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Research Article

A Systematic Review on the Renewable Energy Development, Policies and Challenges in Nigeria with an International Perspective and Public Opinions

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Abstract. Due to the threat posed by fossil fuels to human existence, many countries worldwide have turned attention to renewable sources for power generation to reduce the emission of greenhouse gases and stop ozone layer depletion. This has increased the exploitation of various renewable energy sources, which include: hydro, biomass, solar, geothermal, and wind, in many developed countries. However, most African countries seem not to have awakened to this new reality. This work presents a comprehensive review of available renewable energy capacity in Nigeria, the level of utilization of renewables in Nigeria in comparison to other countries, comparison of renewable energy scenarios among African countries, factors hindering the development of renewables in Nigeria, the country's renewable energy policy and ways of improving its status in the country. Many peer-reviewed journal articles and grey literature were gathered from which the most suitable ones were selected for review. In addition, opinions of people across the country and beyond regarding renewable energy status in Nigeria were sought through a questionnaire. It is found that Nigeria is greatly endowed with different renewable energy sources. However, the level of utilization has been very low due to a myriad of factors such as the non-implementation of renewable energy policies, financial issues, unfavorable government policies, and lack of adequate research. The authors believe that the findings in this work will awaken policies makers in Nigeria to reshape her renewable energy policies and speed up their implementation, and guide individuals wishing to invest in the nation's vast renewable resources.

Keywords: Energy Policy in Nigeria, Public Opinion, Renewable Energy in Nigeria, Prospects of Renewable Energy in Nigeria, Renewable Energy Potentials in Nigeria, Global/African Renewable Energy Scenario.

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1. Introduction

Nigeria has the most significant populace in Africa, with over 200 million individuals. It is one of the most populated nations in the world (Alao & Awodele, 2018). Despite the above assertion, Nigeria is among the least in terms of access to electrical power worldwide. More than half of her populace living within the farther range has no or limited access to power (Eberhard, Gratwick, Morella, & Antmann, 2016). Nigeria's current power generation capacity is 10,480MW, with actual generation of less than 4500MW, by which 37% is from the gas turbine, 38% from hydroelectric plants, and 25% from combine (gas and steam plants). The projection is that by 2020, Nigeria's generation capacity will be more than 40GW and the energy mix will be 4% renewable, 69% thermal generation, 17% hydroelectric and 10% coal (Solicitors, 2016; Uchegbulam, Opeh, & Atenaga, 2014). However, the national prediction of 40 GW by 2020 have not been met, which have now been attributed to the Coronavirus pandemic. In (Falobi, 2019) it was pointed out that Nigeria can only achieve and maintain her predictions in energy generation through quick interventions from the available, underutilized and untapped renewable energy potentials. The research carried out by (Alao & Awodele, 2018) critically looked into the current electrification rate in the six geopolitical regions of Nigeria and proposed using off-grid sun-oriented PV to improve power availability within the provincial zones and urban areas.

The Nigerian Electricity Power Authority (NEPA), which was established in 1986, was saddled with the responsibility to pioneer power control issues in Nigeria (Alao & Awodele, 2018). In the late 1990s, it failed to meet the increasing demand for electricity by the citizens. The Nigerian energy control division was founded by the National Electric Power Policy (NEPP) in 2001. This metamorphosed into the Electric Power Sector Reform Act (EPSRA) in 2005, which gave birth to the Power Holding

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Company of Nigeria (PHCN) (KPMG, 2016). The EPSRA similarly created the Nigerian Electricity Regulatory Commission (NERC), which is in charge of tariffs, codes, license and policies. In 2010, the Roadmap for Power Sector Reform (RPSR) led to full privatization of the distribution company, but the transmission and generation company is still controlled entirely by the Government (Eberhard, Gratwick, Morella, & Antmann, 2016). The transmission company of Nigeria (TCN) are controlled by each State Government in Nigeria. TCN is the mediator between power provided from the plants (GENCOs – Generation Companies) and dissemination companies (DISCOs – Distribution Companies). Nigeria has twenty-five (25) DISCOs connected to the power grid. They are of three (3) categories; Independent Power Producers (IPP), this is often possessed and overseen by the state governments and/or peoples or private companies, National Integrated Power Projects (NIPP), this category is possessed by the Niger Delta Power Holding Company and it is overseen by the three (3) tiers of government in Nigeria (Federal, State and Local), and Successor Generations (SG) companies, completely possessed by the Federal Government of Nigeria (KPMG, 2016).

The setback that power generation in Nigeria is facing is inadequate gas supply. Twenty-two (22) out of the twenty-five (25) power plants connected to the national grid are thermal based plants (Idrisu, 2015). Despite that Nigeria has large gas reserve, due to lack of infrastructure, about 3.56 billion Standard Cubic Feet (bscf) is flared out of 8.9 bscf produced daily. Nevertheless, just 1.4 bscf is what GENCOs need to operate at maximum capacity but only 0.9 bscf is provided to the plants and the rest to other segments of the nation (Solicitors, 2016). Scarcity of gas supply to the plants limits the utilization of the plant's capacity. The transmission company of Nigeria is divided into three (3) diverse categories; the Transmission Service Provider (TSP), the Market Operator (MO), and the System Operator (SO). The TSP has the responsibility to carryout system development and maintenance of transformer substations. Additionally, they plan and develop transmission lines. The Market Operator (MO) execute market rules while the System Operator (SO) monitor the transmission system, guaranteeing unwavering quality and security (Oleka, Ndubisi, & Ijemaru, 2016). The distribution companies in Nigeria are eleven (11) which spread over the six geopolitical zones in Nigeria. They incorporate; Abuja, Benin, Enugu, Ibadan, Jos, Kaduna, Kano, Eko, Ikeja, Yola and Port Harcourt Electricity Distribution Company (NERC, 2016). The transmission company conveys power to the distribution companies that sign the Power Purchase Agreement (PPA) with the Nigerian Bulk Electricity Traders (NBET). NBET is the agency established by the Federal Government that is responsible for the purchase and resale from successor generation companies, IPPs and NIPPs (Justin *et al,* 2021).

The electrical power is being transferred from the generating station to the electrical energy consumers and this process is done by transmission and distribution. The generation and transmission systems in Nigeria make use of a 3-phase 3-wire system while the distribution systems make use of a 3-phase 4 wires or 1-phase 2 wires system depending on the requirements of the energy consumers. Electrical energy in Nigeria is generated at voltages 11.5 kV – 16 kV and increased by a power transformer to 330 kV for transmission. It is at this point that Transmission Companies (TRANSCOs) begin their operation with the use of overhead cable. Transmission begins with the transportation of the 330 kV along transmission lines and is reduced by another power transformer to 132 kV at the transmission substation. This voltage is further conveyed along transmission lines to Injection substations and further brought down to 33 kV by the substation transformer. Distribution firms are taking over the transition of power at this point. The voltage is reduced to 11 kV by a distribution transformer, which in turn is reduced to 415 V that are utilized by industrial facilities or 240 V for customers' homes and workplaces (NESO, n.d).

This report is limited to a review of Nigeria's renewables energy growth, policies and challenges in comparison with other African as well as non-African countries that are key players in renewable power generation. Opinion of people about the status and challenges of renewable power generation in Nigeria was also sort to further evaluate our findings.

2. Methodology

The methodology utilized in this review is mostly focused on finding relevant material from academic or grey literature. This approach is required and critical for the completion of this comprehensive study. The data is organized using a framework based on keyword searches with a methodical approach. First and foremost, extensive talks are held to determine the keywords. The keywords for information sourcing of grey and academic literature are chosen based on the talks. Academic literature refers to publications published in official Conferences and Journals. On the other hand, grey literature refers to technical reports and policy-related studies (Rajvikram, *et al*., 2020).

The most widely used research database, such as the Web of Science (WoS), was used in this investigation. Web of Science's main indexing databases is covered by the keyword search. We made sure that only peer-reviewed publications from the WoS database were considered during data gathering. Thousands of publications were found during the academic literature search. However, only about 900 were examined during the initial screening. The 900 articles were then pre-processed further to select the most relevant papers for the comprehensive review, and the articles that were judged to be unsuitable were deleted. A total of 840 items were rejected throughout the screening process. A manual vetting method is used to determine the eligibility of the articles for review. Following that, just 60 articles were deemed the most appropriate, and they were incorporated into the academic literature. In the public and private sectors, grey literature-related material is comprehensively identified in technical reports and official helpful websites of various organizations in the fields of energy, environment, policy, and economic development. There are 70 sources of information in grey literature, 29 of which are technical reports, and 16 of which are web resources. This evaluation method involved the utilization of 105 documents in total. In addition, public opinions were collated and analyzed using various statistical methods.

3. The Status and Potential of Renewable Energy on a Global Scale

The quest to ensure energy demand-supply balance and the current need to adhere to the Paris agreement under the United Nations Framework Convention on climate change (UNFCCC) which seeks to address the rise in global greenhouse gas emissions, has led international countries to tap from the vast renewable energy sources that exist and hence bolster their energy capacity. This has been discussed in the work of (Pazheri, Othman, & Malik, 2014), where energy demand in the U.S. in 2013 was tagged at 546 Quad-billion British thermal units (BTU) and projected to attain 820 Quad-billion btu by the year 2040. By statistical analysis of this work, it depicts that about 50.18% energy demand growth will be experienced in 27 years which averages 1.86% per annum. Energy capacity record in (Alnaser & Alnaser, 2011) also proved the increasing energy demand in Gulf Cooperation Council (GCC) countries such as United Arab Emirates, Saudi Arabia, Qatar, Kuwait, and Bahrain, where 12.4% energy growth occurred from the year 2005 to 2009 and projections made to be about 9.5% annually. These results have shown that before the year 2015, most international communities experienced an energy demand-supply imbalance.

a) Hydropower

To achieve energy equilibrium, through lump additional power generation capacity, international communities have resorted to tapping from the vast renewable energy sources within their respective countries as well as trying to attain the sustainable development goals (SDGs) 7 and 13, which seeks to ensure that countries achieve affordable/clean energy and favourable climatic condition respectively. As proof of this, (Wang & Yang, 2011) has reported that countries like Brazil, Canada, China, the USA, and Russia are the five countries that have half of the world's hydropower generation capacity. This goes to a long extent to show that these countries are eager to improve their energy capacity through hydroelectric power, which is readily available and abundant.

b) Wind Power

Another alternative renewable energy source actively tapped by international communities such as China, Spain, India, the USA, Germany, Italy, France, Portugal, and Canada is wind. The work in (REN21, 2013) discussed more on the wind power capacity generated in the listed countries in 2012. A graphical representation of the wind power capacity levels of the 10 countries is as depicted in Figure 1. Figure 1 shows that Germany is the country that tapped the highest level of wind power in the world in the year 2012 with about 96 GW which is approximately 31.65% of the total wind power generated by the 10 countries.

