International Journal of Innovative Agriculture & Biology Research 12(1):63-71, Jan.-Mar., 2025

 www.seahipublications.org ISSN: 2354- 2934

doi:10.5281/zenodo.15042049

Accelerating the Transition to Renewable Energy: Sustainable Solutions for Low Carbon Future

Lead Author:
Associate Professor Cynthia Amaka OBIORAH PhD
Centre for Occupational Health Safety and Environment,
University of Port Harcourt, Port Harcourt, Nigeria
cynthia.obiora@cohseuniport.edu.ng

2nd Author:
Prof. Okeke Gerald Ndubuisi
(Professor of Climate Change & Environmental Sustainability)
FNisafetyE, FISPON, etc.
Highstone Global University, Texas, USA.

Engr. Prof. Sony Emeka Ali
(Professor of Civil Engineering & Project Management)
FNSE, FNICE, FNisafetyE, FNIStructE.
Highstone Global University, Texas, USA.

Engr. Ugah Theophilus Aku
Engineer/Environmentalist/Oil & Gas Professional
theogah2004@gmail.com.

Dr. Omatseyione Nesiama
Health Safety & Environmentalist/Geologist/Oil & Gas Professional
Email: otseyione@gmail.com.

Engr. Cletus Onyemhese Agbakhamen
Email ID: cletus.agbakhamen@chevron.com; ceestrides@gmail.com
Phone number: +2348039760095

Eng Dr. Sulaiman Abubakar Gumi FNSE Ph.D

ABSTRACT
This study established that from human evolution and the birth of discoveries and technology, humans have sought solutions to their basic needs, sometimes in advanced forms that lead to bigger problems. The quest to solve issues created in improved forms leads to further discoveries. For humans, as long as they live and explore the earth; discovery, technology, and solving problems to better lives at minimized cost is a continuous cycle. These cycles have led to industrialization and are still leading to new realities such as renewable energy. The primary source of energy in today's world, fossil fuels, including coal, natural gas, and oil, supply about 80% of the world's energy (environmental and energy study institute US). The growing demand for energy despite limited fossil fuel reserves, and the growing environmental concerns from greenhouse gases released when fossil fuels are burned, is a major challenge of the 21st century (Thanon, 2018). Renewable energy is critical in addressing the current climate crisis. Burning fossil fuels like coal, oil, and gas to generate energy produces harmful greenhouse gas emissions such as carbon dioxide, methane, nitrous oxide etc. On the other hand, renewable energy sources are replenished, cost-effective, and with lower manageable risks. Renewable energy is not just cost-effective; it has the potential to deliver the promise of a clean energy future. Nigeria with her population is a large market and a growing economy. Integrating and optimising renewable energy into the national electricity grid without compromising reliability while minimizing other possible risk factors will go a long way to achieving sustainable development However, it is essential to note that, like every other infrastructure, the deployment of renewable energy could have associated social and environmental impacts, like in the present triple planetary crisis of, pollution, climate change, and biodiversity loss. It is therefore critical to assess all impacts carefully while embracing the broader benefits of renewable energy for sustainability.
Keywords: Accelerating, Transition, Renewable Energy, Sustainable, Solutions, Low Carbon , Future.

INTRODUCTION

Nigeria is the most popular country and currently the 4th largest economy in Africa. It is home to one of the fastest-growing populations globally. This leaves her with a rapid increase in demand for energy services which is key to unlocking economic development. This informs a substantial opportunity to develop the rich natural renewable energy resources of the country for greater benefits while minimizing carbon emissions. Nigeria is a lower-middle-income developing country transitioning to sustainable energy and increasing its share of renewables in the energy mix will play a significant role in the country's energy sector and foster not just economic growth and development but also a cleaner environment for the people. For other good reasons such as the health of our communities and the environment, a shift away from fossil fuel to an efficient and renewable-based energy system is a necessity. Availability of adequate, reliable, sustainable, and cost-effective energy is important for the socioeconomic development of any nation (IRENA, 2023). This is not to say that renewable energy is completely risk-free but the risk is a lot less, it is replenished, cleaner, safer, and cost-effective. And as long as the right steps and considerations are properly considered during this shift, there is more to benefit. Nigeria is blessed with abundant renewable energy resources such as hydro, solar, wind, and biomass. Biomass and hydro are already playing a huge factor in the country's energy sector. To achieve sustainability in the renewable energy sector in Nigeria, the origin, usage and approach for these renewables need to be properly managed, addressed extensively and reviewed periodically to meet concurrent needs and new standards for a lasting result.

