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Innovative Use of Renewable Raw Materials in Global South: An Exploration of Energy Situation in Nigeria

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Abstract

The discussions in this paper Centre on the Innovative use of Renewable Raw Materials (RRM) in the Global South (GS): An Exploration of Energy Situation in Nigeria. Contemporary knowledge is demonstrating innovative use of Renewable Energy (RE) across the globe. Literature in public domain have noted that RE is being considered a major part of development for the economic and technological growth as well as for the growth of sustainable development in Nigeria. Yet evidence shows that despite Nigeria's status as Africa's most populous country, the country's economic progress has been hampered by a lack of enough energy supplies. It has further been argued that due to inadequate harnessing of the proper usage of RE resources and insufficient knowledge of it amongst the general population, Nigeria remains underdeveloped in the consumption of RE supplies as compared to other developing nations. This is due to lack of structural approach in Nigerian government to promote the proper usage of these RE tools and techniques for better economic growth. The country has now developed an Integrated Energy Planning Tool to assist Nigerian policymakers and operators in making better informed decisions about their management and strategies to increase RE access in the country. It is positioned that Nigeria's economic development is possible through certain RE's that hold the power and commercial value in the nation. For instance, solar and biomass energies are majorly used energy resources that have made an important contribution to the renewable system for Nigerian people. To this end, the Nigeria Federal Ministry of Environment has concluded that Nigeria lacks in its production of energy through wind power and geothermal power sources as the country's inner crust cannot produce much heat and there seems to be lack of finance and investment. On the one hand, Nigeria heavily depends on their usage of hydropower that constitutes 20.8% of the total amount of energy utilised by her citizens. On the other hand, the RE source requires modernism and technological innovation in their marketing through which it can add value to the people by providing a cost-effective and price favourable energy supplies. In this regard, the government of Nigeria is identifying and investing in proper power generation from RE tools that might help with sustainable development in the country. This paper argues for the innovative use of RE raw materials as part of the

Nigeria energy mix to provide solutions to the perennial energy crises in the country. Considering the other variables involved in the innovative use of RE for development, the paper proposes the use of both positivism (deductive) and interpretivism (inductive) as a research philosophy to demonstrate the need for innovative use of RE raw materials as possible solutions to Nigeria energy inadequacy. The discussion in the paper argues that the economic development of Nigeria's future depends on the innovative use of RE and the long-term availability of affordable, open and harmless energy for the ecosystem, and that security, climate change and general well-being are closely linked to the usage of RE. The paper concludes that innovative use RE is a sine qua non for sustainable development in Nigeria. Finally, the paper recommends that Nigeria should take advantage of her global partnerships for finance, creative alliance and technologically innovative of RE. In view of the complexity of the Nigerian society, the future work should be more empirically based in the collection of primary data through a survey questionnaire and IBM SPSS as analytical tools.

Keywords: Renewable Raw Materials (RRM), Global South (GS), Renewable Energy (RE), Technological Innovation, Sustainable Development

1. Introduction

Nigeria has supplies of abundant fossil fuels and renewable energy such as wind, solar and hydropower energy as compared to other developing countries, but Nigeria lacks ability and technology to harness these resources for proper usage and to make it affordable and accessible for her citizens [1].

The aim of this paper is to explore innovative use of RE as part of Nigeria energy mix to solve the energy crisis in the country. The sole objective is to demonstrate that innovative use of Renewable Energy (RE) in Nigeria is a critical development factor for the economic and technological growth as well as for the growth of sustainable development in Nigeria. As noted above that there is availability of RE in Nigeria, this begs the research question, why has the country's economic progress been hampered by a lack of enough energy supplies and why is it that it remains underdeveloped in the consumption of

RE supplies as compared to some other developing nations which are collectively referred to here as Global South - that is countries in the Southern Hemisphere which are still struggling with structural challenges of underdevelopment. It is a known fact that energy supplies the basic supplements of human life such as food, healthcare, communication and educational support, assists transportation, export and import facilities for the people [1]. While Nigeria supplies abundant fossil fuels such as petroleum and gas as well as RE's such as wind, solar and hydropower energy as compared to other countries in the entire world, there is Nigeria inability to harnesses the proper usage of these resources to make it accessible and affordable for her citizens.

2. Literature Review

Sustainable development has been universally understood as [2] as a development that meets the needs of the present generation, without compromising the ability of the future generations to meet their own needs. This implies that economic growth should be carried on in such a way as to recycle physical resources rather than deplete them, and to keep levels of pollution to a minimum [3]. Sustainable and renewable energy plays an important role for a developing country by implementing economic growth, sustainable development, eradication of unemployment and poverty while increasing development and education amongst people [4]. Despite Nigeria's status as Africa's most populated country, the country's economic progress has been hampered by a lack of energy supplies. It has been studied that Nigeria's growth and development for the future highly depends on the availability of resourceful energy from accessible and renewable sources that are present in the environment [5].