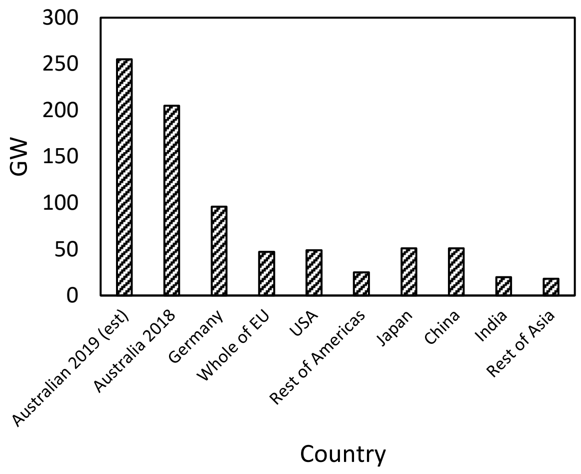

Fig 1. Wind power capacity at year 2012 (REN21, 2013)

Concerning the per capita wind power availability of 7 international communities discussed in (Sahu, Hiloidhari, & Baruah, 2013), it was clearly stated that Denmark, Spain, Portugal, Brazil, China, USA, and India have per capita wind power availability of 0.70, 0.469, 0.379, 0.008, 0.047, 0.15 and 0.013 $kW capita^{-1}$ respectively. This suggests that more populated countries with specified wind power capacity had the lowest per capita wind power availability. This is due to an increased population and power generation densities. The mean per capita wind power generated by these 7 countries is rated at 0.252 kW/capita, which connotes that only 42.86% of the 7 countries exceed the mean per capita wind power generated with a mean deviation of 0.448, 0.217 and 0.127 kW/capita, respectively.

According to the work in (Alnaser & Alnaser, 2011), the Sultanate of Oman in 2008 established Salalah power station, which generated electricity using five wind turbines having a height of 80m and a rotor diameter of 90m to generate a total power capacity of 10 MW which constituted 3% of the total electrical power generated in the station with other percentages evenly split across other forms of energy sources. This depicts that of the 10 MW power generated by the station, about 0.3 MW, which equates to 300 kW power was generated by wind, with each wind turbine generating approximately 60 KW of power. Reports made in (Alnaser & Alnaser, 2011) (Pazheri, Othman, & Malik, 2014) respectively shows that wind turbines with tub heights of 50 m and wind speed of 6 m/s generated approximately 5700 MW of power in Bahrain as of the year 2012 while a total of 53 offshore wind farms created in Europe generated a whooping 3813MW of power at the end of the year 2011. Sequel to this, it entails that if consistent and equal yearly power generation capacity is maintained in Bahrain and Europe, then by the end of the year 2020, Bahrain should have a total generating capacity via wind as 45.6GW, while in Europe, the value should be within the neighbourhood of 34.3GW. This speaks of the tremendous amount of wind power generated in most international communities.

Towards the end of the year 2011, about 53 offshore wind farms were built in Europe with a total capacity of 3813MW (Alnaser & Alnaser, 2011) which in (Wilkes, Moccia, Genachte, Guillet, & P., 2012), Walney wind farm sited in the U.K. generated a total of 367 MW making it to become the largest offshore wind farm in the U.K. This data proves with a great conclusion that Europe happens to be part of the world's continents to have a high amount of power generated through the wind. To prove the fact that Europe is still in the race to tap enough amount of power from wind, made (IRENA, 2019) to clarify that as of the year 2018, North America, Europe, Asia, Latin America, and Oceania to generate wind powers which are 107 GW, 164 GW, 231 GW, 25 GW, and 7 GW while the African continent is generating a meagre 6 GW. This suggests that most international communities generate a total of 534 GW, with Europe and Asia having 30.71% and 43.26% of this total amount of power.

c) Solar

The growing need for a reliable and available renewable energy resource has made most international communities opt for solar energy for power generation. The solar plants which generate power are in (Pazheri, Othman, & Malik, 2014) discussed to be in the form of a Photovoltaic (P.V.) plant or a concentrated solar plant (CSP) where the former uses wafer-based crystalline silicon (c-Si) and thin-film amorphous silicon (a-Si) while the latter uses parabolic trough and solar tower. A critical review of work in (Pazheri, Othman, & Malik, 2014) showed that as of the year 2012, out of the total 17GW power generated by top European countries, Germany, China and Italy had the highest power capacity generated through solar P.V. cells while non-European countries produced a total of 13.9GW. An analysis made on this work shows that Germany had 44.73% of the total power generated from Europe. Also, of the 30.9 GW power generated globally in 2012, European countries have 55.02% while non-European countries generated 44.98%.

In 2019, solar P.V. in Australia exceeded 2 GW, which accounts for the 6-7 GW renewable energy deployed (Blakers, Stocks, Lu, Cheng, & Stocks, 2019). In 2007, solar P.V. was used in Germany to generate a power of 4000 MW. In Spain, they were used to generate 550MW, while other countries like Japan and the U.S. used a few amounts of power (Arent, Wise, & Gelman, 2011). In line with this, Australia tapped into 33.33% of the total renewable energy sources that exist as of 2019, while Germany and Spain had a combined power generating capacity of 4550 MW. A graphical representation of the watts per person per year of the power generated by different countries is given in Figure 2.

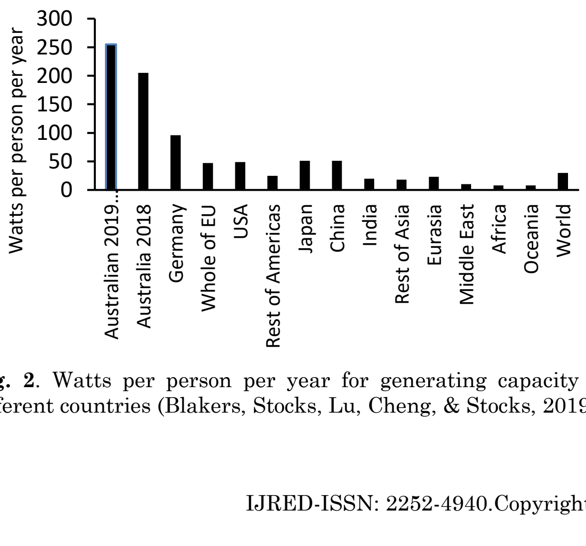

Fig. 2. Watts per person per year for generating capacity of different countries (Blakers, Stocks, Lu, Cheng, & Stocks, 2019)

d) Geothermal

In 2012, the U.S. had 3.4 GW; the Philippines had 2GW; Indonesia had 1.3 GW; Mexico had 0.8GW (Ellabbana, Abu-Rubb, & Blaabjerg, 2014). Also, towards the end of 2012, Mexico produced 1% of geothermal power from 62 GW of energy generated. Mexico currently stands fourth (4th) in the world with respect to geothermal power generation (Flavin, Gonzalez, Majano, & Ochs, 2014). Also, in 2011, central America harnessed 5% of the 12 GW power generated through different energy sources (Flavin, Gonzalez, Majano, & Ochs, 2014). This clarifies that Mexico converted 620MW of geothermal power into electricity in 2012 while the whole of America used 600 MW of power, which can be deduced that the ratio of power generated by Mexico in 2012 to that generated by the whole of America in 2011 is 1.03:1.

e) Biomass

In 2012, the Caribbean tapped biomass energy which was 0.2% of a total of 20GW of power generated, while Brazil tapped biomass energy worth 8% of the 123GW in 2012 (Flavin, Gonzalez, Majano, & Ochs, 2014). Also, in the Southern Cone, which covers Argentina, Chile, Paraguay, and Uruguay, total biomass energy of 1% of the total 63 GW was tapped, with Argentina having over half of the value (Flavin, Gonzalez, Majano, & Ochs, 2014). This means that the Caribbean tapped a total of 4 GW, Brazil 9.84 GW, and Argentina, a massive 31.5 GW of biomass power converted to electricity. Also, in (Leontopoulos & Arabatzis, 2020), between 2007–2017, an average of 8935 PJ per year have been produced, of which 88.2% consisted of fossil fuels, 7.2% of renewable sources, 3.4% of coal, 1.2% of nuclear while biomass comprises only the 4% of the total energy production.

Analysis of renewable energy potentials shows that by 2022, China, Brazil, Canada, the USA, and Russia will reach around 180 GW of power generated by hydropower (University, 2012). This is because of the creation of more dams within those countries. As of the year 2005, China had 5 dams in operation, which generated a power capacity of 760 MW to 22.5 GW, but because of the discovery of more water enclosures along the Yangtze River, 11 more dams have been created to meet up with an installed capacity of 300 GW by the year 2030 (Meisen & Hawkins, 2008). This proves that China intends to bolster its power capacity through hydropower by a whopping 1333.33% within 25 years, suggesting an annual generation growth rate of 111.11%. Concerning geothermal energy, countries such as the U.S., Philippines, Indonesia, and Mexico are currently in headway to devise ways of increasing their power capacity to a range between 140 GW and 160 GW with potential installed capacity reaching up to 800 GW (Ellabbana, Abu-Rubb, & Blaabjerg, 2014). Considering the data obtained in (IRENA S., 2020), the summary of the total installed capacity for the different sources of energy are given in Figure 3.

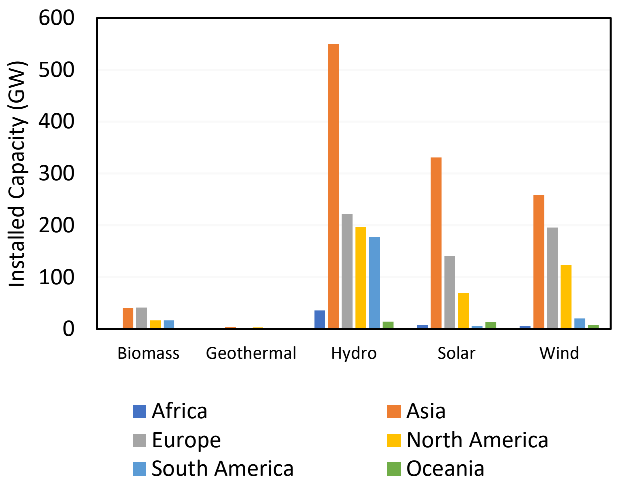

Fig 3. Different installed renewable capacity by continent.

From the data in Figure 3, it shows that for the year 2019, the overall installed capacity of biomass is 118.86 GW, with Europe and Asia having greater biomass energy installed that stands at 41.6 GW (35%) and 40.52 GW (34.09%), with Africa having a meagre 1.71 GW (1.44%). Asia surpasses other continents in the installed capacities of geothermal, hydro, solar, and wind in percentages of 39.52%, 45.97%, 58.14%, and 42.21%, with Europe following a close trend while Africa still battles with low installed capacities of 7.16%, 3.0%, 1.31%, and 0.94% respectively. This goes a long way to show how Africa is yet to tap from the vast renewable energy sources. However, it is also deduced that hydro and solar energy sources constitute the most tapped energy sources in the world.

4. Renewable Energy Prospects and Initiatives Taken to Ensure Progress

The exploitation of renewable energy resources in Nigeria began more than five decades ago (1968) with the installation of the Kainji hydropower plant in Niger state. Since then, exploitation of other renewable sources has been going on but at a very sluggish pace. Various renewable power projects, including hydro, wind, and solar P.V. in Nigeria, have been reported by various authors. In contrast, other renewables such as solar thermal, biomass, geothermal, wave, and tidal energy have not been exploited.