Statement of the problem

The world is facing an unprecedented energy crisis, driven by the increasing demand for energy, the depletion of fossil fuels, and the urgent need to reduce greenhouse gas emissions to mitigate climate change. Despite the growing adoption of renewable energy technologies, the transition to low-carbon future remains slow and the current pace of progress is insufficient to meet global climate goals.

Aim and objectives

The main focus of this study is to examine the acceleration of the transition to renewable energy: sustainable solutions for low carbon future. The specific objectives of the study include:

1. Examine the nature of available resources for renewable energy.

2. Examine the primary sources of energy in Nigeria.
3. Ascertain the sustainable approach to reliable renewable energy in Nigeria.

Research questions

The following research gives direction to the study.

1. What are the available resources for renewable energy?
2. What are the primary sources of energy in Nigeria?
3. How can Nigeria transition to a reliable renewable energy system while minimizing environmental impacts and ensuring social and economic stability?

Significance of the study

This study is significant for several reasons:

1. Informing Energy Policy: The study will provide insights for policymakers and energy regulators to develop effective policies and regulations that support the transition to renewable energy.
2. Guiding Investment Decisions: The study will provide valuable information for investors, developers, and industry stakeholders to make informed decisions about renewable energy investments.
3. Supporting Sustainable Development: The study will contribute to the achievement of sustainable development goals, including reducing greenhouse gas emissions, improving energy access, and promoting sustainable economic growth.

Scope of the study

This study focuses on available resources for renewable energy, the primary sources of energy in Nigeria, and Nigeria transition to a reliable renewable energy system while minimizing environmental impacts and ensuring social and economic stability.

REVIEW OF RELATED LITERATURES

What is renewable energy?

Renewable energy refers to energy that comes from natural sources that can be replenished constantly. Renewable energy comes from unlimited, naturally replenished resources, like the sun, tides, and wind (Office of Energy Efficiency and Renewable Energy US). Renewable energy is also known as sustainable energy or clean energy because it does not emit harmful substances to the environment. The United Nations defined renewable energy as energy derived from natural sources that are replenished at a higher rate than are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished. Renewable energy sources are plentiful and all around us. Renewable energy comes from sources or processes that are constantly replenished. These sources of energy include solar energy, wind energy, geothermal energy, and hydroelectric power (twiglobal.com). Similarly, the International Renewable Energy Agency (IRENA) has a statutory definition, ratified by 108 members (107 states and the European Union) as of February 2013: "renewable energy includes all forms of energy produced from renewable sources in a sustainable manner, including bioenergy, geothermal energy, hydropower, ocean energy, solar energy and wind energy."

Available resources for renewable energy in Nigeria.

The inception of renewable energy may seem recent but the reality is that humans have had access to natural sources of energy for centuries. For instance, the sun has been used as a source of fire and heat for the longest time just as water wheels and windmills were used to power granaries. A range of renewable energy resources has been identified and developed, each offering its advantages and challenges which are dependent on factors such as geographical location, requirements for use and even the time of year. The following are renewable energy resources available for Nigeria.

Solar energy: This is the most abundant of all energy sources as it can be accessed even in cloudy weather. The amount of energy to meet the planet's power needs for an entire year reaches the earth from the sun in just one hour (twi-global.com). Nigeria has high solar resource potential characterized by an average annual global horizontal irradiation ranging between 1600 kilowatt hours per square metre (kWh/m2) and 2 200 kWh/m2 with the highest values (greater than 2000 kWh/m2) located in the northern part of the country. IRENA estimates the technical potential for solar photovoltaic (PV) in the country at 210 gigawatts (GW) considering only 1% of the suitable land can be utilized for project