Rural areas, which are inaccessible due to poor road networks, have limited access to conventional energy sources such as electricity and petroleum products. Petroleum items such as kerosene and gasoline are sold at prices that are 150 percent more than the official pump prices in rural areas [6, 2012). As a result, the rural population's daily needs for thermal energy are almost exclusively satisfied by fuel wood. In the unorganized private sector, the sale of fuel wood and charcoal is generally unregulated. For example, In Nigeria, the sale of kerosene, electricity, and cooking gas is largely influenced and controlled by the Federal Government or its agencies - in the case of kerosene and cooking gas, the Nigerian National Petroleum Corporation (NNPC). The federal government's goal had been to subsidize the cost of domestically used petroleum products, such as power. The government has lowered and abolished tariffs on various energy

resources in Nigeria in order to make the petroleum downstream sector more efficient and to reduce petroleum product usage as a policy emphasis. The various policy approaches have invariably resulted in product price hikes [7]. With the restructuring of the power sector and the privatization of the electricity industry, it is clear that rural areas that are isolated from the grid and/or have low consumption or power purchase potential will not be attractive to private power investors, especially in the privatized power sector [8].

Indeed, there is a clear case of energy crisis and challenges of economic development in Nigeria. The country is growing at an average of 2% per year in its economic and technological growth. As per the statistics of 2020, the country's production of total renewable energy is 142.38 kWh while its consumption lacks by more than 50%, i.e., 24.72 bn kWh. Nigeria's energy balance depicts that their own production is being facilitated to the development of other countries as it lacks proper consumption of that energy which increases economic growth and standard of living of people Nigerian society [9]. Only 55.4% of people in Nigeria have access to electricity facilities while the other half lives with the help of firewood [9]. The poor performance of Nigeria's energy services has contributed significantly to the country's high unemployment rate and aggravated poverty. The majority of the population lives on less than \$2 a day. It is well known fact that a country's living standard is directly proportional to its per capita energy usage [10].

3. Classification of Renewable Energy (RE) sources and options for Nigeria

The economic development of any nation depends on its abundance usage and production of energy resources which in-turn supports the current development and economic status of the nation [11]. There are a number of classifications of RE done on the basis of source from which these energies are derived from, such as solar, wind, hydro, tidal, geothermal and biomass. Nigeria's major energy comes from the usage of traditional waste and fossil fuels which accounts for more than 80% of total energy. Remainder energy is from hydropower that produces electricity from moving water and helps population consumption of power production and increases the contribution of sustainable power to the energy mix [12]. It may be appropriate to add incentives and pricing to stimulate investment in use of new renewable energy and bio-energy for power generation and use of bio-fuels. These energy sources help perform various functions such as solar heat facilities, wind energy, gas fuels through biomass and electricity through hydropower. It is imperative for every nation, both developed and developing alike to promote energy diversification

that supports energy supply as well as increases a country's framework to earn better profits as well as better natural and sustainable energy resources [13]. Nigeria is vulnerable in its production and consumption of renewable energy sources as it has always highly been dependent on non-renewable energy [12]. Hence it is important for the country to produce more natural energy products that can support her economy to grow.

Renewable energy (RE) resources are energies which are derived from the sources that are renewable, and would not extinguish from continuous use by the humans. RE is the opposite of non-renewable energy, which is derived from the sources which are limited, and could not replenish at faster pace. These energy sources in the case of Nigeria are fossil fuels such as petroleum and coals which have so far been used for her goals and needs for economic and technological development [14].

In Nigeria, one of the most basic renewable energies is solar energy that uses sun's power directly or indirectly to produce energy for nation's growth through industrialization, construction, transportation and consumption of solar power that turns into electricity for many urban or sub-urban households. Solar energy is classified into various categories such as Photovoltaics energy (PV) and Solar Thermal Energy [15]. PV is a type of solar device that converts solar energy into little volts of electricity using composed modules of PV energy. This system majorly focuses on direct or diffused beams of sun-rays directly on their incident mirror that further converts the PV rays into little molecules of electricity which is used by general population. Another category of solar energy is solar thermal technology that collects the sun's energy and converts it into electricity through thermodynamic cycle which is a special metal pipe that contains a heat transform fluid. It has been concluded in certain studies that solar thermal energies are better than PV devices because they are intermittent with natural sunrays and are cost effective for population [16]. Despite efforts to raise knowledge about the efficient use of solar radiation, solar energy applications technologies have yet to become household goods. Electricity generated from the combustion of fossil fuel energy resources and hydropower facilities provides a bigger percentage of all energy services. Solar energy applications to supplement energy from fossil fuel energy resources utilising cleaner fossil fuel technologies will provide energy availability to meet rising demand in socio-economic activities and improve living standards for Nigerians [13]. For now, Nigerian population depends on 40% electrification usage through solar heaters and thermals which generate an ineffective marketing sale for the businesses. Hence, it is important for the business to communicate with their customers and

create input supply as per their demand and economic profits [15].