Naturally, Nigeria has abundant reserves of intermittent renewable energy sources as well as non-renewable energy that are largely untapped and under-utilized (Adewuyi, Shigenobu, Senjyu, Lotfy, & Howlader, 2019). An off-grid renewable energy intervention, Operation Light-Up Rural Nigeria (OLRN), was developed by the Federal Ministry of Power in 2014. The purpose of OLRN is to empower pastoral communities in Nigeria to have access to power. Pastoral communities have fewer than twenty thousand individuals, more prominent than ten kilometers from the metropolitan area and less than twenty kilometers from the nearest 11 kV line. Also, the land area is below 200 sq. meters (Elusakin, Ajide, & Chuks, July 2014). In agreement with Schneider Electrics of France and Philips Electronics of the Netherlands, the OLRN projects have been commissioned in rural areas. The Federal Ministry of Power is also initiating Renewable Energy Micro Utilities (REMU) and other foreign companies. According to recent figures, however, the off-grid authorization of the National Electricity Regulatory Commission is just 350 megawatts, compared with 19,470 megawatts for on-grid plants. The analysis demonstrates that Nigeria has not harnessed its capacity for renewable energy for off-grid systems (GIZ, 2015). Although there are a few notable renewable power projects in Nigeria, such as the 7.1 MW solar hybrid project for Bayero University in Kano State and the 2.8 MW solar hybrid project for Alex Ekwueme Federal University in Ebonyi state (Smart Energy International, 2019), Nigeria's available renewables sources is still greatly under-exploited. Researchers have explored various renewable energy sources in Nigeria. Some of these sources are presented hereunder:

4.1 Review of Hydro Power Projects in Nigeria

One of the main sources of power productions in Nigeria is from Hydro Power plants. As previously reported, it contributes more than 30 percent of the total installed capacity. This is due to the country's availability of large rivers; many still untapped. The current electricity supply crisis will be alleviated by the proper maintenance and implementation of further projects to exploit the untapped hydropower potentials in the region. Natural contamination related to the utilization of fossil fuels will be drastically decreased (Aliyu, Dada, & Adam, 2015). Numerous possible sites have been distinguished over the nation for Small Hydro Power (SHP). SHP is a hydropower station capable of generating 10 MW of energy in Nigeria. The SHP potential is exceptionally huge considering its accessibility of different sources in numerous parts of the nation. Such capacity can be used to improve power generation for rural, off-grid, and grid customers. SHP total electricity generation has been estimated to be within 3500 MW, almost more than the present total generation capacity (TSERN, 2014). Developing these identified SHP sites will help to improve Nigeria's energy sector.

Hydroelectric power is the oldest renewable power generation technology that was exploited in Nigeria. The oldest hydropower projects are the 760 MW Kainji Hydro Power commissioned in 1968, 576.8 MW Jebba Hydro Power in 1985, and the 600MW Shiroro Hydro Plant of 1990, all in Niger state (Falobi E. O., 2019). Hydropower, apart from being renewable and environmentally friendly, is also one of the cheapest energy sources (Akuru & Okoro, 2014). Nigeria's small and large hydropower capacity stands at 3500 MW and 11235 MW respectively (Oseni, 2012) while only 39 MW representing 1.1% of the available small hydro capacity and 1936.5 representing 17% of the available large hydro has been installed (Akorede, Ibrahim, Amuda, Otuoze, & Olufeagba, 2017; Falobi E. O., 2019). Despite this large hydro capacity, all the grid-connected power plants installed in the last decade (from 2012) till date are gas-fired (Falobi E. O., 2019). This may be because there is also abundant natural gas in the country, but its harmful effect on the environment has been ignored. The estimated hydro capacity in selected states in Nigeria is shown in Figure 4.

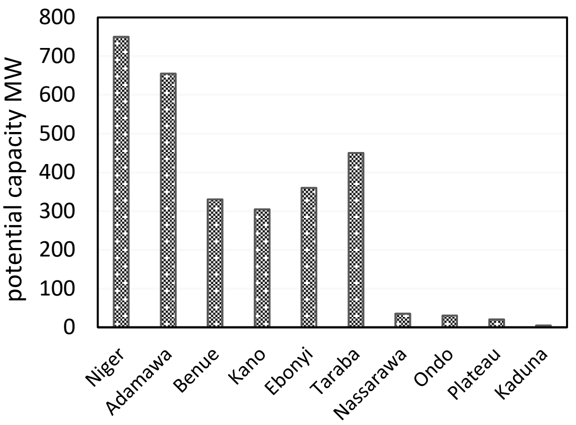

Fig 4 Small hydro capacity in some Nigerian states.

4.2. Solar-thermal and Solar PV activities in Nigeria.

Nigeria has a massive solar energy potential unutilized. Nigeria is located close to the equator and can run a full-scale solar energy-driven economy. The daylight is equitably disseminated throughout the year. Nigeria's everyday sun-powered radiation is estimated to be 3.5 kWh/m²/day within the southeast region and 7.0 kWh/m²/day within the North. It is melancholy and despairing that the current capacity of the sun-oriented power in Nigeria is less than 1 MW. The estimation is that it will increment to 1 MW in 2020 and 20 MW by 2030. This estimation will also imply improved access to power for provincial settlements. The earliest power generation project in Nigeria using solar P.V. is the 7 kW P.V. plant in Tunga-Buzu and Gotomo villages built-in 1985 with funds provided by the Sokoto state government (Ilenikhena & Ezemonye, 2010). A research institution in Sokoto state known as SERC (Sokoto Energy Research Centre) installed another 7.2 kW for electrification of a rural community (Kwakwalawa village) in 1993. Another research center NCERD (National Center for Energy Research and Development), domiciled in Nsukka, also built a 1.5 kW P.V. plant to augment the power supply from the utility. The Nsukka center, NCERD, also installed at a nearby Iheakpu-Awka community a 2 kW P.V. plant and a 2.85kW solar P.V. project at Hu-Mbauzo in Abia State (Ilenikhena & Ezemonye, 2010).

Several solar P.V. systems have been installed in Nigeria recently, especially for standalone home power supplies. Most of these small projects are not reported in the literature. However, according to the 2020 Project Impact Report of the Rural Electrification Agency (REA), the following installations shown in Table 1 have been made in recent years (REA, 2020). According to the REA report in (REA, 2020), 6805 standalone solar home systems are deployed in six states under the REA's Rural Electrification Fund. Table 1 shows that there has been a significant increase in solar P.V. exploitation in Nigeria in recent time; the total reported installation in 2020 being 9302.14 kW or 9.302 MW. However, no solar thermal project was reported in Nigeria at the time of writing. Solar thermal technology has a better potential for bulk power generation than solar P.V. technology (Odo, Ogbuka, & Madueme, March 2020) and thus needs to be harnessed in Nigeria.

Nigeria is blessed with abundant sunlight. The estimated potential for concentrated solar power and solar photovoltaic generation is 427000 MW (Falobi., 2019). Nigeria's total electricity demand by 2030 is projected to be about 119200 MW (Falobi, 2019). If we harness only 30% (128100 MW) of the available solar potential by 2030, it will be enough to power the whole country with solar energy if proper energy storage is implemented. Nigeria's solar irradiance is estimated to be between 3.5 – 7.5 kWh/m²/day (Falobi., 2019). Nigeria has a mean of 6.5 hours daily sunshine which ranges from 4 hours in areas around the coastal regions to 9 hours in the states at the far North (Akorede, Ibrahim, Amuda, Otuoze, & Olufeagba, 2017). The exploitation of solar energy as an alternative to the small household generator (popularly known as "I better pass my neighbor") is gaining popularity among wealthy Nigerians, but still, for now, out of the reach of an average Nigerian due to its high initial installation and running cost. Many small businesses have also embraced solar P.V. as an alternative to the epileptic power supply from the utilities and personal generators. However, Nigeria's potential for large-scale grid-connected solar power generation has not been tapped into by government or private investors. Apart from solar photovoltaic, Nigeria also has enormous potential for solar thermal power generation. The scorching Nigerian sun can easily be concentrated using a parabolic trough collector to drive a gas turbine, given that the installation cost per kW for a solar thermal plant has been on the decline over the years (Odo, Ogbuka, & Madueme, March 2020). However, these have not much been tapped into.

4.3. Review of Wind Energy Activities in Nigeria.

Wind energy sources are another renewable energy resource that almighty God, in His infinite mercy, bestowed on Nigeria as a natural endowment. The Northern part of Nigeria is ferociously wasting energy from the wind, and little or nothing has been done in this sector to harness it and improve the country's erratic and epileptic power supply. Analysts have examined the potential of wind vitality in entirely different parts of Nigeria with centers on the North-East to decide the reasonability for power generation. The following parameters, the mean speed of the wind, turbulence intensity, statistical distribution of wind speed, and the cost of the wind turbine system, are the requirements in their findings. The results showed that the annual wind speed at the selected sites ranges from 3.18 m/s to 7.04 m/s, and the sites were recommended for medium scale and standalone wind power generation (Fagbenle, Katende, Ajayi, & Okeniyi, 2011; Ohunakin, 2014). There is only one notable wind power generating station in Nigeria, though not commissioned yet. Located in Rimi Village in Katsina province, the wind farm with thirty-seven turbines incorporates an add-up capacity of 10MW. This project is one of the attempts to incorporate renewable energy into the power sector by the Federal Government of Nigeria (Salisu & Garba, 2013). Windmills were utilized for water pumping in some parts of Northern Nigeria in the 1950s and 1960s, but they are no longer available.

Table 1
Solar PV projects in Nigeria in 2020.

Name of fund.	Project description/location	Power (kW)
COVID - 19 intervention	1.UATH isolation Centre , Abuja	53.1
	2. NCDC pub Health Lab, Lagos state	25
	3. 128-bed isolation Centre, Ikenne, Ogun	20
	4. 100-bed Iberekodo isolation Centre, Ogun	10
Rural Electrification Fund (REF)	1. Eka Awoke, Ebonyi state	100
	2. Adebayo com., Edo state	100
	3. Dakkiti com, Gombe state.	85
	4. Goton-Sarki com, Niger state	40
	5. Bambami village, Kastina	30
	6. Olooji com, Ogun	100
	7. Budo Are com, Oyo state	100
Capital Projects	1.250-bed cottage hospital, Okpogo com, Kogi state.	65
	2. Government Cottage hospital Adavi Eba, Kogi	5.4
Energizing Education Programme (EEP)	Solar Hybrid power plant at the Federal University of Agriculture Markudi (FUAM)	8200
Nigeria Electrification Project	1.Solar hybrid mini-grid serving Akipelia and Oloibiri in Bayelsa	134.64
	2. Solar hybrid mini-grid serving Shimankar, Plateau.	234

*Com is used in the table as short for community.

Table 2
Wind speed data in different places in Nigeria

Zone	**City**	**Annual mean wind speed (m/s) at 10 m height.**	**Annual mean wind speed (m/s) at 70 m height.**
South west	Shaki	4.50	5.80
	Isevin	4.01	5.16
	Lagos Mainland	4.61	5.94
	Lagos Island	4.69	6.04
	Ibadan	3.86	4.97
	Ijebu-Ode	3.62	4.66
	Oshogbo	3.33	4.29
	Benin	3.38	4.35
South-South	Port-Harcourt	3.30	4.25
	Calabar	4.60	5.92
	Ogoja	3.68	4.74
South-East	Enugu	5.73	7.38
	Oweri	2.80	3.61
North-West	Yelwa	3.88	5.00
	Sokoto	7.21	9.29
	Gasau	6.17	7.95
	Kaduna	5.13	6.61
	Kastina	7.45	9.59
	Zaria	6.08	7.83
	Kano	9.39	12.09
North-Central	Ilorin	5.04	6.49
	Mina	5.36	6.90
	Abuja	3.77	4.86
	Lokoja	2.92	3.76
North-East	Bauchi	4.83	6.22
	Potiskum	5.25	6.76
	Maiduguri	5.22	6.72
	Jos	9.47	12.20
	Yola	4.16	5.36

Source: (Ohunakin , Ojolo, Ogunshina, & Dinrifo, 2012; Adaramola & Oyewola, 2011; Adaramola & Oyewola, 2011; Ojosu & Salawu, 1990; Ohunakin, 2011; Ohunakin O., 2011; Akorede, Mohd Rashid, Sulaiman, Mohamed, & Ab Ghani, 2013)

The 0.75 kW windmill at Dan-Jawa village in Sokoto, 1 kW at Energy Research center in Benin, Edo State, and 5 kW at Sayya Gidan-Gada, Sokoto state (Sambo, 2005), are other generation stations. Low financing for legitimate upkeep and execution, the need for mindfulness and innovation are the key variables contributing to the low entrance of wind energy into the Nigeria energy blend. Appropriate policies and legislation will help boost wind energy generation and reduce our carbon footprint (Ajayi, 2009).