development (IRENA and AfDB, 2022). The potential for concentrated solar power (CSP) is also very significant with a potential of approximately 88.7 GW and is mostly located in northern Nigeria, where the direct normal irradiance is highest (Ogunmodimu, 2013). In simple terms, the sun has a huge potential to supply human electricity. Electricity and heat producers, Industry, Transport, Residential, Commercial, and public services, Agriculture Fishing Final consumption not elsewhere specified other energy industries needs. The rate at which solar energy is intercepted by the Earth is about 10,000 times greater than the rate at which humankind consumes energy. With the help of solar technologies sunlight is converted into electrical energy either through photovoltaic panels or through mirrors that concentrate solar radiation. Solar energy can deliver heat, cooling, natural lighting, electricity, and fuels for a host of other applications.

Wind power: Also known as wind energy utilizes the kinetic energy of moving air. With the use of a large wind turbine technology located on land (onshore) or in sea- or freshwater (offshore). Nigeria has moderate wind potential with average wind speeds at 10 metres (m) height ranging between 2.1 m/second (s) and 8 m/s with the highest values (greater than 7 m/s) located in the northern part of the country. IRENA estimates the technical potential for wind at 3.2 GW considering only 1% of the suitable land can be utilized for project development (IRENA and AfDB, 2022). Apart from the coastal and offshore locations, the wind speed in southern Nigeria is relatively low, while higher wind speeds are experienced in the northern region (Emodi and Yusuf, 2015; Idris, Ibrahim and Albani, 2020). At the moment, Nigeria has not identified any offshore potential yet.

Biomass: an organic matter from plants and animals that can be used to generate energy. Nigeria has a huge biomass potential. Exploiting the huge potential of biomass resources in the country, especially in the form of agricultural residues for power generation, will go a long way to resolving the current energy crisis in Nigeria (Simonyan and Fasina, 2013)

Hydro Power: utilizes energy from water moving from higher to lower elevations. Nigeria has a large hydro potential of around 24 GW and a small hydro potential of about 3.5 GW. This potential for the most part is yet to be exploited. In 2015, Nigeria had about 1.9 GW installed capacity of large hydro and about 60 megawatts of small hydro (ECN, 2014b; IHA, 2021; U.S. Department of Trade, 2021).

Why renewable energy? Humans have become increasingly dependent on the use of fossil fuels including coal and natural gas. The widespread use of these types of energy has been identified to have a detrimental impact on the planet, with increasing global temperatures, an increase in extreme weather events and the loss of natural habitats as a result.

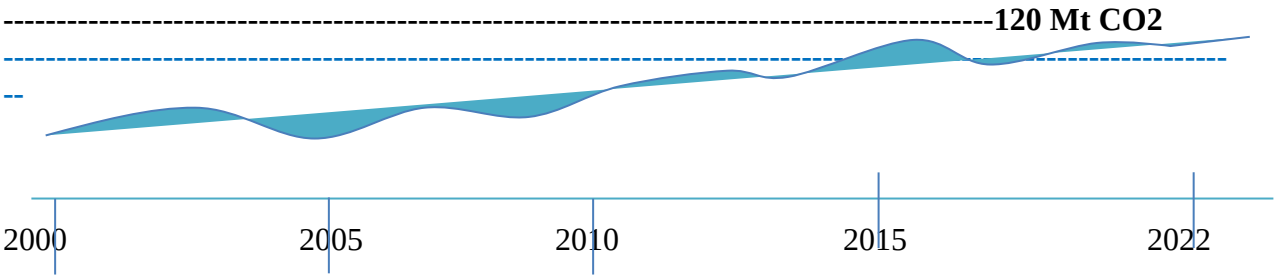
Recent advances in capture and storage, along with the global drive towards net zero have created an expansion in renewable and green energy production. These advances range from small-scale production, such as the placing of solar panels on a home, to large-scale facilities like offshore wind farms. (twi-global.com).