Wind is a plentiful source of environmentally friendly electricity. Wind farms are becoming more common in countries such as the United Kingdom, as wind power contributes more and more to the National Grid. Turbines are used to operate and power generators, which subsequently feed electricity into the National Grid, allowing wind energy to be harnessed. Despite the availability of household or "off-grid" generation solutions, not every location is appropriate for a domestic wind turbine [17]. These turbines can help produce electricity with their power of fan in reverse technique which results in power production in industrial and household areas. Wind energy, for example, is theoretically a kind of solar energy because there would be no wind without the sun. The movement of air generated by the sun's uneven heating of the Earth is known as wind. The strength of the wind can range from a gentle breeze to a powerful tornado. In any case, the wind is such a powerful natural resource that scientists have devised a method of converting it to energy using wind turbines [18]. Nigeria has been generating a strong wind renewable energy since 2020, however, the operating wind farms were unable to function at full capacity due to lack of finance and sustenance amongst citizens. It has been surveyed that the Federal Ministry has to attain and formulate certain policy frameworks to encourage a proper development of technology in wind farms and bring forth more investors and capital for the better operation of wind turbines [19].

Geothermal energy makes use of the heat contained in the Inner crust of Earth, which is produced by the gradual decay of radioactive particles in the planet's core rocks. We can send highly heated water to the surface via wells, which can then be exploited as a hydrothermal resource to turn turbines and generate energy [20]. Pumping the steam and hot water back into the earth reduces emissions, making this renewable resource cleaner. Geothermal energy generation is intimately linked to geographic location, with places like local variations in subterranean heat movement, fluid cycle (groundwater) systems, and lithology causing thermal conductivity variabilities over the Niger Delta region of Nigeria. Hence it has become a long-term goal for Nigeria to produce an abundance of geothermal energy for the sustainable and proper use of energy resources. Nigeria's geothermal setting reveals that thermal reservoirs are linked to volcanic rocks. The Benue valley, Biu Plateau, Jos Plateau, hot springs, geysers, lavas, volcanoes, and death toll in Guatemala Volcanoes are all products of volcanic activity [13]. Certain studies predict that there are geothermal oddities and volcanic emissions present

that might help the Nigeria's consumption of this energy resources.

Another renewable energy that promotes the usage of resources amongst the general population of a country is Hydropower energy. It is the process of transforming the force of water into electricity or machine power, and is widely used around the world. Hydropower is typically generated by a high-speed river current or rapid descending water point from a high location. Hydropower, in particular, has its drawbacks; a common issue is the displacement of populations near hydroelectric power building sites, as well as the threat of reservoir banks disintegrating, especially during heavy rainstorms. It has been surveyed that there exist almost 30 hydroelectric power plants in Nigeria that generate a maximum of 13000 MW [21]. However, till today Nigeria lacks sustainability through these plants as they remain undeveloped for consumer consumption of electricity. Nigeria as a developing country lacks in her entailment of proper habitat and construction of facilities to the general population. As a result, the development of power plants has a significant impact on the immediate environment. These repercussions can be both good and negative, with positive impacts being beneficial to the ecosystem and negative impacts being detrimental to the environment. It is, moreover, important to effectively regulate these repercussions of electric power generation in Nigeria in order to create a conducive, balanced, and sustainable environment.

Last, but by no means the least is the Biomass energy resources which have been used since mankind first started cooking with wood and keeping warm. Nowadays, wood remains the most abundant biomass renewable resource in Nigeria [22]. Food crops, meadow and woody plants, agricultural or forestry residues, oil-rich algae, and the organic component of municipal and industrial wastes are among the other sources. Even waste fumes (which contain methane, the primary component of natural gas) are used to generate biomass energy [14]. Biomass can also be utilised to make fuels, generate electricity, and produce things that would otherwise be manufactured using fossil fuels. These particles can be converted into transportation fuels, electricity and are typically used to make petroleum through decayed waste. Hence, as the name goes, biomass renewable energy resources products from biodegradable waste while reducing harmful gas emissions. For example, Nigeria has been accounted for its significant biomass energy resource base that has been underdeveloped due to agriculture waste, livestock degradation and forest residuals that has been considered for a long time. Due to this, the country has been majorly dependent on its usage and hence lacks in their growth for other energy sources [23]. It was predicted that the energy potential will increase from around 3.2 EJ in 2010 to around 5.5 EJ

in 2020, with a possible peak of 29.8 EJ in 2050. This survey came to be true as 78% of the population of Nigeria depends on biomass energy for heating, electricity and meeting basic standards of human life.

It has been a global trend since 2008 for countries to integrate renewable energy resources as a major part of their power production and energy mix which might meet the nation's needs and services. The first major principle of renewable energy is current energy that subscribes to the definition of sufficiency of natural energy present in the local environment. This principle implies that usage of energy is only valid when the local environment is analysed and modified as per the consumer requirements and it meets their standard of living by converting energy into resources [24]. Nigeria has been considered a prominent part of renewable energy source for other countries; however, it lacks its integration and consumption through energy mix which makes these resources an insignificance for the consumers. Nigeria uses solar energy and biomass energy to the best extent, but they do not reform or develop their wind energy and hydropower base for better consumer usage, hence, the outcome affects their economic growth [15].