Nigeria also has enormous potential for power generation from wind energy. Wind is another viable renewable energy source that, if fully exploited, contributes a great deal in proffering solutions to the country's power problem. There are a few recorded wind power projects in Nigeria. The oldest wind project is the 5 kW Sayya Gidan-Gada wind farm in Sokoto state installed in 1988 (Saddik, Tijjani, & Alhassan, 2012). Others include the 0.75 kW wind farm at Dan-Jawa village Sokoto, 1 kW wind farm at Energy Research Centre, Benin, and the 10 kW wind farm in Kastina, Kastina state (Saddik, Tijjani, & Alhassan, 2012).

Appreciable wind speed is obtained in various places in the country's six geopolitical zones. Despite its abundance, wind energy has not been exploited much for power generation either in the standalone or grid-connected form in Nigeria. Many research efforts have been geared towards determining the wind energy potential in various places in the six geopolitical zones, as shown in Table 2. The minimum mean wind speed required for a turbine to start generating useful power generally lies within 3 – 5 m/s, while the speed for peak power output is between 10 – 15 m/s depending on the size of the turbine (REA, 2020).

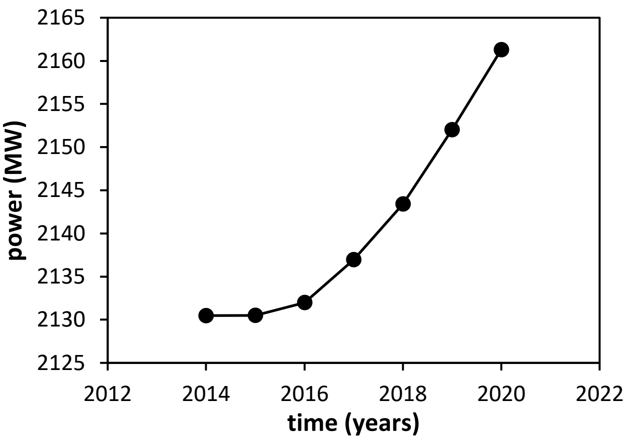

Fig 5 Growth of renewable energy in Nigeria (IRENA, 2019).

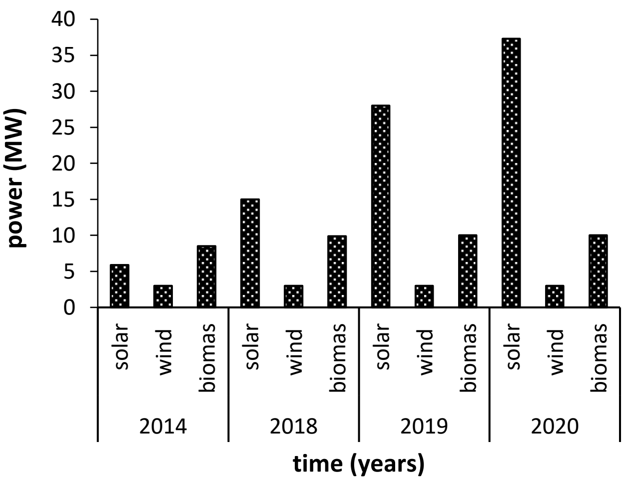

Fig 6 renewable energy growth by type (IRENA, 2019)

From Table 2, it is seen that at a height greater than or equal to 70 m, appreciable wind power can be generated in several locations in the country. This shows that Nigeria has enormous potential for power generation from wind.

Another renewable energy resource available in Nigeria that has been neglected or received little or no attention from the Federal Government is biomass or bioenergy. The biomass assets accessible to Nigeria incorporate animal waste, forage grasses, and shrubs, manure from livestock and wood. Approximately 227,500 tons of new animal waste can be generated daily in Nigeria, and it has been accessed that 1 kg of freshly prepared animal waste can deliver 0.03 m^3 biogas. Subsequently, Nigeria can deliver 6.8 million meters cubed of biogas daily from animal waste as it were (TSERN, 2014). The development of biomass power and its role in reducing Nigeria's current power issues is encouraging if the government wanders into the venture.

The smart grid in Nigeria's context is still a nightmare, yet there is light at the end of the tunnel as many researchers are working tirelessly on this subject matter. As an emerging technology, the smart grid can lead to modern electrical power systems with a reliable communication system, distributed generation with different storage elements and loads (Elizabeth, Samuel, Felix, & Simeon, 2018). The researchers (Elizabeth, Samuel, Felix, & Simeon, 2018) pointed out that a smart grid can be introduced into the present grid system, it will help to manage energy use, reduce CO_2 emission by encouraging variable renewable energy sources and provide customer's satisfaction since there will be a significant drop in power outage currently being experienced. Renewable energy growth in Nigeria is shown in Figure 5 while Figure 6 shows the growth by type for the renewable resources. It can be observed from both figures that the rate of growth is still low when compared to other leading countries.

5. Comparison of the Renewable Energy Scenarios Among Few African Countries.

Energy access has remained a significant obstacle in the development of many African countries. The growing population has resulted in an increase in energy demand without a corresponding increase in energy supply. Moreover, the larger percentage of energy supply still comes from fossil fuels which are not economically sustainable and have been causing severe environmental pollution within Africa. Hence, the need for a massive transition into renewable energy resources. Within the continent, a few nations have effectively prevailed in setting measures important to scaling up renewables. Countries like South Africa, Kenya, Egypt, and Morocco are driving renewable energy within the African continent, while others are still setting targets to achieve similar feet (IRENA, 2015). (IRENA, 2020) Stated that sub-Saharan Africa could meet up to 67 percent of its energy needs by 2030 if member countries could adequately promote sustainable policies, governance, regulation and ensure easy access to financial markets.

Consequently, the difference in renewable energy growth within the continent can be related to several factors. To have a broader perspective on renewable energy in Nigeria, this comparison would be made regarding other key players within the African continent. The countries would include South Africa, Kenya, Egypt, and Morocco. This section would address the countries based on available renewable energy sources and the deployment level of renewable energy.

5.1. Renewable Energy in South Africa

The climate and geographical location of South Africa provide enormous access to different renewable resources. The viable resources of sustainable energy in this region are waste to energy, wind, biomass, geothermal, solar, tidal energy, and hydropower (Jain & Jain, 2017). Among these available resources, the country has a great potential for power generation from solar and wind, with a smaller capacity for hydropower, biomass, and waste gas (Hundermark, 2020). Apparently, solar is the most adopted renewable resource in the country, having about 2500 hours of sunshine per year and 4.5 to 6.6 kWh/m2 of radiation level (Jain & Jain, 2017). The country is expected to reach 8,400 MW of installed capacity by 2030 (Hundermark, 2020), while the total wind power potential is rated to be 6,700 GW (Jain & Jain, 2017).

In the past decade, South Africa's renewable energy sector has witnessed massive development. The available renewable capacity is estimated to increase from 8 G.W. in 2017 to about 12 G.W. in 2023, representing a 40% growth rate (Surridge, Mpeqeke, & Kritzinger, 2019). The Solar P.V. is driving this inexhaustible development representing practically 50% of all the increments (1.6 GW) followed intently by inland wind (1.4 GW), CSP (0.4 GW), and bioenergy (0.2 GW) (Surridge, Mpeqeke, & Kritzinger, 2019). The country has a high installed capacity of hydropower with an estimated potential of 41,000 MW (Hundermark, 2020).

So far, the installed hydropower limit is a bit less than 12,000 MW, addressing 21.5% of the overall power limits, of which 97.6% is macro hydropower (Hundermark, 2020). Under the Renewable Energy Independent Power Producer Procurement Program (REIPPPP), development is driven by serious sell-offs for utility-scale projects. In contrast, dispersed solar P.V. sees development from net-metering and self-utilization projects (Surridge, Mpeqeke, & Kritzinger, 2019). According to (IRENA S., 2020), Figure 7 shows South Africa's installed capacity for renewable energy sources in 2019.

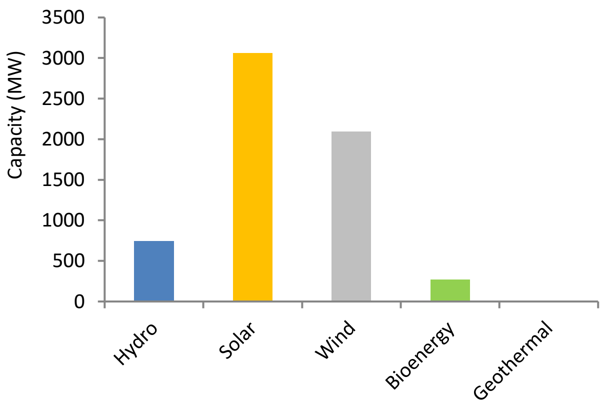

Fig 7 Graphical Illustration of the Installed Renewable Energy in 2019.

5.2. Renewable Energy in Kenya

Kenya has an enormous amount of renewable energy resources consisting majorly of geothermal, biomass, hydropower, solar, and wind (Kiplagat, Wang, & Li, 2011). Hydropower and geothermal resources contribute about 30% each to the country's power mix (Samoita, Nzila, & Østergaard, 2020). Furthermore, geothermal has a high chance for larger-scale integration with a potential of increasing from the 200 MW capacities to 10 G.W. (Ogola, Davidsdottir, & Fridleifsson, 2012). Due to the tendency of drought, Kenya's hydropower plants are usually implemented through a dam (Samoita, Nzila, & Østergaard, 2020). The country has a potential of 6000 MW from large hydro bodies and 3000 MW from small hydro bodies (Gitonga, 2017). There is a high solar P.V. potential since the region is close to the equator, which provides a good amount of solar irradiation. (Oloo, Olang, & Strobl, 2015) Stated that within a year, about 70% of the land territory in Kenya can get roughly 5 kWh/m2/day and annual radiation of 6.98 kWh/m2. This potential provides an opportunity for the country to increase the solar P.V. share. Report from the nation's ministry of energy shows that regions including Marsabit, Turkana, Ngong, and the Coastal region have capabilities to support large scale electricity production due to the presence of wind speed that falls within 8 m/s to 14 m/s (Kiplagat, Wang, & Li, 2011) (Ministry of Energy, 2004). Biomass energy means are also available in Kenya, with sources from woodlands, forests, farmland, bushland, plantations, and agricultural and industrial residues (Kiplagat, Wang, & Li, 2011).