The exploration, production, consumption and combustion of fossil fuels are the main drivers of climate change. Phasing out fossil fuels is necessary to address climate change, and transitioning towards an efficient energy system based on renewable energy sources is widely recognized as the key solution to tackle the triple planetary crisis of climate change, pollution, and biodiversity loss. The transition to a renewables-based energy system is a unique opportunity to build a more inclusive and fairer energy system, economy, and society. In addition to drastically reducing greenhouse gas emissions and pollution – thereby mitigating climate change and improving human health – renewable energy can enable local energy production. This can support energy security and it offers the potential to reduce conflicts over resources. Renewables can foster energy access, support local industrial and economic development, create jobs, and enable bottom-up, decentralized governance and energy democracy (REN21, 2021).

At the moment, fossil fuel generates the highest number of energy supply globally. The process of burning fossil fuel to generate power releases toxic gases that deplete the greenhouse effect which results in an increase in global warming which in turn alters the planet's climate system. Higher concentrations of greenhouse gases, and carbon dioxide (CO2) in particular, are causing extra heat to be trapped and average global temperatures to rise. For most of the past 800,000 years—much longer than human

civilization has existed—the concentration of CO2 in our atmosphere was roughly between 200 and 280 parts per million. (In other words, there were 200 to 280 molecules of the gases per million molecules of air.) But in the past century, that concentration has jumped. In 2013, driven up largely by the burning of fossil fuels and deforestation, CO2 in the earth's atmosphere surpassed 400 parts per million—a concentration not seen on the planet for millions of years. As of 2023, it has reached more than 420 parts per million, which is 50 per cent higher than pre-industrial level (NRDC, 2023). In 2022, for CO2 emission global ranking for fuel combustion, Nigeria ranked 38th globally and 4th in Africa at 100.389 MT(million tonnes) CO2. Between 2000 and 2022 is trending at 126% (Iea 50, 2022).

CO2 emissions from fuel combustion, Nigeria



Source: International Energy Agency. License CC BY 4.0

As of 2015, electricity generation was the largest source of CO2 emissions in the energy sector in Nigeria. However, by 2030, the transport sector will likely become the largest source of CO2 emissions in the energy sector and is expected to maintain this position up to 2050, owing to the huge growth of the fossil-powered transport system. In 2030, within the energy sector, transport emissions will account for 47% and increase to 59% by 2050. The decline in the share of the power sector in total CO2 emissions from the energy sector can be attributed to the rapid growth of renewable energy technologies deployment in the power sector, which is cost-effective to install at scale even without additional incentives (NE23, 2023).

Primary Energy Sources in Nigeria

The primary energy supply of Nigeria is highly renewable at a share of approximately 47%. Biomass dominates the energy mix in Nigeria with a share of 43%. This is as a result of its extensive use for heating and cooking purposes where substantial progress remains to be made in terms of access to clean cooking fuels. The biomass subsector in Nigeria is highly informal with a lot of uncertainties regarding its usage, especially in rural areas, and issues relating to fuel stacking in the Nigerian buildings sector. It is also unclear to what degree biomass is used in the Nigerian industry sector. Hence, the share of biomass in Nigeria's primary energy supply may be greater than the value from the model due to differences in methodological approaches, energy access levels and efficiency values of the modelled biomass technologies used (NE23, 2023). The Nigeria Bureau of Statistics reported 18% access to clean cooking gas in 2019 after a living standard survey. However, international statistics reported 12% access to clean cooking gas in the same year. The data discrepancies could be attributed to the differences in survey methodology and measurement techniques and what counts as clean cooking.

Oil comprises a similar share of primary energy requirement as bioenergy. While Nigeria is working to get its refineries working at optimum capacity, the existing capacity is insufficient to satisfy the local demand for petroleum products. To meet this requirement, 80% of the refined oil products used in Nigeria are imported from abroad (PWC, 2017). As it is Nigeria has more to gain from pivoting towards domestic renewable energy sources in place of domestic fossil fuels. Encouraging local development of available renewable energy resources will empower champions in the local innovative renewable energy in a way that could lead to local job creation and the rise of industries.

Natural gas, hydropower and natural gas make up the remainder of the primary energy requirement of Nigeria and are used in the power sector for the most part. The low penetration of variable renewables such as solar and wind shows the opportunity embedded in integrating them into the power sector, given

the substantial cost reductions of the technologies in recent years and the enormous natural resource that Nigeria has, especially for solar power (IRENA, 2021b). A lot of advantages lie within these technologies; their design makes them easier to put into use in a decentralised setting, and in combination with storage can reliably provide power to a large extent.