Energy requirements varies with their usage and consumption as the consumers' take notice of their dynamic variabilities with time. The present renewable energy contribution to the energy mix in Nigeria is around 35 MW, made up of 30 MW small hydropower and 5 MW solar photovoltaic. Electricity outages are common in Nigeria's electricity sector, which operates significantly below its anticipated capacity. Blackouts are common and unpredictable for the minority of Nigerians who are linked to the electric grid. Many regions of the country go without power for days at a time. Power is frequently rationed, as towns only get electricity on alternating days, and only for a few hours at a time. To make up for such power disruptions, the industrial and commercial sectors are increasingly relying on privately owned generating units. Hence Nigerian consumers' power utilization highly depends on solar energy to follow the underpinning principles that have been regulated by the government [21].

While the energy supplied is often generalised with political investment and consumer behaviour, it is important to discuss the quality of energy which usually go unnoticed as energy quality gets abundantly low while using biomass renewable resource due to the consumption of waste residual. Another quality of energy is affected in solar and hydropower renewable sources as they use mechanical power to generate heat which later gets converted into electricity, however, that heat consumes 65% of the total energy and hence produces less electrical power supply [23]. As per the ESPR Act supported by Nigeria, it has been

stated that targets on access to electricity are expected to be met through grid-based extensions of current electrical systems, independent mini-grids for remote areas with concentrated loads where grid service is not cost-effective or will take many years to arrive, and stand-alone renewable electricity systems for remote areas with scattered, small loads.

Hence, it has been concluded that while renewable energy resources are easy to be consumed and produced in dispersed underdeveloped locations, they are expensive to form a base and require lot of concentrated innovation and technology to formulate better consumer behaviour and marketing strategies. The current position of Nigeria's use of renewable energy majorly depends of the commercial value of solar energy and biomass energy which generates better investment and profits on capital for the nation. But at the present, there are only a few of the RE sources that are being used at a commercial level, and those includes solar, wind and hydropower energy sources.

According to Kannan and Vakeesan [25], the world is switching to different sources of energy as a result of growing need of energy. This is because of technological advancement and population explosion. Thus, the need for technology or source of renewable energy, which is able to provide the population around the world, and specifically, to the population of Nigeria with energy that is sustainable. Kannan and Vakeesan [25] focused on one such RE, which is solar energy. This is a RE which is cost-effective and also, everlasting, which emphasizes its appeal of using this RE by the consumers. This is also a RE source, which is freely and abundantly available, and would not diminish for another few million years. It has been estimated that Nigeria, with a device conversion rate of 5% will be able to provide annually 1.50×10^{18} J worth of useful energy. This has been estimated to be equivalent to the energy which is created with the help of 258.62 million oil barrels, in a year [26]. This is also equivalent to the crude oil which is being produced currently in Nigeria, nationally on annual basis. But this potential of the country has not been realised, and the use of this source of RE is being used up to 0.1%, which is very less, considering the potential the country has, and the subsequent benefit from the use of this source of energy [27]. Currently, Nigeria is not producing the solar panels or cells, which uses the photovoltaic technology in order to convert the energy into electricity (from photons to voltage). Although this is a RE which is being used at a commercial level, it is still underused, and not very effective in being able to provide the value which is demanded or expected from this RE source. For promotion of use of this RE for consumers, solar farms, which would have a large number of solar cells for capturing the RE, is required. Only when this RE is adding value to the people and being

provided in a cost effective and cost-efficient manner, then the development of sustainable Integrated Marketing Communication (IMC) is possible for widespread usage of RE. Exploration of this RE is being done within the country, as it is advantageous to use this RE for Nigeria [28]. This is due to the fact that the country is located near the equator, and the large land area of the country support installation of the solar cell farms, enabling the switch which is needed by the country in order to change its energy consumption from non-renewable and resources to RE source. With the help of commercialisation and wider use of RE, the economy of Nigeria can be boosted, as the country will have the required energy sources for limitless supply, while also raising employment opportunities with the help of setting up of the RE sources at wider scale [28].

Another source of RE which has commercial value in Nigeria is hydropower energy, which is produced with the help of water, and it is also one of the oldest and most used sources of RE that is used by majority of the countries. This is a RE which Nigeria uses as part of its energy creation mix, and is also widely used within the country [21]. The population is aware and have knowledge about this RE, which makes it possible for people to have a better outlook and consumer behaviour where this RE is concerned. When it comes to exploration of this RE and its exploration in Nigeria, hydropower is one of the most prominent sources of energy. The hydro-electricity used within Nigeria constitutes 20.8% of the total amount of energy utilised by the people of the county [27]. But as per a study by Stanford, the capacity and potential of the hydropower plants is not utilised at full potential within Nigeria. The large hydropower plants are being used at 24% potential, while the smaller hydropower plants are being utilized at 4% capacity [27]. It is estimated that with the help of the potential energy generation with the help of the hydropower plants, Nigeria would be able to generate 8,824 MW of electricity on annual basis, in excess of the 36,000 GWh, which it is currently producing at present [27]. The Renewable Energy Master Plan is in place to help increase the overall use of the renewable energy of the country, and its aims to increase the overall energy generation in Nigeria using the RE to almost 23% by the year 2025 [29].