Most of the power in Kenya is supplied through renewable energy resources. According to (African Review, 2017), 87% of the country's power blend is renewable energy. This development is in line with the vision 2030 of the government of Kenya to increase electricity production through renewable energy from the current 2341 MW to 23000 MW capacity (African Review, 2017). In the past few years, total electricity generation has been on a steady increase. In 2017, total electricity generated was 10,360 GWh and 11,180.64 GWh in 2018 (EPRA, 2019). Then in 2019, total electricity generation rose by 3.9%, amounting to 11,620.7 GWh (EPRA, 2020). Among this share, 45% of total electricity generated came from Geothermal (EPRA, 2020). Hydropower produced a 43.6% increase in 2018 to the 2,776.6 GWh supplied in 2017 (EPRA, 2019). However, hydropower production experienced a 19.6% decrease in 2019 (EPRA, 2020). The complete operation of the Lake Turkana wind power plant resulted in an increase in wind electricity to 1,562.7 GWh in 2019 from 375.6 GWh in 2018 (EPRA, 2020).

More so, with the connection of the Garissa Solar plant and its full operation, solar power contribution to Kenya's energy mix increased from 13.7 GWh in 2018 to 92.3 GWh in 2019 (EPRA, 2020). Biomass also accounts for a fraction of the total electricity of Kenya. Forestry and agro-residues have been exploited to produce electricity with a particular concentration on bagasse and biogas. Sugarcane bagasse has produced 193 MW of energy. On the other hand, biogas has installed capacity within 29 – 139 MW, representing 3.2 to 16.4% of the country's total electricity generation (EPRA, 2020). According to (IRENA S., 2020), Figure 8 shows Kenya's installed capacity for renewable energy sources in 2019.

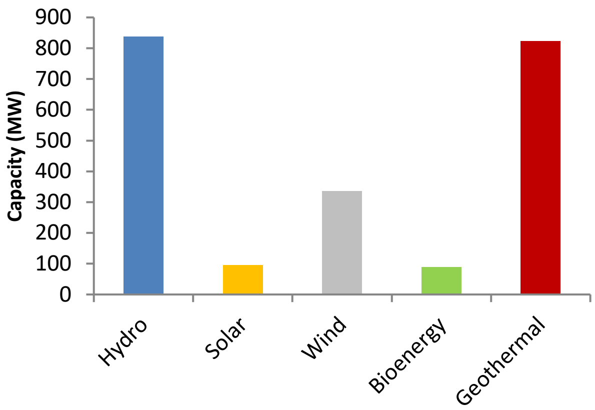

Fig 8 Graphical Illustration of the Installed Renewable energy in Kenya, 2019.

5.3. Renewable Energy in Egypt

The location of Egypt provides it with a vast potential for renewable energy resources consisting majorly of hydro, solar, wind, and biomass (IRENA, 2018). Specifically, the River Nile serves as the main hydropower electricity source of the country. The Aswan, a section along the Nile, has the most hydro potential, scaling up to 2800 MW and producing 13545 GWh of hydroelectricity every year (IRENA, 2018). There is enormous wind energy potential across the Red seashore and other places (Fayek & Abdalla, 2020). The Gulf of Suez, which is an extension of the northwest trend of the Red sea, has a stable wind speed within the average range of 8 and 10 m/s at the height of 100 meters (IRENA, 2018). This region provides one of the best locations in the world to utilize wind energy. More so, New regions such Beni Surf, Menya Governorates, and El Kharga Oasis exhibiting wind speed within 5 and 8 m/s have been discovered, and they have a high potential for electricity production (IRENA, 2018). Egypt enjoys solar energy irradiance per square meter between the range of 5 and 8 kWh every day alongside a total time of 3000 – 4000 hours per year (Fayek & Abdalla, 2020; Abdalla, Fayek, & Abdel Ghany, 2019). Solar irradiance is utilized through various means, including Centralised grid-connected solar P.V., Distributed solar P.V., and concentrated solar power and solar water heating. Egypt is also home to vast biomass resources consisting of majorly agricultural waste, urban solid, and animal dung (IRENA, 2018). Over 35 million tonnes of agricultural waste are generated every year. Among this capacity, about 60% is adopted in energy production, and about 40% is utilized in animal feeding (IRENA, 2018). With regards to improving the generation of electricity from biomass, different biomass technologies are continuously being exploited.

The Integrated Sustainable Energy Strategy 2035 developed by the government of Egypt has increased the deployment of renewable energy technologies across the country. According to (IRENA, 2018), 3.7 GW is the total capacity of installed sustainable energy in Egypt as of 2018, with hydropower producing 2.8 GW and a combination of solar and wind generating 0.9 GW. Also, the government is working on achieving 19.2 GW of installed renewable energy capacity by 2021/22 and with estimations of 49.5 GW in 2029/30 and 62.6 GW in 2034/35 (IRENA, 2018). By implementing suitable policies alongside the support received from international financial institutions, the International Renewable Energy Agency (IRENA) stated that the country could draw 53% of its electricity from renewable energy by 2030 (IRENA, 2018). According to (IRENA S., 2020), Figure 9 shows Egypt's installed capacity for renewable energy sources in 2019.

5.4. Renewable Energy in Morocco

Located in North Africa, Morocco possesses a high potential for renewable energy, especially wind and solar. The total wind potential of the country is calculated to be about 25 G.W., with its 3500 km of coastline at a mean speed of 11 m/s (Haddouche, 2006) (Kousksou, *et al.*, 2015). This wind potential is predominant both in the North and south of the country. The North experiences an annual average wind speed between 8 m/s and 11 m/s, and the south experiences between 7 m/s and 8 m/s (Ouammi, Sacile, Zejli, Mimet, & Benchrifa, 2010). The country experiences solar radiation with 5.3 kWh/m^2 varying from 2700h in the North to about 3500h in the south (Kousksou, *et al.*, 2015) (MASEN, 2019). Morocco is home to many dams having high hydroelectric potential. (Energétique, 2011) states that the hydroelectric potential of Morocco is estimated at 5000 GWh/year. The Office National de l'Electricité et de l'Eau Potable (ONEE) is responsible for constructing hydroelectricity projects in Morocco. This initiative operates an installed capacity of 1360MW produced from 26 hydropower stations (Kousksou, et al., 2015). Moreso, hydropower is also generated from a pumped storage plant with a capacity of 464 MW in Afourer, Morocco (Kousksou, *et al.*, 2015).

Over the years, the Kingdom of Morocco has been facing energy challenges that stem from the limitation of conventional hydrocarbon and high energy import from other countries (Azeroual, El makrini, El Moussaoui, & El markhi, 2018). To resolve these challenges, the country embraced massive deployment of renewable energy comprising majorly of solar, wind, and hydro (Azeroual, El makrini, El Moussaoui, & El markhi, 2018). Table 3 shows the country's target to increase energy production from renewable sources to 42% by 2020 and 52% by 2030 of the overall electricity generated (Azeroual, El makrini, El Moussaoui, & El markhi, 2018; MASEN, 2017).

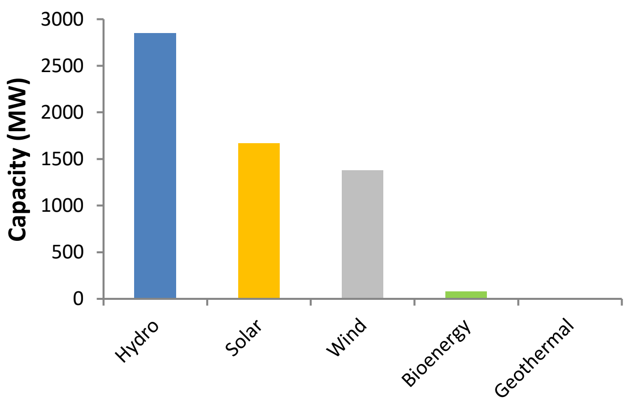

Fig 9 Graphical Illustration of the Installed Renewable energy in Egypt, 2019.

At the end of 2016, the country's installed wind power capacity was 803 MW (MASEN, 2017). To achieve its 2000 M.W. target of 2020 and 4200 MW of 2030, the government has continued constructing more wind farms (Azeroual, El makrini, El Moussaoui, & El markhi, 2018; MEMEE, 2016). In this regard, ONEE is building six wind farms toward 2020, with a plan to build others towards 2030, with a total capacity of 1000 MW (Azeroual, El makrini, El Moussaoui, & El markhi, 2018). At the end of 2016, 180 MW of the total installed solar capacity consisted of Concentrated Solar Panel technology (Richts, 2012). Others include 160 MW Ouarzazate Noor 1 project and 20 MW solar thermal CSP and gas Ain bni Mathar (Richts, 2012). Hydropower has been a long-established means of power generation in the kingdom of Morocco. As of 2015, hydropower installed capacity was 1770 MW, and it has been continuously utilized in electricity production (Azeroual, El makrini, El Moussaoui, & El markhi, 2018). To achieve the set goal of 3100 MW by 2030, ONEE has continued constructing more pumped energy storage. According to (IRENA S., 2020), Figure 10 shows Morocco's installed capacity for renewable energy sources in 2019.

Comparison of the installed renewable energy capacity in Nigeria to South Africa, Kenya, Egypt, and Morocco in 2019 (IRENA S., 2020). From figure 11, it can be deduced that Nigeria, with 2152 MW total installed renewable energy in 2019, is still lagging behind African countries such as South Africa, Kenya, Egypt, and Morocco, having installed capacity of 6167 MW, 2179 MW, 5973 MW, 3267 MW respectively. In the same year, Nigeria, with 2111 MW surpassed South Africa, Kenya, and Morocco in the installed hydro capacity. However, other sources such as solar, wind, bioenergy, and geothermal had little or no boost in the capacity compared to other examined countries. Table 4 illustrates the most adopted renewable energy sources and their deployment/target levels in five African countries.

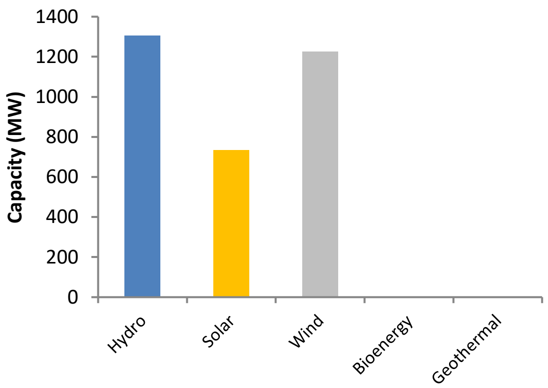

Fig 10 Graphical Illustration of the Installed Renewable Energy in Morocco, 2019.

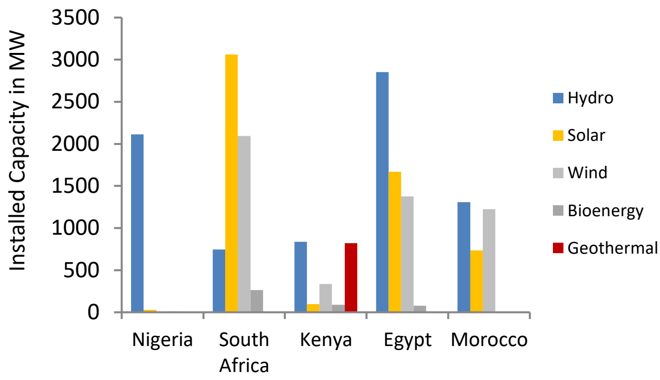

Fig 11 Graphical comparison of the installed capacity of Nigeria, South Africa, Kenya, Egypt and Morocco in 2019.

