solar energy and effective utilization of these resources would help our energy problem which in turn would improve various aspects of our economy [23].

Despite all the natural resources Nigeria is blessed with, the country is in a situation whereby 7 out of 10 people in Nigeria do not have access to Power [24]. Nigeria has the seventh-largest gas reserve in the world and the largest in Africa, in fact, 95% of our export revenue is attributed to our gas reserves [23] and yet with all that resource we do not have a constant power supply. Below let me enumerate why: PHCN is Nigeria's current major power distribution company, and the company itself needs to undergo reform. Its inefficiency affects all other aspects of the economy such as manufacturing of products which also affects the cost of services and it all becomes a compounding problem. The cost of manufacturing in China is about nine times more affordable than in Nigeria just because of these energy problems [21]. The sad part about these problems is that they are not only a result of mismanagement on the part of our power producing companies, they are also as a result of the inherent costly nature of technology, shortage of skilled expertise and absence of innovative technological policies [25]. Individuals vandalize and pilfer PHCN equipment for personal gain, Nigerians are unwilling to develop alternative means of energy generation, and the consumers of Power both from the public sector and the private sector are unwilling to pay for the services provided by PHCN. Not to mention the numerous amount of people who use their services without getting billed (tampering with PHCN meters, connecting directly to power lines etc.) Among the other problems our Power Holding Company has is the

poor funding by the government as well as the delay in the provision of funds promised by the federal government. The delay in funds ultimately leads to poorly maintained equipment and the use of very outdated equipment [26]

3.2 Effect of these constraints on the economy

Presently in Nigeria, more than 120 million people do not have access to grid-supplied electricity [27]. The inefficient electricity hampered the growth and development of many aspects of the country. The lack of efficient power affects our social, political and economic sectors in astounding ways. Power is central to the development of a nation; this lack of power affects the production of food, manufacturing of products, transportation, health, education and communication. The rate of development in these sectors has slowed down due to the rising costs caused by the lack of efficient power [12]. The lack of power as it slows down all of the aforementioned sections of the economy, in turn, affects the Revenue of the nation, that is it affects our exports and imports, and it affects our GDP, this affects our employment rate in a negative way and in turn leads to poverty. The effect of indirect losses in firms in Nigeria accounts for about 61% according to a conducted survey which is a binding constraint for more people wanting to do business in the country. This also affects the quality of education received in the country and ultimately leads to the country having more unskilled workers, which is a snowballing effect on people having lower salary or being unemployed, leading to poverty. The poverty level has a direct relationship to the number of crimes that are committed in the country [23].

3.3 Pillars to Effective and Efficient Energy Systems in Nigeria

According to [28], small-scale businesses, population increase and local industrial innovations have led to the rise in demand for energy in Africa. In Nigeria alone, the government has to meet the demands of about 200 million people by providing clean energy with favourable economic standards. Meeting these demands according to the Sustainable Development Goal 7 is an issue contending with Nigeria and other African countries. One of the things that would lead to efficient energy systems in Nigeria is a Power Sector Reform [29]. This reform was sanctioned by the Federal Executive Council. Here are the points they came with:

- Regulating tariffs and powers of quality service to supervise the industry properly.
- Powers of NERC in relation to anti-competitive behavior which would affect the industry such as mergers etc.
- NERC licensing Private Power Distribution companies
- Creating policies that encourage the use of renewable energy as well as policies that ensure citizens enjoy energy provision.

Nigeria has a lot of prospects for renewable energy; in fact, the potential for sustainable energy resources in Nigeria outclass conventional energy resources. Nigeria's over-dependence on non-renewable energy has caused a lack of utilization of renewable energy. Another problem with our dependence on crude oil is that it causes oil spills, environmental degradation, depletion of the ozone layer, these are all bad consequences or results of our usage of crude oil [30]. The energy supply of the future needs to be more sustainable so that it can easily be maintained with good efficiency. It should have a low environmental impact to reduce the global crises we are suffering as a result of our non-renewable energy resources. Anyways nation Nigeria as a result of its location has been endowed with a good quantity of sustainable energy resources such as: Solar energy, Hydro energy, Biomass energy and Wind energy [7].