Lastly, the source of RE which is also adopted within Nigeria for energy generation and commercial use by the consumers is Wind energy, which is a RE that is generated with the help of strong winds and wind turbines. The wind turbines, which are connected to the drive shaft, move when the strong winds are flowing, and generate energy, which is stored within electricity generator which is turned on by the drive shaft [30]. As per various studies, which are focused on the cost-benefit relationship of

building the wind energy plants and turbines in Nigeria have been considered, and it is found that the country has vast opportunities when it comes to wind energy. The government is also considering these RE, including wind energy, for the generation of electricity, as evidence has been derived from the developed countries regarding development of RE plants and benefitting from energy generation which is sustainable [31]. It has been found to be particularly true for northern states, along with the mountainous regions of the eastern and central states and also, for the offshore areas, which are considered to be the regions where the wind for electricity generation would be in abundance. In a study carried out [32], the researchers focused on 15 sites for wind power generation, which would be economic and also help in generation of electricity. These sites have different capacity of generating different level of energy, and will be accordingly be provided with the wind turbine that suits the potential of each site. These sites in different region further provide the hope of generation of energy using RE, which provides sustainable source of continuous energy source.

4. Consumer Price Sensitivity and Government economic indiscipline

The government of Nigeria is heavily investing in building these RE, as these RE power plants and farms are being funded by the government. However, the presence of corruption within the system of Nigeria has hindered the investment in these RE and generation of energy (mostly electricity). Also, the consumers of the Nigeria have higher price sensitivity. This has been found in a study conducted by [34]. Although people might be willing to buy and prefer the purchase of the sustainable products, and also use of RE, but the price sensitivity of this population hinders the population to support RE and its adoption at a larger scale. It has been found in the study conducted by [6] that the consumers are often going without paying the fee for utilizing the electricity, which makes it further difficult to encourage the building of RE energy sources for generation of energy, and to further develop sustainable IMC as a result [19]. Other issues have also been identified for the adoption of RE and consumer behaviour, including the indiscipline by the consumers, lack of maintenance of the plants, lack of distribution networks that are based on the systematic studies, and helps in avoiding the extraordinary costs and losses that occur due to the haphazard expansion of the system [6]. Consumer Behaviour (CB) and IMC have been identified to resolve some of these issues. IMC is the tool which is used to spread information and promotion of RE, such as solar, wind and hydropower. IMC will be able to spread awareness, and also help in addressing

the issues that are associated with adoption of RE in Nigeria, including the price of energy, effective adoption and better awareness, and others [33].

5. Synthesis of Literature Review

The following are the synthesis of the literature review conducted concerning this paper:

- Renewable Energy (RE) is being considered a major part of development for the economic and technological growth in the region of Nigeria while considering the growth of sustainable development within the country [24].
- There appears to have a very limited amount of knowledge over the consumers' behaviour regarding the demand and supply of energy consumption in Nigeria [19].
- Despite Nigeria's status as Africa's most populated country, the country's economic progress has been hampered by a lack of energy supplies [5].
- Due to lack in harnessing the proper usage of these resources and insufficient knowledge amongst the general population, Nigeria remains underdeveloped in consumption of energy supplies as compared to other developing nations [1].
- There is a lack of structural approach by Nigerian government to promote the proper usage of these RE tools and techniques for better economic growth [4].
- Nigeria's economic development is possible through certain RE's that hold the power and commercial value in the nation. Solar and Biomass energies are majorly used energy resources that have made an important contribution to the renewable system for Nigerian people [11].
- The Federal Ministry of Environment in Nigeria has concluded that Nigeria lacks in its production of energy through wind power and geothermal power sources as the country's inner crust cannot produce much heat and there seems to be lack of finance and investment [19].
- Nigeria's another part heavily depends on their usage of hydropower that constitutes 20.8% of the total amount of energy utilised by the people of the county [27].
- Nigeria has also developed their energy mix through certain underpinning principles such as energy planning, end-result of energy on time and power utilization for future use [21].
- Furthermore, the RE source requires modernism and technological innovation in their IMC

through which it can add value to the people and provide a cost effective and cost-efficient manner, hence the development of sustainable IMC is possible [28].

- Lastly, the government of Nigeria is identifying and investing in problems such as proper power generation from energy tools that might help with sustainable IMC amongst the country [34].

The exploration of literature reveals that Nigeria's economic development is possible through certain RE's that hold the power and commercial value in the nation. Solar energy, hydropower energy and Biomass energy are majorly used energy resources that have made an important contribution to the renewable system for Nigerian people, while the country still lacks innovative ways to developing wind and geothermal energy supplies. It is clearly demonstrated in the review that Nigeria's RE source requires modernism and technological innovation and the application of IMC tools which can add value to the people and provide a cost effective and cost-efficient manner to the consumers.