6. Renewable Energy Policy of the Federal Government of Nigeria

The overall objective of the renewable energy policy (National Renewable Energy and Energy Efficiency Policy -NREEEP) of the federal government (developed in 2015) is, among other things (Ministry of Power, 2015):

i. To make sure that the country's energy resources develop in a diversified manner with an efficient system for energy delivery and optimal energy mix geared towards national energy security.
ii. To ensure adequate and equitable supply of renewable energy, for national development, to the various economic sectors in a manner that is reliable, affordable, and cost-effective.

The long-term target of the policy is to generate 23134.80MW (20% of total projected grid power) from the various renewable sources (hydro, solar, biomass, and wind) by 2030 (Ministry of Power, 2015). In order to ensure this target is achieved, the National Renewable Energy Action Plan (NREAP) was developed in 2016. The NREAP recommends the following policies and measures for achieving the target of NREEEP: feed-in tariffs, competitive procurement programme, GIZ-Nigerian energy support programme, national policy on public-private partnership, soft loan, renewable energy subsidy and grant, rural electrification strategy, and implementation plan, and national biofuel policy (the Federal Republic of Nigeria, 2016).

Table 3
Moroccan renewable energy targets for 2020 and 2030

Renewable Energies	Solar	Wind	Hydro
Installation Target for 2020	2,000 MW	2,000 MW	2,000 MW
% of Capacity for 2020	14%	14%	14%
Installation Target for 2030	4,560 MW	4,200 MW	3,100 MW
% of Capacity for 2030	20%	20%	12%

Source: (Azeroual, El makrini, El moussaoui , & El markhi, 2018; MASEN, 2017)

Table 4
Most adopted renewable energy source and their deployment/target level in Nigeria, South Africa, Egypt, Morocco and Kenya.

Country	Available Renewable Sources/ Technology	Deployment level/Target
Nigeria	Solar PV (Large scale > 1 MW)	50 MW by 2015; 400 MW by 2025
	CSP	1 MW by 2015; 5 MW by 2025
	Wind power	20 MW by 2015; 40 MW by 2025
	Hydropower (small scale)	75 MW by 2015; 500 MW by 2025
	Bio power	600 MW by 2015; 2 GW by 2025
South Africa	Solar	PV 8.4 GW by 2030
	CSP	1 GW by 2030
	Wind	8.4 GW by 2030
	Others	0.4 GW by 2030
Egypt	Solar PV	220 MW by 202; 700 MW by 2027
	CSP	1.1 GW by 2020; 2.8 GW by 2017
	Wind power	12% of generation and 7.2 GW by 2020
	Hydropower	2.8 GW by 2020
Morocco	Solar	2000 MW by 2020, 4560 MW by 2030
	Wind	2000 MW by 2020, 4200 MW by 2030
	Hydro	2000 MW by 2020, 3100MW by 2030
	Geothermal	1.9 GW in 2016; 5 GW by 2030 (Gitonga, 2017)
Kenya	Hydro	794 MW in 2016, 2,776.6 GWh supplied in 2017 (Gitonga, 2017)
	Solar	423 MW in 2016, 92.3 GWh supplied in 2019 (Gitonga, 2017)
	Wind	635 MW in 2016, 375.6 GWh supplied in 2018 (Gitonga, 2017)

Source: (Azeroual, El makrini, El moussaoui , & El markhi, 2018; MASEN, 2017; REN21, 2015; Aliyu, Modu, & Tan, 2017)

The hindrances to implementing the renewable energy policies were enumerated in (Emodi & Ebele, 2016) as: financial investment, power purchase agreement, legislation/regulation, politics, policy/strategies, technology/innovation, environmental support program, and public awareness. Apart from the NREEEP and NREAP, there are other renewable energy policies that were developed. These include (Emodi & Ebele, 2016):

- National Electric Power Policy (NEPP), 2001
- National Energy Policy (NEP), 2003, 2006, 2013
- National Power Sector Reform Act (EPSRA), 2005
- Renewable Electricity Action Programme (REAP), 2006
- Nigerian Biofuel Policy and Incentives (NBPI), 2007

All these policies are aimed at improving the country's electricity generation if implemented.

7. A Pathway for Nigeria to Become a Global Renewable Energy Leader

It is clear from the foregoing that Nigeria is blessed with enormous renewable energy resources. Despite its abundance, renewable energy exploitation in Nigeria has been on the low side. To increase the rate of growth of new green energy projects, Nigeria must create a highly conducive policy environment that will attract a steady influx of capital into the sector, take advantage of newer technologies, and falling prices of materials. Furthermore, Nigeria must learn from and adopt successful strategies of leading countries in the renewable energy sector, such as China, Japan, Germany, and the USA.

China enacted the Renewable Energy Law (REL) in 2005 (Chinese government, 2005). The purpose of the REL is to remove notable barriers to renewable energy, promote its utilization, and speed up its development in the People's Republic of China. The key features of the REL include: provision for a preferential loan for RE projects in article 25, tax benefits for RE projects in article 26, and provision for the grid operators to prioritize power purchase from RE in articles 14 and 29 (Chinese government, 2005). In addition, Customs duty exemption is also provided for the importation of RE generation equipment. In Japan, Feed-in-Tariff (FIT) scheme was introduced for all renewable energy technologies in July 2012 after the Fukushima reactor explosion. This legislative action caused Japan's renewable power generation to increase from 17GW in 2012 to 50.4GW in 2016; an increase of 33.4GW (or 196.5%) in just four years (Matsubara, 2018). In Nigeria's case, these policies are already captured in the NREAP developed in 2016 but have not been fully implemented. Implementing the NREEEP/ NREAP and other RE policies will help Nigeria achieve her renewable energy target.

Nigeria's transmission system currently has 5300MW capacity, far below the total installed generation capacity of 12,522MW (NERC, 2006). The transmission losses are also high, at about 7.4%, far greater than the global average of 2.6% (NERC, 2006).

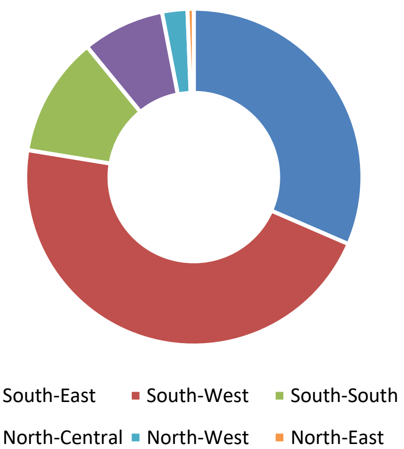

Fig 12. Geographical distribution of respondents

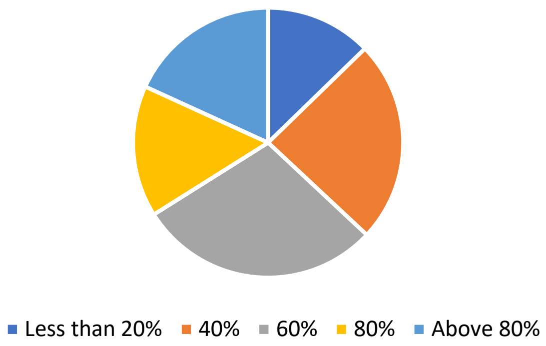

Fig 13 Knowledge rate assessment of Respondents

Table 5
Age Brackets of Respondents

Age	frequency (f)	Mean age (X)	Percentage (%)
18-24 years	168	21years	16.97
25-30 years	576	27.5years	58.18
Above 30 yrs	228	not accessed	23.03
I prefer not to say	18	not accessed	1.82

Source: Survey report

Nigeria also has an insufficient distribution infrastructure. The survey report carried out in (NESP, 2015) shows that an average of 44.2% of households across Nigerian states has no access to grid electricity. To solve these problems, Nigeria needs to invest heavily in grid extension and modernization. Inadequate grid capacity is, in fact, one of the greatest challenges facing the Nigerian power sector, and until it is fixed, increasing generating capacity will not have any effect on the lives of the people or the economy since the power generated cannot be evacuated to places where it will be used.

8. Analysis of Public Opinions Regarding Renewable Energy in Nigeria

An online questionnaire was published using Google Form to air the opinions of people. A total of 990 completed forms were received and used to analyze the 15 questions which were put forward (containing 3 demographic/knowledge rate assessments and 12 inquiries related to renewable energy as it concerns Nigeria).

- **Age**: The responses received based on the ages of respondents are given in Table 5. From the result obtained, it can be deduced that 58.18% of the respondents are within the 25-30years age bracket with a mean age of 27.5years.
- **Geographical Region:** The geographical region based on geopolitical zones in Nigeria, the frequency of respondents is as shown in Fig 12. Responses received from the SE, SW, SS, NC, NW, and NE are 312, 456, 114, 78, 24, and 6, respectively, with the greater percentage coming from the SW as shown in Figure 12 above.
- **Knowledge Rate:** A chat of the knowledge rate of the 990 respondents to the online questionnaire is shown in Figure 13. It is seen from the chat that most of the respondents have knowledge of renewable energy in Nigeria.

The questions which are contained in the questionnaire are thus:

1) Do you think the Nigerian government is investing or willing to invest in renewable energy to fight climate change?
2) Do you think investment in renewable energy in Nigeria has been on the increase in recent years?
3) Are government policies with regards to renewable energy well implemented?
4) Are you concerned about the pollution and emissions caused by the current use of conventional power plants?
5) What is the biggest barrier to achieving 100% renewable and sustainable energy transition in Nigeria with respect to your region?
6) What is the biggest barrier to achieving 100% renewable and sustainable energy transition in Nigeria with respect to your region?
7) What is your opinion about the cost of renewable energies as compared to other energy sources such as diesel, gas, and coal?
8) Do you think Nigeria should have a decarbonization target for its energy system?
9) Do you think Nigeria can meet 100% of its electricity demand through renewable energy sources only?
10) What is your opinion about renewable energy penetration in Nigeria compared to other African countries?
11) To what extent has Covid-19 affected investment in Nigeria's renewable energy sector?
12) What do you think policymakers should do to encourage investment in renewable energy?

To analyse these opinions, we have decided to use the Pearson Chi-square method on questions 1, 4, 7, and 11, while the rest of the responses to the remaining questions are used to back up claims of the former. The Chi-square analysis for question 1 is shown in Table 6.
Two hypotheses (null and alternative) have been used in question 1:
H_0: Government willingness to invest in renewable energy does not impacts climate change
H_1: Government willingness to invest in renewable energy impacts climate change

From Pearson Chi-square test,

$$X^2 = \sum \frac{(f_o - f_e)^2}{f_e} \quad (1)$$

where: f_o = observed frequency
f_e =expected frequency

$$\text{Decision} \begin{cases} X^2_{cal} > X^2_{cri}, & H_1 \text{ holds, and } H_o \text{ is rejected} \\ X^2_{cal} < X^2_{cri}, & H_0 \text{ holds and } H_1 \text{ is rejected.} \end{cases}$$

Obtaining X^2_{cal} for the individual responses gives: X^2_{cri} =7.81. Since $X^2_{cal} > X^2_{cri}$, then we conclude that the alternative hypothesis (H_1) holds, which implies that the government's willingness to invest in renewable energy impacts climate change. This is further made clear with the responses received for question 2, as shown in Table 7, and Table 8 shows the analysis.

