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ENERGY TRANSITIONS IN NIGERIA: THE ROLE OF POLICIES FOR THE ADOPTION OF LOW-CARBON TECHNOLOGIES AND SYSTEM INTEGRATION

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ABSTRACT
This study underscores the role of Policies for adopting low-carbon technologies and system integration in Nigeria's energy transition. Although the nation has abundant energy resources, a sizeable section of its people lacks access to power, creating severe problems with energy accessibility. To address this problem, the government has implemented several programmes and plans. However, the high initial costs of low-carbon technology, particularly in rural regions, have hampered their development. The study emphasises the importance of a user-centred approach, contextualisation of technology, consideration of social norms, and the role of intermediaries in facilitating the adoption and use of low-carbon technologies. It also highlights how policy interventions can either accelerate or delay the adoption of low-carbon technologies. The study recommends that policymakers and technology developers adopt a holistic approach by considering various issues in policy formulation concerning the transition to low-carbon technologies.
KEYWORDS: *Energy Transitions, Low-Carbon Technologies, System Integration, Policies, Plans, and Nigeria*

1.0 INTRODUCTION

The fight to lessen climate change's effects is facing an unprecedented challenge due to limitations in adopting low-carbon technologies, and incorporating renewable energy sources into the present energy mix, with non-renewable energy source accounting for 76.5% of global electricity supply (International Renewable Energy Agency [IRENA], 2018). The transition to a low-carbon economy necessitates extensive government policy action to encourage the adoption and ensure proper integration into current systems. The energy sector produces a sizable amount of greenhouse gas (GHG) emissions, and changing to a low-carbon economy necessitates changing the energy system. Policies that promote the use of low-carbon technologies, such as wind and solar energy, can aid in lowering the carbon footprint of the energy sector. In addition, such laws could cover the usage of renewable energy in the energy mix, feed-in tariffs for renewable energy generation, and incentives for renewable energy projects.

According to Heiskanen, et al. (2017) systems integration is critical for low-carbon technologies to reap the advantages of the global energy transition. Coordination and optimisation of multiple energy sources, storage infrastructure, and on-demand resources are included in the system integration. In addition, the reliability and efficiency of the energy system can be improved with policies that support system integration. Regulations regulating the installation of smart grids, creating energy storage technologies, and promoting demand management techniques are examples of such policies.

Low-carbon technologies and system integration have significant economic advantages, such as energy security. Energy security can improve by using renewable sources, which can assist in lessening the reliance on fossil fuels. Developing low-carbon technologies can also lead to new markets and employment possibilities. Governments can use these economic advantages to design programmes to encourage the adoption of low-carbon technologies and system integration (Sadiq, 2020).

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Adopting low-carbon technologies and integrating systems both present difficulties for the energy transition. System integration needs to be improved because of the erratic nature of renewable energy sources like wind and solar. In addition, the effectiveness of regulations meant to encourage the adoption of low-carbon technology can also be hampered by the absence of suitable infrastructure for the distribution and storage of renewable energy. Comprehensive and integrated low-carbon technology deployment and systems integration strategies are required to address these issues. They must consider the overall energy system and the interconnections between various energy sources and technologies. To successfully transition to a low-carbon economy, policies must be developed with a long-term vision and implemented over many years.

It is essential to reiterate that systems integration and the deployment of low-carbon technology are critical to reducing the effects of climate change. However, doing so needs massive political action on the part of governments. Reduced GHGs, improved energy security, the emergence of new industries and employment opportunities, and an improvement in the dependability and efficiency of the energy system can all be achieved with the aid of policies that support the adoption of low-carbon technologies and systems integration. The political, economic, technological, and public perception and acceptance levels must all be considered while developing and implementing these policies.

2.0 LITERATURE REVIEW

Nigeria is transitioning to cleaner energy sources, such as renewable energy and improving energy efficiency and to address the challenges of energy security, climate change and GHG emission, policies have been developed to encourage the adoption of low-carbon technologies, such as the National Renewable Energy and Energy Efficiency Policy (NREEP), which aims to increase the share of renewable energy in the country's energy mix. In addition, initiatives such as the Nigerian Electrification Project (NEP) and the Energizing Education Program have been launched to support adopting low-carbon technologies and increasing access to electricity. However, system integration is also crucial to Nigeria's energy transition, and integrating renewable energy into the grid requires significant political support. This review will examine the role of public policy in promoting the uptake of low-carbon technologies and systems integration in Nigeria's energy transition.