6. Methodological Approach

This paper proposes methodological that has objectivism as its ontological position, while its research philosophy is both positivism (deductive) and interpretivism (inductive) [37]. The strategy adopted here is the survey and the instrument used is the questionnaire. The tools and techniques for analysis are the SPSS tools such as Factors analysis for validity of the questionnaire, Cronbach's Alpha for reliability of the questionnaire.

The approach of descriptive statistics helps in drawing major kind of inferences about the estimation of parameters and populations [38].

6.1. Limitation study

The assumptions made from the selected sample and hoped to generalized to the population may be rather to small for a population of 200 million people in different regions and cultures of the country. Also, the cost and finance as well as political factors may hinder the application of relevant innovative use of RE raw materials as technology is not readily available. Still, Nigeria has fossil fuel in abundance as major source of foreign reserve and high price of RE may prevent political will and consumers to focus on RE.

6.2. Initial Findings

The initial results of the preliminary study show that Nigeria government is aware that innovation and technology and consumer demands are known to ameliorate energy challenges [43]. Also, the Nigeria

Renewable Energy Plan Model controls the flow of electrical energy consumption since 2015 and has attempted to reach 100% usage of electricity in Nigeria by 2030 [35]. Furthermore, Nigeria policy makers have analysed the proper integration of solar, wind, hydropower and biomass energy for natural energy to different sectors through dynamic modelling that can help with energy consumption, proper power production and carbon usage reduction in Nigeria.

The Federal Ministry of Environment in Nigeria has implemented certain energy plans that take care of investment in energy utilization, carbon emission and degradation of air, production of electricity through mass supply of renewable energy [36]. The consumption and the financial articulation of these energies have become a huge issue for Nigeria as the costs of usage requires a high amount of investment which may invariably affect the RE consumer price (see Figures 1 and 2).

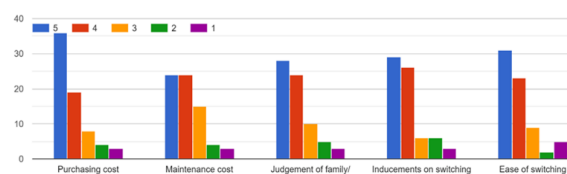


Figure 1. What Factor Influence your Decision-Making while Choosing RE Products?

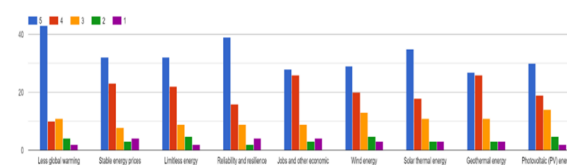


Figure 2. What are the Benefits of RE which Influence your Decision to Consume RE? Rate them

The demand for sustainable energy is growing, but the widespread use of renewable energies is crucial to achieving sustainability in the energy sector in Nigeria [40]. Once Nigeria renewable resources are fully exploited and used, they will lead to reduced demand on fossil fuel and sustainable development [41]. Renewable energies and advanced technologies are the basic components of sustainable development.

Practices in Nigeria's industrialization process have been described as unsustainable for the climate [42]. The study shows that ecological degradation can have a variety of structures, as seen in the unsustainable use of natural resources extracted in the Niger Delta in Nigeria in which Ogoni land is hard hit [39].

7. Proposed Contribution

It is proposed that this paper will add to the knowledge base on the adoption of innovative use of RE raw materials as part to the Nigeria energy mix to mitigate against the shortage of power.

Also, it will contribute to government policy change that will enhance social, economic, and environmental impact as well as citizens wellbeing and technological developments.

8. Recommendations

It will be helpful for Nigeria government to establish an organisation to promote the use of energy efficient products and ensure correct practices which will promote the environmental consciousness among citizens. The establishment of a public enlightenment agency will be helpful to promote the usage of renewable energies e.g. solar and wind, while leveraging on global partnerships like the UK's Residential Energy Efficiency Project to help the country build a creative alliance for renewable energy systems. Furthermore, the creation of renewable energy financing or lending institutions, such as the Indian Renewable Energy Agency in India will help to provide foreign investment in Nigeria RE system, and the Clean Energy Office can be integrated with all sectors of the Nigerian economy as driver for implementation of various government policies on RE.

In future work, a wider critical review of government policies and implementations will help in offering energy solutions to Nigeria, while further study in available and affordable technology that adds innovation to the use of RE raw materials will go a long way in promoting uptake of RE by consumers.

9. Conclusion

The Study and findings reveal that people are influenced by factors such as price of the energy, need for sustainability, less global warming, stable price of energy, ease of switching, and other factors. It is important that these issues are recognised and future study is conducted so that these issues can be resolved in Nigeria and adoption of RE can be made possible in Nigeria. Since the beginning of electricity generation in Nigeria, all established laws and institutional methods have tried to achieve the development of the electricity grid and thus expand the country's electricity market. These efforts have not yet fully yielded results, so outside the grid, limited generation of electricity from renewable energies is urgently needed as an effective and sensible regulation.