Table 6.
Chi-Square Analysis 1

Response	**Fo**	Fe	$X^2 = (f_o - f_e)^2 / (fe)$
Yes, the government is willing	204	247.5	7.65
No, the government is not willing	564	247.5	404.74
The government has inadequate fund	84	247.5	108.01
I have no idea	138	247.5	48.45
Total	**990**	**990**	**568.84**

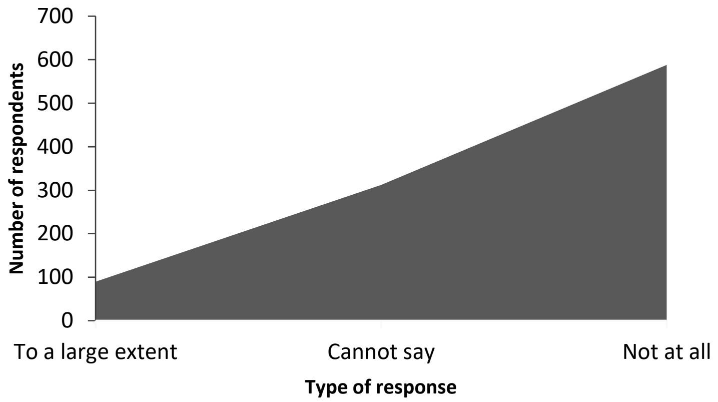

Fig 14 Frequency distribution for question 3

Table 7
Responses received for question 2

Response	Frequency	Percentage (%)
Cannot say	138	13.94
Yes, it has been on the increase	378	38.18
No, it has not been on the increase	474	47.88

There is a clear link between the level of government willingness to invest in renewable energy, which the 47.88% of public opinion proves that the level of renewable energy development in Nigeria is not on the increase as compared with the positive response that it is on the rise by 9.7%. This non-willingness of the government to invest in renewable energy has clearly verified the reason for the increase in carbon emission from fossil fuel-based energy systems, which Literary works reviewed in this work have been able to posit. Also, the responses received from question 3 show that government policies regarding renewable energy are not fully implemented. The responses received are in graphical form, as shown in Figure 14.

Two hypotheses (null and alternative) have been used in question 4:

H_0: Use of conventional power plants does not affect climate change and should not be a concern

H_1: Use of conventional power plants affects climate change and should be a concern

We again adopted the Excel-2016 format of checking the critical chi-square (X^2_{cri}). This gives: X^2_{cri} =5.99. Since $X^2_{cal} > X^2_{cri}$, then we conclude that the alternative hypothesis (H_1) holds, which implies that the use of conventional power plants affects climate change and should be a concern. This is further made clear with the responses received for question 5, shown in Figure 15.

This proves that 354 out of the 990 responses received agree that government policies constitute the greatest barrier to Nigeria's inability to achieve 100% renewable and sustainable energy transition. From the public opinion received for question 6, when the government makes policies that will stop the use of fossil fuels, zero carbon emission can be achieved. This is seen from the responses received for question 6 as shown in Table 9.

Table 8
Chi-Square Analysis 2

Response	**Fo**	**Fe**	**X^2**
I am very concerned	948	247.50	1982.63
Pollution is not our problem	36	247.50	180.74
I am not concerned	6	247.50	235.65
Total	**990**	**742.50**	**2399.01**

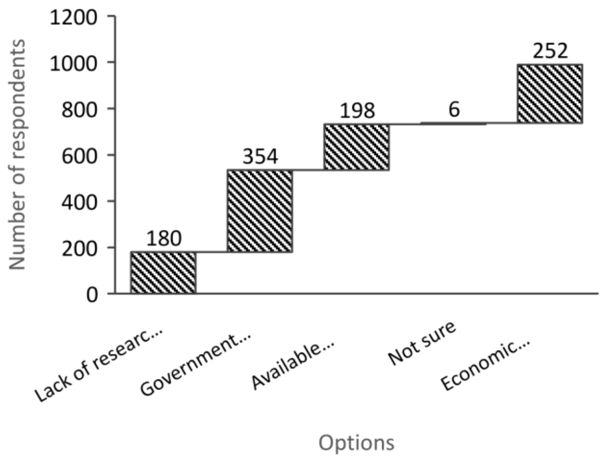

Fig 15 Frequency distribution for responses to question 5

Two hypotheses (null and alternative) have been used in question 7:
H_0: The cost of renewable energy is expensive compared to diesel, gas, and coal in the long run
H_1: The cost of renewable energy is inexpensive compared to diesel, gas, and coal in the long run

From the Pearson Chi-square test in Table 10, it is seen that $X^2_{cal} > X^2_{cri}$, then we conclude that the alternative hypothesis (H_1) holds, which implies that the cost of renewable energy is inexpensive compared to diesel, gas, and coal in the long run. To maintain an environment free from high carbon emissions, there is a need to set a target for decarbonization by reducing the use of fossil fuel-based energy systems and adhering to the Paris Agreement. The majority of the respondents have their opinions that there is a need for the Nigeria Government to set a decarbonization target for energy systems as collated from responses of question 8, which is represented graphically as shown in Figure 16.

Table 9
Frequency distribution for question 6

Response	Frequency
When government make policies to favour the use of renewable energy sources	528
Not sure	162
When renewable energy devices are made cheap	300

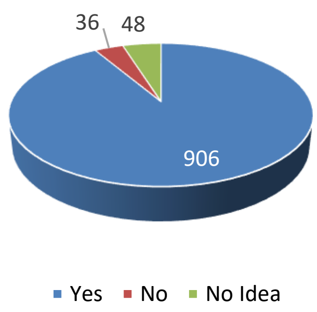

Fig 16. Responses to question 8.

Table 10
Square analysis 3

Response	Freq (Fo)	fe	fo-fe	X^2
I do not know	66	198	-132	88
Renewable energies are cheaper in the long run	642	198	444	995.6364
Renewable energies are more expensive	198	198	0	0
Renewable energy sources are cheaper in the long run	48	198	-150	113.6364
Renewable energy sources are more expensive	36	198	-162	132.5455
				1329.8

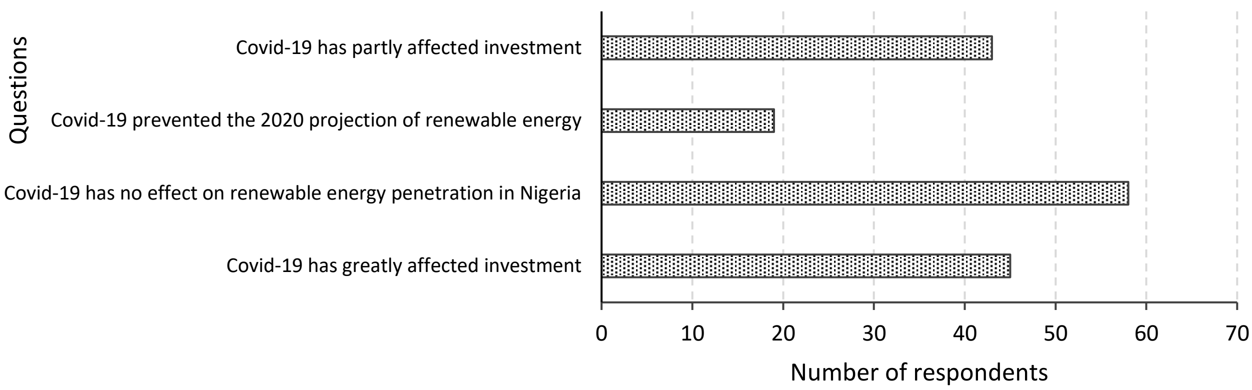

Fig 17 Level of Covid-19 impact assessment

Table 11
Responses to question 10

Response	Frequency
Nigeria is ahead	78
Nigeria is behind	660
Nigeria is on the same level with others	60
Not sure	192

Table 12
Responses to question 12

Response	Frequency
Reduce import duties on imported equipment for renewable energy technology	228
Provide soft loans for investment in renewable energy	198
Impose taxes on power plants using fossil fuels	24
All of the above	540

The above responses show that Nigeria can meet 100% of her energy demand through renewable energy sources owing to their abundance. Based on the data collated, it is seen that 52.12% of the 990 responses believe there is an abundance of energy sources in Nigeria that can be tapped to generate electricity which will create a balance in energy demand-supply. To prove that Nigeria is behind in tapping from renewable energy sources as compared to other African Countries, the responses received are as shown in Table 11 (sequel to question 10).

The respondents (66.67%) believe that Nigeria is behind as compared to other African countries, which can be attributed to government policies that do not foster the rapid development of renewable energy in the country as compared to others who have continued to grow their energy capacity through the use of renewable energy sources.

Apart from government policies which public opinions have suggested to be the greatest barrier to the development of renewable energy in Nigeria, another question (question 11) was used to envisage if the recent pandemic (COVID-19) contributed to the low investment in renewable energy in Nigeria, responses show the statistics in Figure 17.

The statistics prove that to an extent, Covid-19 has slightly affected investment in renewable energy. However, this year 2021, economic activities have improved, which is expected to drive investment in renewable energy. Analysis of the responses received from Online google form, question 12 was used to access what policymakers should do to encourage investment in renewable energy. It proved that all of the points listed hereunder should be considered as shown in Table 12.

10. Discussion

The results obtained from question 1 show that the Nigerian government seems unwilling to fight climate change. This claim is substantially based on inference drawn from works of (Pazheri, Othman, & Malik, 2014), where Nigeria belonging to Africa, generates less than 1% of the solar power generated by non-European countries as of 2012. Further claims made in (Wang & Yang, 2011) showed that despite the few water sources and wind levels in countries like Brazil and China, the countries have still been able to generate a combined power of over 35 GW as at 2015 while Nigeria having over 10 rivers and high level of wind capacity is yet to generate 1 GW of combined power at the same year.

As rightly commented by online responses, investment in renewable energy has shown that the investment rate is low. This is backed up in the work of (Falobi E. O., 2019), where Nigeria's forecasted load demand will be over 119.2GW by 2030 with a split of 13.24GW equal rise per year starting from the year 2021. As at the year 2021, it is known that of the meagre 4GW generated, less than 20% is from renewable energy sources, which are abundant in the country. This clearly depicts that the data collated from online responses are in unison with the claims of (Falobi E. O., 2019). Even the policies made by the government to tap a little from the abundant renewable energy sources are not well-implemented as rightly depicted in the responses received and even in the literary works of (Summaries, 2021) where there is a claim of a tax rate of 20% yearly for high profit earning firms that establish renewable energy companies within the country. This is also seen in (Danjuma & Attah, 2016), where bureaucracy is another issue that hinders the growth of renewable energy in Nigeria. These works also exonerate the responses received for question 5, where it is believed that when the government makes policies that favour the use of renewable energy, then the growth rate of renewable energy in the country will be high.

Also, a decarbonization target should be set to achieve a fast rate of tapping into renewable energy. This is rightly accepted by online respondents and even in the Paris Agreement, where it was stated that decarbonization is a strategy to reduce global warming and the increased rate of health-related issues, which has been on the increase. To place Nigeria ahead of other countries in terms of delving into renewable energy, which was stated in the report of (IRENA, Global Renewables Outlook: Energy transformation 2050, 2020) that Nigeria had no substantial solar and wind plants as compared to the likes of Kenya, Egypt, Morocco, and South-Africa that had over 65% of their energy installed to be from renewable energy sources. So for Policy Makers to encourage utilisation of renewable energy resources, online respondents believe that government should reduce taxation in terms of import duties, and there should be a provision for a soft loan as rightly accepted in the work of (Luthra, Kumar, Garg, & Haleem, 2015), (Emodi & Boo, 2015), (Shaaban & Petinrin, 2014).