The International Energy Agency's (IEA, 2020) report on transitions to low-carbon electricity systems, key economic and investment trends changing course in a post-pandemic world, analyses the trends and challenges in the transition to low-carbon electricity systems, particularly in the context of the COVID-19 pandemic. The report highlights the significant decline in electricity demand and investment due to the pandemic but also points out the opportunity to accelerate the transition to clean energy. In addition, the report emphasises the need for ambitious policies and regulatory frameworks that support deploying renewable energy technologies and the decarbonisation of the power sector. The report also highlights the importance of investments in grid infrastructure, energy storage, and flexible options to integrate higher shares of variable renewable energy sources. Overall, the report provides valuable insights into the key economic and investment trends shaping the energy transition and emphasises the urgent need for action to achieve a low-carbon electricity system.

Heiskanen, et al. (2017) in their study examine the adoption and use of low-carbon technologies in Finland using data from 100 pilot studies, field experiments, and demonstrations. According to the authors, several variables, such as the technical properties of the technology, user behaviour and practices, and the institutional framework in which the technology is used, affect whether low-carbon technologies are adopted and used.

Schwarz's (2020) study thoroughly analyses California and Switzerland’s policies to encourage the adoption of low-carbon technology and its integration into the energy system. According to Schwarz, regulations are essential in facilitating the shift to a low-carbon energy system, and decision-makers should prioritise policies that offer long-term predictability and stability for investors in the renewable energy sector. Schwarz further suggests that decision-makers prioritise initiatives that encourage energy efficiency and transportation electrification.

Olufolahan, Frank, and Agni (2018) explore applying the multi-level perspective on socio-technical transitions to rentier states: the case of renewable energy transitions in Nigeria underscores the renewable energy sector in Nigeria and how the multi-level perspective (MLP) framework can be applied to analyse the interactions among different levels of actors and factors involved in socio-technical transitions. The authors found that the renewable energy sector in Nigeria faces several challenges, including the dominance of the oil and gas industry, limited policy incentives and support for renewables, and inadequate infrastructure. However, there are also niche-level developments, such as the emergence of solar energy entrepreneurs and community-based renewable energy initiatives, which offer opportunities for sustainable development. The authors recommend the need for more supportive policy

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frameworks and incentives, increased investments in infrastructure, and greater awareness and education about renewable energy to promote the transition towards a more sustainable energy system in Nigeria.

Sadiq (2020), in his investigation of models of community-based low-carbon distributed energy systems in Nigeria, used different models and methods to analyse their technical, economic, social, and environmental feasibility. The author found that community-based low-carbon distributed energy systems have the potential to provide affordable and reliable electricity to underserved communities in Nigeria while also reducing carbon emissions. However, implementing these systems faces several challenges, including financial barriers, lack of government support, and limited awareness and education about renewable energy. Therefore, the author recommends that relevant government agencies engage and coordinate their efforts to address energy challenges like climate change and increase the deployment of innovative technologies such as small-scale distributed energy systems and energy storage. These efforts involved introducing new players into the sector, with various decision-making institutions, including the Energy Commission, the Ministry of Power, and the Ministry of the Environment, coordinated by the Ministry of Planning.

Shialsuk's (2021) study is an insightful analysis of the ongoing energy transition in Nigeria. The author argues that despite focusing on fossil fuels, Nigeria is quietly transitioning towards renewable energy sources, particularly solar energy. The study highlights several examples of this transition, including the emergence of solar energy entrepreneurs and the adoption of solar energy systems in homes and businesses. The author also notes that the growth is driven by a combination of factors, including the declining cost of harnessing solar energy, increasing energy demand, and environmental concerns. The study concludes by recommending the need for greater awareness and education about renewable energy, supportive policy frameworks and incentives, and increased investment in renewable energy infrastructure to accelerate the energy transition in Nigeria. Overall, the article provides valuable insights into Nigeria's shift towards renewable energy sources and offers practical recommendations for policymakers and stakeholders in the energy sector.

The book "Low-Carbon Development Opportunities for Nigeria" (Cervigni, Rogers, & Henrion, 2015) comprehensively analyses low-carbon development opportunities in Nigeria. The authors examine different sectors of the Nigerian economy, including energy, agriculture, transport, and waste management, and explore ways to reduce carbon emissions and promote sustainable development. The book highlights several key findings, including the need for supportive policy frameworks and incentives, increased investment in renewable energy and energy efficiency, and greater collaboration between the public and private sectors. The authors also recommend greater awareness and education about low-carbon development opportunities and the potential benefits of transitioning towards a low-carbon economy. The book provides a valuable resource for policymakers, stakeholders, and researchers interested in promoting low-carbon development in Nigeria and other developing countries.