The power sector in Nigeria: This sector is grouped into two, a. centralised (connected to grid) b. decentralised (off-grid) systems.

Centralised system: consists of large-scale generation of electricity at centralised facilities like large hydro and thermal plants.

Decentralised system: comprises electricity supply of a few kilowatts to megawatts capacities like gasoline/diesel generators and renewable energy technologies solar home systems, street lights and mini-grids.

The total installed grid-based systems capacity is around 13 GW. However, today's available ongrid peak generation varies and hovers around 4.5 GW. Nigeria's on-grid generation is dominated by natural gas power stations (86%) and large hydropower plants (14%). However, the unavailability of gas, machine breakdowns, seasonal water shortages, and limited grid capacity have severely limited the operational performance of these power plants (Yetano Roche et al., 2020). The inability of grid-based systems to supply enough needed power has led to blackouts lasting for hours in a day. The situation has also made many households and business units result in the self-generation of off-grid electricity using diesel/gasoline generator sets as a backup. In terms of installed capacity, there is considerable uncertainty about the total capacity of fossil fuelbased self-generation. However, looking at the number of generators imported annually into the country, it is assumed that around 15 GW of diesel and petrol-based generation capacity were available in the country as of 2015 (NE23).

Nigeria is the leading importer of generators globally. It is like a home survival pack for every household in Nigeria. The poor power supply system and the relatively expensive generators have by far negatively impacted the economy in both residential and industry sectors. Small and medium enterprises and households get to spend two or even three times more on diesel, petrol, and kerosene than they do on electricity (All one, 2016).

For the reasons mentioned above and more, there is a need for Nigeria to improve the generation and distribution of reliable electricity in the country. This in turn will minimise the cost on end users, and reduce noise pollution and CO2 emission. It will also boost the economy at large.

According to the renewable energy roadmap report 2023, it will cost Nigeria around USD 34.5 billion to provide quality electricity access to households by 2030.

Renewable energy outlook

Nigeria's current energy system is quite dynamic. It will be beneficial if long-term energy goals are re-evaluated from time to time to reflect changing market dynamics and the country's energy priorities. The opportunities and challenges of the energy context in Nigeria have been identified earlier.

The macroeconomic factors that apply to any country serve as the basis of its development trajectory and also play a key role in determining its future energy demand trajectory and corresponding emissions (Renewable energy roadmap. Nigeria,2023).

The Planned Energy Scenario (PES) to 2050 is a series of government policies developed in partnership with international bodies for Nigeria's energy sector dating back to 2003 - 2016 with all the challenges it faces, it is still a hopeful ambition.

With the growing population of Nigeria and the increase in demand for energy both at residential and industrial levels, considering both the cost of production and decline in fossil fuel reserves, the Nigeria government needs to prioritise and maximise the renewable energy option as a reliable alternative to meeting the country's energy needs for economic growth and improved life for the citizens.

A sustainable approach to reliable renewable energy in Nigeria

The complexity of renewable energy requires continuous attention in both policy and regulation. To build shared trust and understanding on matters relating to renewable energy for sustainability as such that have economic, social, and environmental implications; prioritising knowledge diversity and

collaborations with various stakeholders is critical to making informed decisions. To achieve stability in renewable energy sectors in Nigeria, mainstream best practices such as **avoiding, reducing,** and **mitigating risk** approaches must be integrated to ensure credibility, stability, reliability, and accountability for maximum benefit.