11. Barriers to Renewable Energy Development in Nigeria

In recent times, many factors have played a significant role in hindering the development of renewable energy in Nigeria. The summary of most literary works suggests that 5 fundamental factors have acted as barriers to renewable energy development in Nigeria.

- *Unfavorable Government Policies*

The policies made by the Government of Nigeria constitute the primary barrier to renewable energy development in Nigeria, as proven in the work of (Summaries, 2021) where it was observed that the government placed high taxation of 20% yearly for companies with a gross turnover of more than 20 million and less than 100million. This suggests that setting this high taxation rate for a renewable energy company whose gross turnover is 50million will entail the company paying taxes worth 10million. This is exorbitant and can inhibit investment rate, as rightly agreed in the work of (Summaries, 2021) where they clearly stated that high taxation could inhibit investment rate. When these high taxes are placed as part of the government's policies, then there is a low rate of investment in the renewable energy sector both from foreign and local persons.

Asides from high taxation, the work of (Danjuma & Attah, 2016) rightly suggests that bureaucracy in establishing firms/companies in Nigeria which support renewable energy development poses a significant threat to renewable energy development in Nigeria. It has been discussed in (Luthra, Kumar, Garg, & Haleem, 2015) that one has to go through lots of protocols before being certified by the Corporate Affairs Commission (CAC) that allows the individual to start up a company. This goes a long way to impede Angel Investors from partnering with Citizens of Nigeria to successfully set up a renewable energy firm and hence lower the rate of renewable energy development within Nigeria.

Also, due to the change of political power after every 4years, there is inconsistency in policies made. The work in (Luthra, Kumar, Garg, & Haleem, 2015) shows that when there is a lack of long-term policies favorable to establishing energy firms in Nigeria, then there are high tendencies that the rate at which renewable energy development will be poor. An assessment of this statement suggests that if there are short-term policies made to guide the establishment of industries within Nigeria, then there are tendencies that continued change of those policies will pose a threat to the continued existence of the renewable energy company in Nigeria.

- *Financial Issues*

In Nigeria, some Entrepreneurs seek to address the imbalance of energy demand and supply, which has remained part of the energy crisis in Nigeria. These Entrepreneurs often lack funds to establish such firms within the country. The only way to generate capital to start-up these companies is to acquire loans from banks or access grants from private or government-approved agencies. The works of (Shaaban & Petinrin, 2014; Emodi & Boo, 2015) posits that accessing these loans and grants is usually difficult due to the protocol to be observed and the high-interest rate that accompanies a collection of the loans. These difficulties in acquiring loans and grants in Nigeria often discourage skilled Nigerians from delving into the country's energy sector.

- *Lack of Adequate Research*

Research into ways of optimizing the use of the various renewable energy plants also constitutes a barrier to renewable energy development in Nigeria. As in (Pasqualetti, 2011), it is believed that inadequate research facilities constitute the problem faced in Nigeria. There are no facilities that Researchers can use to investigate ways of optimizing the use of power plants. Even Institutions of higher learning where Researches are expected to be performed lack the necessary infrastructure. This affects the development of Renewable energy in Nigeria.

12. Dependent Factors for Choosing a Renewable Energy Resource in Nigeria

Nigeria is endowed with various renewable energy resources, including hydro, solar, geothermal, and biomass energy resources. These energy resources are distributed in densely and less-dense quantities in Nigeria's various six 6) geopolitical zones. Some factors suggest why renewable energy sources would be selected in different locations and not accepted in some other parts. These factors are summarized in the subsequent sections.

- *Availability of the Energy Source*

Nigeria has six (6) geopolitical zones, including North-East, North-West, North-Central, South-East, South-West, and South-South. In the work of (Abdulhameed, Benyoh, & Jong, 2019), the annual solar radiation in Nigeria varies from one place to another in which the country is zoned in three solar radiation zones with the NC and NE zoned into I, NW in zone II and SE, SW, SS in zone III. A review of this work shows that zone I consisting of Adamawa, Bauchi, Borno Gombe, Taraba, and Yobe states have the largest monthly solar radiation of 5.69, 5.76, 5.89, 5.77, 5.57, and 5.96 kWh/m^{2}day, respectively. This suggests that 16.67% of the states in Nigeria can generate an overall monthly average solar energy of 1039.2 kWh for a 1 m^2 solar panel installed within that zone. This can also supply an overall 51.96 MWh of energy for 50 m^2 solar panel installed and hence 51.96 Wh for 1 million of Nigerians within that zone.

Considering the work of (Okoye, Taylan, & Baker, 2016), three (3) states in Nigeria were accessed using the simulated meteorological year (TMY2) data for predicting global solar radiation on a 365-period. Kano state had daily solar radiation of 6.08kWh/m^2 while Onitsha (Anambra state) and Lagos state had 4.43 kWh/m^2 and 4.42 kWh/m^2, respectively. This proves to a long extent the availability of solar energy in the Northern region of Nigeria. Also, with 100 solar panels of 1m^2, each of these states can boost their energy by 608, 443, and 442 kWh, respectively. It also shows that installing more solar systems within the Northern region of Nigeria can bolster Nigeria's energy per person owing to the high availability of solar radiation in the Northern part of Nigeria.

Concerning the availability of hydro-energy resources, it has been discussed in (Maduawuchi, 2020) that there are 10 primary rivers in Nigeria that include Rivers Niger, Benue, Gongola, cross-River, Yobe, Sokoto, Osun, Zamfara, Anambra, have flow lengths of 2597, 870, 342, 330, 304, 200, 199, 166, 160 and 130 miles respectively. Suffice to state that the overall flow length of these rivers is 5298 miles and is equivalent to 8526.31 km, with River Niger having the highest availability with per overall length of 0.49 (49%).

On the part of wind energy, it has been accessed in (Renewable Nigeria, 2009) that at 25m height, a wind turbine installed in some selected states in the six (6) geopolitical zones in Nigeria, the mean wind speed and monthly mean wind energy potential within Maiduguri (NE), Sokoto (NW), Plateau (NC), Enugu (SE), Calabar (SS) and Lagos (SW) are 3.486 m/s||8.42kWh, 4.476 m/s||16.47 kWh, 4.43 m/s||16.05 kWh, 3.372 m/s||7.38 kWh, 1.702 m/s||1.12 kWh and 2.671 m/s||4.36 kWh. These data imply that wind is abundant in Sokoto and Plateau, and installing wind turbines in these states can improve the energy generating capacity and energy supplied.

Apart from the above-stated sources of energy available in abundance in some states and less in some others, there is still availability of geothermal energy sources in most parts of SW and NE regions of Nigeria as stated in (Ikechukwu, Derick, & Agbidi, 2015). This work clearly elucidated that those areas around Borno and Sokoto states are good sites where geothermal energy is readily available.

As a sequel to the availability of Biomass energy in Nigeria, it is believed in (Imasuen, Oshodi, & Onyeobi, 2013) that high forest reserve/plantation population density is needed for Biomass energy generated. It is pertinent to state that Nigeria is a country having enough forest reserve. A prove to this is seen in (Imasuen, Oshodi, & Onyeobi, 2013), where it is clearly stated that states like Borno, Sokoto, Plateau, Enugu, Lagos, and Cross-river have a total of area of forest reserves and forest plantation of 2.219×10^6 ha and 4.61×10^5 ha, respectively. This shows a large area of land which can be harnessed from fading leaves and generate power.

- *The lifespan of the Energy Resource*

Another factor that suggests the choice of a renewable energy resource is the lifespan of the energy resource. Every power plant has a lifespan of which after the plant's lifespan, there are high tendencies of sharp degradation inefficiency of the plant and the consequent overhauling of the plant. In the works of (Bowman, 2021; Energy, 2004; Benefits, 2020), the various energy source plants' lifespan has been stated and the economic cost of installing the plant as in (Administration, 2016). Considering the analysis made in these works, it is imperative to note that hydropower plants well-maintained would have a lifespan of 100years. This implies that for a nominal capacity of 500 MW of power generated through hydro costing $2936 per kW, a total of $8,808 could be saved over using wind energy whose lifespan is 25 years.

- *Economic Cost*

As in (Administration, 2016), economic cost constitutes a significant factor that is to be considered in choosing a renewable energy resource in Nigeria. The work shows that for hydro, wind, solar, and biomass energy resources, a capital cost of $2936/kW, $2213/kW, $3873/kW, and $8180/kW, respectively, are needed to install the various plants at nominal capacities of 500 MW, 100 MW, 150 MW, and 20 MW. Applying a linear algorithm on this data shows that at the same nominal capacity of 500 MW, capital costs of $2,936/kW, $11,065/kW, $12,910/kW, and $204,500/kW. This proves that one would choose to install the cheapest power plant close rather than select the most expensive Biomass energy resource.

- *Environmental and Safety Consideration*

From the work of (Mahesh, 2020), it is seen that virtually all the various forms of energy resources have environmental impact. Although the degree of impact of the various forms of energy sources varies from minor to major. A summarized form of the impact is as shown in the Table 13.

13. Implication of the study

The complete analysis and assessment of available works of literature in this work provide various implications for policymakers and researchers concerned with renewable energy development in Nigeria. Research and development (R&D) programs would play an essential role in developing renewable energy, especially if the government sponsors the R&D. Researchers should pay more attention to the elements that influence people's willingness to use renewable energy. The government can develop a strategy to grow renewable energy technologies in Nigeria and teach this subject in secondary schools and higher education levels. Government policies and incentives should make a variety of renewable energy options available.

There is a clear need for more excellent research that includes public opinion and renewable energy resources to significantly prevent public objections and encourage future utilization of renewable energy sources and renewable energy technology. The implication of our study to industry, policymakers might use public opinion to build appealing policies that incorporate the desired option of renewable energy resources. Another key practical aspect for the government and policymakers is implementing welfare programs associated with RE projects to gain public support. The ramifications for academia are huge. They could include the academic sector, where R&D might be working on renewable energy technologies. In this instance, it would be critical to hold seminars for students from many fields to impart RES and RET expertise. Additionally, the study emphasizes the need to obtain meaningful data from the relevant opinion that potential researchers could use to ensure that RE is accepted successfully.

Table 13
Impact Assessment of energy sources

S/N	Energy Source	Impact	Impact Assessment
1	Solar PV	Toxin	Minor-Major
		Visual	Minor
2	Wind	Noise Visual	Minor
3	Hydro	Agriculture River damage Displacement	Minor-Major
4	Geo-thermal	Odor Seismic activity	Minor
		Pollution	Major
		Noise	Minor

Source: (Mahesh, 2020)

14. Conclusion

This work has explored the renewable energy potential in Nigeria, compared the level of renewable energy utilization for power generation in Nigeria to other countries, reviewed Nigeria's renewable energy policy, factors inhibiting its exploitation and ways of improving it as well a guide to choosing the right renewable energy source to harness in any given location in the country. It is found that Nigeria is endowed with enormous renewable energy resources. Still, the level of exploitation has remained on the low side due to unfavorable government policies, financial constraints, non-implementation of renewable energy policies, inadequate research, among others. Therefore, it is believed that the overall objectives of this research work, which is to explore the level of renewable energy development in Nigeria and compare with other countries ahead of Nigeria to borrow a leaf from it, have been achieved. People's opinions were critically analysed, and recommendations were made. If the authors' recommendations are implemented, there will be a great improvement in the renewable energy status of Nigeria.

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Ethics approval and consent to participate

Not applicable

Consent for publication

All the authors agreed to publish the article. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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