Agaptus Nwozor et al. (2021), in their study of the transition to green energy and sustainable development in Nigeria, employ a literature review approach to analyse the prospects of green energy transition and sustainable development in Nigeria. The study found that Nigeria has a high potential for renewable energy sources, particularly solar and wind energy. Still, the transition to green energy requires supportive policies, institutional reforms, and investments. Therefore, the authors recommend a comprehensive energy transition strategy considering sustainable development's economic, social, and environmental dimensions. They also suggest the importance of stakeholder engagement, public awareness, and technology transfer to facilitate Nigeria’s transition to green energy. Overall, the article provides valuable insights into the challenges and opportunities of green energy transition and sustainable development in Nigeria and offers recommendations for policymakers, stakeholders, and researchers in the energy sector.

Aye, I., Odude, F., Odekina, I., & Iheonye, I. (2022), in their study of Renewable Energy Law in Nigeria, provide an overview of the legal framework and policies governing renewable energy development in Nigeria. The authors highlight Nigeria's ambitious target of achieving 30% renewable energy penetration by 2030 and the government's efforts to create an enabling environment for renewable energy investment. They also discuss the challenges facing the renewable energy sector in Nigeria, including inadequate infrastructure, high investment costs, and a lack of access to financing. The authors recommend that the government implement more incentives and regulatory frameworks to attract private sector investment in the renewable energy sector and ensure that renewable energy projects are integrated into the national grid. They also suggest the need for increased public awareness of the benefits of renewable energy and the condition for sustainable energy development.

The oil and gas industry in energy transitions report by the International Energy Agency (IEA) (2020) examines the role of the oil and gas industry in the transition to clean energy and the challenges the industry faces in this transition. The report argues that the oil and gas industry has a critical role in the energy transition by reducing greenhouse gas emissions, increasing energy efficiency, and

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investing in renewable energy sources. However, the report also highlights the industry's challenges, including policy uncertainties, high investment costs, and the need for technological innovation. The report recommends a collaborative effort between the industry, policymakers, and other stakeholders to address these challenges and accelerate the transition to a low-carbon energy system, primarily through adopting low-carbon technologies and system integration.

Beck, Bellone, Hall, Kar, & Olufon (2020), in their contributions to the big choices for oil and gas in navigating the energy transition report by McKinsey and Company, analyse the challenges and opportunities for the oil and gas industry in transitioning to a low-carbon future. The authors highlight three strategic choices that the industry must make: (1) prioritise decarbonisation efforts, (2) expand into low-carbon businesses, and (3) enhance operational efficiency. The report also emphasises the importance of collaboration between industry players, governments, and other stakeholders to achieve a successful energy transition.

2.1 Global Energy Transition

The present global energy transition is the fourth energy transition initiated at COP21, which saw 196 countries ratifying a legally binding worldwide agreement on climate change to keep global warming between 1.5 and 2℃ by the year 2050. At COP 21, developed countries pledged about $100 billion per year toward developing renewable energy initiatives to usher in the non-fossil fuel era, setting the foundation for the fourth Energy Transition, which has seen changes in government policy and investment flows (Beck, Bellone, Hall, Kar, & Olufon, 2020).