Best practices: Avoiding or minimising potential negative impacts on land, water, and biodiversity, why shifting or deploying renewable energy by careful siting of renewable energy infrastructure. This can be achieved through sensitivity mapping and environmental assessments to avoid endangering critical habitats and species and disrupting local communities (REN21, 2021)

Proper regulation will help reduce the impacts of renewable shifts on citizens. Regulated practices such as following up with community engagement and industry standards can help promote:

- The deployment of renewables on degraded land or former industrial, contaminated, and marginal lands; the integration of renewables in existing infrastructure such as rooftops, railway infrastructure, highways, and floating platforms; and the use of waste streams in energy production.
- multiple uses of land and water, such as integrated solar photovoltaics (PV), agrivoltaics, floating solar PV, and nature-positive management of land used for renewable energy installations as well as for grid infrastructure;
- Sustainable agricultural practices, such as agroforestry, sustainable crop rotations, appropriate feedstock selection, and natural pest control. Regarding Bioenergy and considering the diversity of technologies, feedstock, and location (REN21,2021).

For best practices to yield credible results, measures must be taken to address protocols that could hinder efforts. These measures include but are not limited to;

a. Efforts must be made to mitigate unsustainable practices such as illegal logging, deforestation and pollution;

b. Ensure the inclusion of all relevant stakeholders in planning processes, especially those potentially affected by the deployment of new infrastructure, to ensure that diverse perspectives are integrated and that local knowledge is used to maximise benefits;

c. Ensure the protection of human rights – including land rights, labour rights, and the rights of Indigenous Peoples (such as through the implementation of Free, Prior and Informed Consent, FPIC) – as well as the inclusion of women along the renewable energy supply chain; (REN21, 2021)

d. Ensure third-party verification and mandatory due diligence to ensure that regulations are implemented effectively to minimize risk and waste.

To reduce resource demands, the principles of the circular economy and energy efficiency can be employed: redesign, reduce, repair and renovate, re-use, recover, and recycle.

Findings of the study

1. The study established that the primary source of energy in today's world, fossil fuels, including coal, natural gas, and oil, supply about 80% of the world's energy (environmental and energy study institute US).
2. The study also established that, solar energy is the most abundant of all energy sources. The study further observed that, Nigeria has high solar resource potential characterized by an average annual global horizontal irradiation ranging between 1600 kilowatt hours per square metre (kWh/m2) and 2 200 kWh/m2 with the highest values (greater than 2000 kWh/m2) located in the northern part of the country.
3. Conversely, the study findings out that, the deployment of renewable energy could have associated social and environmental impacts, like in the present triple planetary crisis of, pollution, climate change, and biodiversity loss.

METHODOLOGY

The study will adopt an exploratory approach to identify and examine the key factors influencing the transition to renewable energy. The study l employ analytical techniques, such as content analysis and thematic analysis, to examine the qualitative data collected from expert interviews, A comprehensive

literature review was conducted to identify existing research on the transition to renewable energy. A semi-structured interview with policymakers, industry leaders, and civil society representatives was conducted to gather insights on the transition to renewable energy. Similarly, a survey of renewable energy stakeholders was conducted to gather data on their perceptions and experiences with the transition to renewable energy.

CONCLUSION

A good percentage of Nigeria's energy mix is renewable however; the options available and the potential of renewable energy are safe to say it's still untapped. The dependence of Nigeria on oil is not enabling proper investment in renewable energy to maximize its full benefits. It therefore calls for urgent and collaborative efforts from policymakers and independent stakeholders to mitigate this gap for the growth and development of this country. Availability, distribution, and cost of energy play a crucial role in the growth and development of any nation especially in the industrialization phase. Nigeria is currently at that key point in time when capitalizing on its abundant renewable energy resources to meet the growing needs of its population will not only be simultaneously addressing her socio-economic challenges but also be improving the environment and making it a lot more habitable.

RECOMMENDATIONS

Drawing insights from various studies and research reports, government policies, and approaches to maximizing renewable energy, one common challenge is funding and untapped potential. It is therefore recommended that:

1. Broad base national planning implementation, regulation, and accountability will go a long way in ensuring proper management of action plans in ways that the benefits of renewable energy transition outweigh the costs.
2. Among other measures, a fiscal system is required to facilitate the adoption of energy transition solutions while disincentivizing new investments in fossil fuel technologies and supporting a national phase-down and -out of these technologies aligned with a climate-compatible pathway.
3. Conversely, policies and procedures that facilitate access to finance encourage innovation, and raise awareness among consumers (citizens) to embrace and support transition-related technologies are a wholesome necessity for a sustainable and reliable transition to renewable energy.