10. References

- [1] Olanipekun, B. A. and Adedokun, N. O. (2020). Assessment of renewable energy in Nigeria: challenges and benefits. *International Journal of Engineering Trends and Technology (IJETT)*–Volume, 68.
- [2] Brundtland, C. (1987). *Our Common Future*. New York. United Nations.
- [3] Giddens, A. (2009). *Sociology*. 6th edition, Cambridge. Polity Press.
- [4] Adebajji, B., Ojo, A., Fasina, T., Adeleye, S. and Abere, J. (2022). Integration of Renewable Energy with Smart Grid Application into the Nigeria's Power Network: Issues, Challenges and Opportunities. *European Journal of Engineering and Technology Research*, 7(3), pp.18-24.
- [5] Akorede, M. F., Ibrahim, O., Amuda, S. A., Otuoze, A. O. and Olufeagba, B. J. (2017). Current status and outlook of renewable energy development in Nigeria. *Nigerian Journal of Technology*, 36(1), pp.196-212.
- [6] Oyedepo, S. O. (2012). Energy and sustainable development in Nigeria: the way forward. *Energy, Sustainability and Society*, 2(1), pp.1-17.
- [7] Oyedepo, S.O. (2014). Towards achieving energy for sustainable development in Nigeria. *Renewable and sustainable energy reviews*, 34, pp.255-272.
- [8] Bazilian, M., Nussbaumer, P., Rogner, H. H., Brew-Hammond, A., Foster, V., Pachauri, S., Williams, E., Howells, M., Niyongabo, P., Musaba, L., and Gallachóir, B. Ó. (2012). Energy access scenarios to 2030 for the power sector in sub-Saharan Africa. *Utilities Policy*, 20(1), pp.1-16.
- [9] Ibrahim, I. D., Hamam, Y., Alayli, Y., Jamiru, T., Sadiku, E. R., Kupolati, W. K., Ndambuki, J. M., and Eze, A.A. (2021). A review on Africa energy supply through renewable energy production: Nigeria, Cameroon, Ghana and South Africa as a case study. *Energy Strategy Reviews*, 38, p.100740.
- [10] Emodi, N. V., and Boo, K. J., (2015). Sustainable energy development in Nigeria: Overcoming energy poverty. *International Journal of Energy Economics and Policy*, 5(2), pp.580-597.
- [11] Twidell, J. (2006). *Principles of renewable energy*. In *Renewable Energy Resources* (pp. 23-50). Routledge.
- [12] Mutezo, G. and Mulopo, J. (2021). A review of Africa's transition from fossil fuels to renewable energy using circular economy principles. *Renewable and Sustainable Energy Reviews*, 137, p.110609.
- [13] Aliyu, A. S., Dada, J. O., and Adam, I. K. (2015). Current status and future prospects of renewable energy in Nigeria. *Renewable and sustainable energy reviews*, 48, pp.336-346.