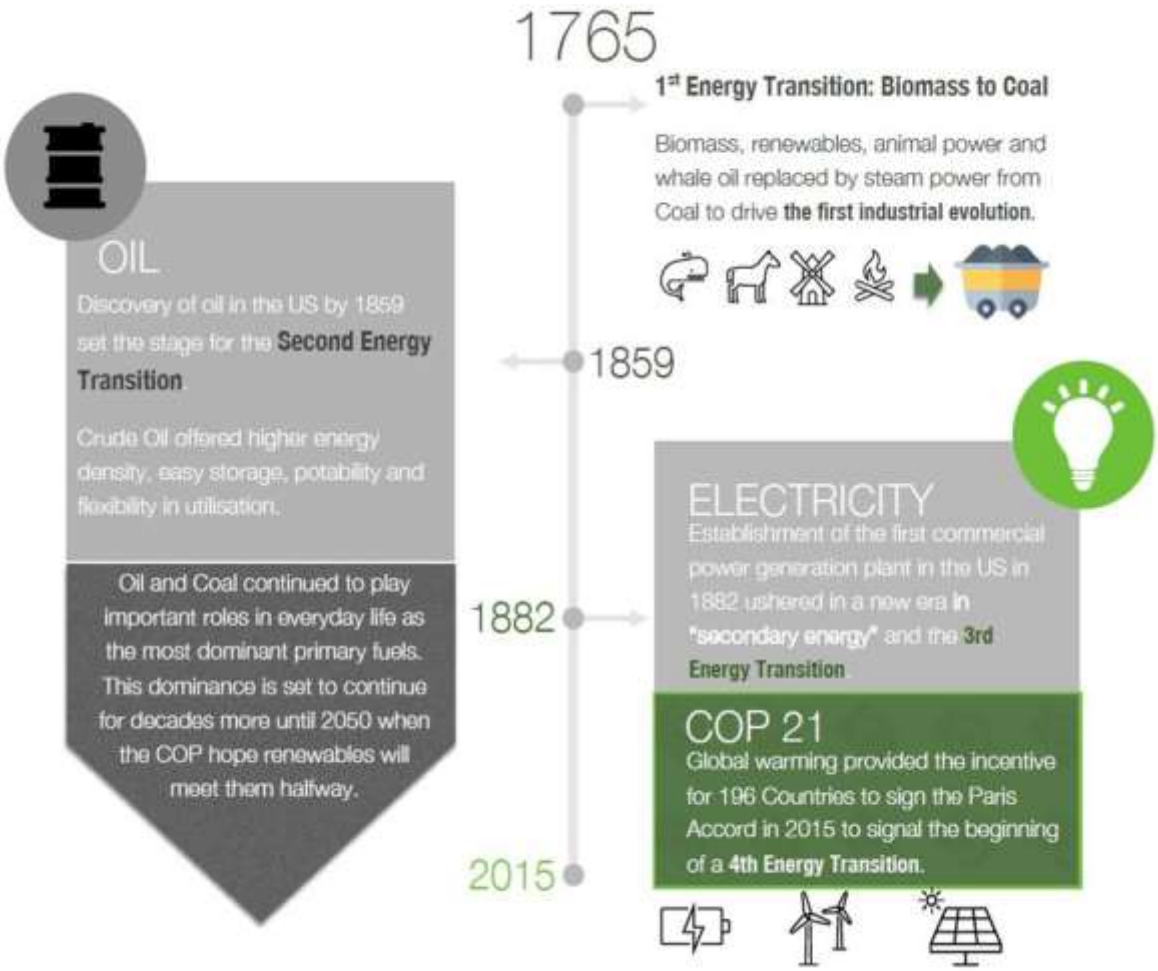

Figure 1: Global Energy Transitions. Adapted from Shialsuk, N. N. 2021, Hidden in Plain Sight: Nigeria's Energy Transition. Seplat Energy Summit

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Global concerns over increasing climate change, global warming, energy security and sustainable development have sparked an increase in demand for a global effort towards transitioning from fossil fuel-based energy systems to more sustainable and greener renewable energy systems (Gielen et al., 2019). This has led governments, corporations and organisations to set ambitious targets to limit their carbon footprints and transition to renewable energy. For instance, the European Union aims to achieve carbon neutrality by 2050 (European Commission, 2019). China has pledged to reach peak carbon emissions by 2030 and achieve carbon neutrality by 2060 (Sun et al., 2022). This has also spurred the demands and adoption of renewable energy technologies such as wind, solar, and hydropower towards meeting these targets (IRENA, 2018).

Issues around intermittency and a need for energy storage pose a significant challenge for the full transition to renewable energy systems (Kebede et al., 2022). However, research suggests that transitioning to renewable energy presents promising socio-economic opportunities, including job creation, poverty alleviation, increased health and wellness and reduction in environmental catastrophe (Arndt et al., 2019).

Furthermore, advances in energy storage technologies such as batteries and hydrogen fuel cells have led to significant strides in addressing the intermittency Challenge and improving the integration of generated renewable energy into the existing power grids (IEA, 2020).

2.2 Low-Carbon Technologies and System Integration

The urgent need to limit greenhouse gas emissions, climate change, and global warming makes adopting and deploying low-carbon technologies and system integration critical in current global energy systems (IEA, 2020). Low-carbon technologies involve properly harnessing resources such as wind, solar, and hydropower, as well as energy-efficient buildings, electric vehicles, and optimal energy storage systems (IRENA, 2018), while system integration involves the coordination of the energy output from the various low-carbon technologies, optimise their performance and minimise their associated costs (Arent et al., 2021).