Hydro energy is one of the renewable resources we can utilize in Nigeria as a country. Hydropower energy is present as Nigeria has some rivers such as the river Niger to provide hydropower. Hydropower is obtained from the potential energy water possesses when its storage is higher than where it is falling from and that force is used to drive a turbine which converts the energy to electrical energy [1]. The places that are the most desirable to build hydro plants are southern, south-eastern, and the plateau areas of the country as their topography provides the appropriate drops and hydraulic heads which makes hydropower functional. These areas are also where rainfall is highest and of the longest duration. In the North and Jos Plateau, their River flow

is ephemeral so small hydro power plants would require storage tanks and reservoirs to keep the Hydro plants afloat in these areas nevertheless. Hydropower plants can be operated around the country [31].

The energy obtained from wind is renewable and has little or no effect on the environment. Wind is produced by the difference in atmospheric pressure due to the temperature difference caused by the sun. Local winds and Prevailing winds are all caused by this temperature difference between places and the corresponding pressures that make wind move. Nigeria is blessed with very good wind conditions in places like the deep upland regions of the north and mountainous zone in the middle belt as well as the coastal areas such as Lagos, Ondo and Delta state. Normally, Wind energy is effective when there are a lack of obstructions such as trees and buildings [1]. There have been studies that measured the wind speeds in Northern locations such as Kaduna, Katsina, Kano, Bauchi, Potiskum. The lowest wind speed recorded in the study conducted over the course of the year was 4.02 m/s with a power density of 46 W/m² and the highest was 7.96 m/s with a power concentration of 391.31 W/m². The study showed that wind energy could be used as a reliable source of energy for Nigeria [27].

Among all the renewable energy resources, solar energy offers the most potentials. Nigeria has an average annual daily sunshine of about 6.25 hours ranging from about 3.5 to 9 hours for coastal to and Northern Nigeria respectively. The solar energy that Nigeria receives in a year is 27 times more than the conventional energy units we use and 117,000 times more than the electricity produced by the country. So there is really resources available at hand for proper electric generation. Solar energy can be stored and converted to electrical energy through Photovoltaic cells which convert solar energy to electricity and can be applied as a grid stand-alone as back up, or connected in a grid (Emodi, 2014).

Biomass is simply the transformation of saved energy in plants into usable energy. It is also referred to as the energy of biological systems such as wood and waste. It can be seen as an indirect form of Solar energy as Solar energy is one of the factors the helps biomass energy. Nigeria is blessed with agriculture that it has many biomass used as energy. It can be divided into mainly 2 categories: Traditional agricultural products such as sugar, oilseeds etc., and lignocellulosic such as trees and shrubs. Other things such as Animal Wastes, Human wastes also fall in on the Biomass energy resource (Fasina, 2013). There are many methods in converting biomass into other energy sources; some are:

- The first method is by burning. Burning of wood has been done since man has existed and is the simplest way of converting biomass energy into another energy resource. Wood can be burnt fully or partially which forms charcoal.
- The second way is by Alcohol fermentation. Fermentation is the breakdown of an energy rich compound without the use of oxygen to carbon dioxide and any form of alcohol. This breaks sugar rich compounds to alcohol which is an energy source that can be used to produce thermal energy.

Conclusion

Electricity is a commercial form of energy today. It is the final form of energy to which others are converted. Access to sufficient electricity in our homes and businesses is critical to our country's development. Renewable energy sources, preferred for their environmentally friendly characteristic and inexhaustible supply have gained a stronger foothold in our world today, thereby, replacing older and more conventional means of generating electricity. It is impossible to overstate the sheer importance of optimizing the use of energy in our everyday lives and in economic growth as a country. Nigeria is a country blessed with abundant renewable energy sources which include biomass and hydroelectric power; but, these sources are not utilized as they ought to because they lack the political profile possessed by petroleum. For Nigeria to experience an obvious and undeniable upgrade in her energy systems, both in the urban and rural centres, petroleum would have to be ignored (to an extent) to make room for more investments in other sources of energy such as the ones mentioned above. Of course, this cannot be achieved without strong political backing. Nigeria, both in the colonial and post-colonial eras, has seen the creation of multiple organizations by the government for the purpose of transmitting and distributing

electricity. Now, providing electricity is a responsibility of the private sector, and we do not seem to have mastered it sufficiently for we have not. The obstacles to the efficient power supply the large and steadily growing population, the mismanagement, the lack of law enforcement about the power supply appear very daunting but, there is no obstacle we cannot overcome. All obstacles are for us; we are not for the obstacles.

Acknowledgement

The author will like to acknowledge the open access publication privilege by Covenant University

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