REFERENCES

All On (2016), Nigeria: Energy needs assessment and value chain analysis.

Bernard Thanon (2018) - Advanced sustainable energy technologies for cooling and heating applications. Available at: https://www.researchgate.net/publication/327270002_Advanced_sustainable_energy_tec technologies_for_cooling_and_heating_applications (Accessed 12 November 2024)

ECN (2014b), National Energy Master Plan, Energy Commission of Nigeria

Emodi, N.V. and Yusuf, S.D. (2015), 'Improving electricity access in Nigeria: obstacles and the way forward', International Journal of Energy Economics and Policy, 5(1), pp. 335–351.

Environmental and Energy Study Institute (2021). Available at: https://www.eesi.org/topics/fossil-fuels/description (accessed 12 November, 2024)dis

Fossil fuel, the dirty facts. Available at: https://www.nrdc.org/stories/fossil-fuels-dirty-facts#secwhatis (Assessed 11 November 2024)

Iea50 - How much CO2 does Nigeria emit? Available at: https://www.iea.org/countries/nigeria/emissions (Accessed 13 November 2024)

IHA (2022), Nigeria Country Profile. Available at: www.hydropower.org/countryprofiles/nigeria (accessed: 13 November 2024).

International Renewable Energy Agency - IRENA (2023). Available at: https://energy.gov.ng/reports/IRENA_REMap_Nigeria_2023.pdf (Accessed 11 November 2024)

IRENA and AfDB (2022), Energy Transition Central to Africa's Economic Future. International Renewable Energy Agency, Abu Dhabi.

IRENA renewable energy road map REmap 2023 Available at: https://energy.gov.ng/reports/IRENA_REMap_Nigeria_2023.pdf (Accessed 13 November 2024).

National grid - what is the clean energy transition? Available at: https://www.nationalgrid.com/stories/energy-explained (Accessed 10 November 2024)

NRDC - Greenhouse effect 101. Available at: https://www.nrdc.org/stories/greenhouse-effect101 (Accessed 13 November 2024)

NDRC - renewable energy- the clean facts. Available at: https://www.nrdc.org/stories/renewable-energy-clean-facts#sec-other (Accessed 11 February, 2025).

NE23 - Renewable energy roadmap (2023). Available at: https://www.nigeriaenergy.com/content/dam/markets/emea/nigeria-energy/en/2023/docs/NE23- NigeriaEnergyRoadmap-Report.pdf (Accessed January, 2025).

Ogunmodimu, O.O. (2013), 'CSP technology and its potential contribution to electricity supply in northern Nigeria', International Journal of Renewable Energy Research (IJRER), 3(3), pp. 529–537.

PWC (2017), Nigeria's Refining Revolution. Renewable energy and sustainability report. REN21 pp 13 -14

Simonyan, K.J. and Fasina, O. (2013), 'Biomass resources and bioenergy potentials in Nigeria', African Journal of Agricultural Research, 8(40), pp. 4975–4989.

Types of renewable energy sources. Available at: https://www.twi-global.com/technicalknowledge/faqs/renewable-energy (Accessed January, 2025).

United Nations - Climate action - what is renewable energy? Available at: https://www.un.org/en/climatechange/what-is-renewable-energy (Accessed 12 January, 2025).

United Nations - What is renewable energy- Climate action. Available at: https://www.un.org/en/climatechange/what-is-renewableenergy?gad_source=1&gclid=CjwKCAiAudG5BhAREiwAWMlSjC_86dqtupSBkXNoC dUO9NKCwxYyo (Accessed 12 January, 2025).

U.S. Department of energy - energy efficiency and renewable energy. Available at: https://www.energy.gov/eere/renewable-energy (Accessed 11 January, 2025).

U.S. Department of Trade (2021), Nigeria - Country Commercial Guide. Available at: www.trade.gov/country-commercial-guides/nigeria-electricity-and-power-systems (accessed: 12 January, 2025).

Yetano Roche, M. et al. (2020), 'Achieving Sustainable Development Goals in Nigeria's power sector: assessment of transition pathways', Climate Policy, 20(7), pp. 846–865