- [14] Jekayinfa, S. O., Orisaleye, J. I., and Pecenka, R. (2020). An assessment of potential resources for biomass energy in Nigeria. *Resources*, 9(8), p.92.
- [15] Ogbonnaya, C., Abeykoon, C., Damo, U.M., and Turan, A. (2019). The current and emerging renewable energy technologies for power generation in Nigeria: A review. *Thermal Science and Engineering Progress*, 13, p.100390.
- [16] Oniemola, P. K. (2011). Integrating renewable energy into Nigeria's energy mix through the law: lessons from Germany. *Renewable Energy L. and Pol'y Rev.*, 2, p.29.
- [17] Ayodele, T. R., Ogunjuyigbe, A. S. O. and Amusan, T.O. (2016). Wind power utilization assessment and economic analysis of wind turbines across fifteen locations in the six geographical zones of Nigeria. *Journal of cleaner production*, 129, pp.341-349.
- [18] Uduma, K. and Arciszewski, T. (2010). Sustainable energy development: the key to a stable Nigeria. *Sustainability*, 2(6), pp.1558-1570.
- [19] Ley, K. (2015). The Nigerian Energy Sector: An Overview with a Special Emphasis on Renewable Energy, Energy Efficiency and Rural Electrification.
- [20] Sovacool, B.K. (2012). Design principles for renewable energy programs in developing countries. *Energy and Environmental Science*, 5(11), pp.9157-9162.
- [21] Fakehinde, O. B., Fayomi, O. S., Efemwenkieki, U. K., Babaremu, K. O., Kolawole, D. O., and Oyedepo, S. O. (2019). Viability of hydroelectricity in Nigeria and the future prospect. *Energy Procedia*, 157, pp.871-878.
- [22] Nwozor, A., Owoeje, G., Olowojolu, O., Ake, M., Adedire, S., and Ogundele, O. (2021, February). Nigeria's quest for alternative clean energy through biofuels: an assessment. In *IOP Conference Series: Earth and Environmental Science* (Vol. 655, No. 1, p. 012054). IOP Publishing.
- [23] Ben-Iwo, J., Manovic, V. and Longhurst, P. (2016). Biomass resources and biofuels potential for the production of transportation fuels in Nigeria. *Renewable and sustainable energy reviews*, 63, pp.172-192.
- [24] Joshua, O. O., Michael, O. O. and Ufua, D. E. (2020). The legal regime on renewable energy as alternative sources of energy in Nigeria's power sector: the impacts and the potentials. *Academy of strategic management journal*, 19(3).
- [25] Kannan, N., and Vakeesan, D. (2016). Solar energy for future world: -A review. *Renewable and Sustainable Energy Reviews*, 62, pp.1092-1105.
- [26] Stanford, (2022). Renewable Energy in Nigeria. <http://large.stanford.edu/courses/2017/ph240/nwagbo2/> (Access Date: 25 April 2022).
- [27] Statista, (2022). Distribution of electricity generation in Nigeria in 2020. <https://www.statista.com/statistics/1237541/nigeria-distribution-of-electricity-production-by-source/> (Access Date: 25 April 2022).
- [28] Ho, S. M., Lomi, A., Okoroigwe, E. C., and Urrego, L. R. (2019). Investigation of solar energy: The case study in Malaysia, Indonesia, Colombia and Nigeria. *International Journal of Renewable Energy Research*, 9(1).
- [29] International Trade Administration, (2021). <https://www.trade.gov/country-commercial-guides/nigeria-electricity-and-power-systems> (Accessed 22/12/2022).
- [30] Ajayi, O.O., Fagbenle, R.O. and Katende, J. (2011) Wind Profile Characteristics and Econometric Analysis of Wind Power Generation of a Site in Sokoto State, Nigeria. *Energy Science and Technology*, 1, 54-66.
- [31] Idris, W.O., Ibrahim, M.Z., Albani, A. (2020). The Status of the Development of Wind Energy. https://scholar.google.co.uk/scholar_url?url=https://www.mdpi.com/1996-1073/13/23/6219/pdf&hl (Access Date: 18 January 2023).
- [32] Ayodele, T.R., Ogunjuyigbe, A.S., and Amusan, T.O. (2016). Wind power utilization assessment and economic analysis of wind turbines across fifteen locations in the six geographical zones of Nigeria. <https://www.researchgate.net/publication/312210591> (Access 8/02/2023).
- [33] Sharyan, E., Karimova, I. and Bagdasarova, E. (2019). Green economy: a role of IMC in formation of public consciousness. In *E3S Web of Conferences* (Vol. 135, p. 04011). EDP Sciences.
- [34] Ogiemwonyi, O., (2022). Factors influencing generation Y green behaviour on green products in Nigeria: An application of theory of planned behaviour. *Environmental and Sustainability Indicators*, 13, p.100164.
- [35] Okonkwo, C., Osho, I.W., Bamsile, O, Abid, M., Al-Ansari, T, (2021). Grid integration of renewable energy in Qatar: Potentials and limitations. In *Energy Volume* 235, 15.
- [36] Newsom, C. (2017). Renewable Energy Potential in Nigeria: Low-carbon Approaches to Tackling Nigeria's Energy Poverty. The Sungas Project. International Institute for Environment and Development. Retrieved on June 14th.
- [37] Rahi, S. (2017). Research design and methods: A systematic review of research paradigms, sampling issues and instruments development. *International Journal of Economics and Management Sciences*, 6(2), pp.1-5.
- [38] Hardwick, S. W. (2016). Case study approach. *International Encyclopedia of Geography: People, the Earth, Environment and Technology: People, the Earth, Environment and Technology*, pp.1-6.
- [39] Wojuola, R.N. and Alant, B.P. (2017). Public perceptions about renewable energy technologies in Nigeria. *African Journal of Science, Technology, Innovation and Development*, 9(4), pp.399-409.

[40] Ogbeibu, S., Senadjki, A., Emelifeonwu, J., Gaskin, J., and Pereira, V. (2021). Augmenting environmental sustainability through the exchange of green creative ideas—evidence from an emerging economy. *Sustainable Production and Consumption*, 26, pp.275-287. World Bank Group. 2020. Global Gas Flaring Tracker Report. <https://pubdocs.worldbank.org/en/503141595343850009/WB-GGFR-Report-July2020.pdf>. Last (Access 28/08 2021).

[41] Lau, L. S., Senadjki, A., Ching, S. L., Choong, C. K., Seow, A. N., Choong, Y. O., and Wei, C. Y. (2021). Solar photovoltaic as a means to sustainable energy consumption in Malaysia: the role of knowledge and price value. *Energy Sources, Part B: Economics, Planning, and Policy*, pp.1-21.

[42] Huan, N. Q., and Hong, T. T. T. (2021). Role of Corporate Social Responsibility in Sustainable Energy Development in Emerging Economy. *International Journal of Energy Economics and Policy*, 11(2), p.172.

[43] Stankevich, A., Yusuf, Y.Y., Gunasekaran, A. (2017). Explaining the consumer decision-making process: Critical Literature review. *Journal of international business research and marketing*, 2(6), pp.7-14.