Renewable energy sources have grown significantly recently while their costs have simultaneously decreased significantly, with technologies like solar and wind energy becoming increasingly competitive with fossil fuels (IRENA, 2021). However, integrating these low-carbon energy sources into existing power grids presents challenges around energy storage, grid flexibility and capacity (Phuangpornpitak & Tia, 2013). Storage systems such as Li-ion batteries and hydrogen fuel cells are being developed to address these energy storage challenges (Kebede et al., 2022). In addition, advanced control and optimisation algorithms are used to monitor and manage the system to ensure reliability and stability (Jin & Peng, 2018).

Utilising energy-efficient buildings and electric vehicles as virtual power plants is also essential to a low-carbon future, integrating these technologies into the global energy systems will provide the additional flexibility and reliability critical for optimum low-carbon systems integration (Barone et al., 2022). In addition, smart grid technologies and demand response programs can help achieve the desired systems integration (Pfeifer et al., 2018).

3.0 ENERGY TRANSITIONS IN NIGERIA

Nigeria's energy demand is witnessing a big upsurge due to the country's high Population growth and economic development, like in many countries in the Global South (IEA, 2019). Nigeria is Africa's largest oil producer and exporter with fossil fuel accounting for most of its energy mix (IEA, 2021). The Nigerian government has recognised the need to diversify its energy mix and its need for energy transition and has set an ambitious target of achieving 30% renewable energy share by 2030 (Daudu & Idehen, 2021).

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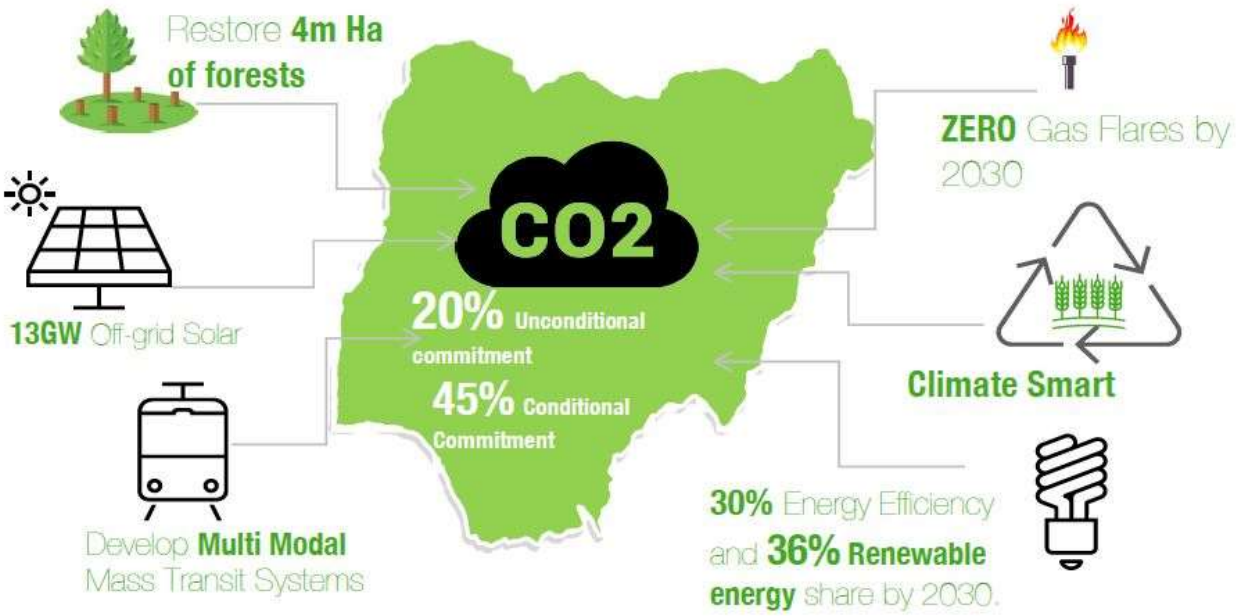

Figure 2: Nigerian Commitment to the Energy Transition. Adapted from IRENA 2018, *Renewable https://www.irena.org/publications/2018/apr/renewable-energy-policies-in-a-time-of-transition*

According to the Nationally Determined Contribution (NDC) report, Nigeria is committed to reducing GHG emissions by 20% unconditionally and 45% conditionally with the necessary assistance to comply with the COP21 Paris Agreement (Shialsuk, 2021).
A key driver of Nigeria's energy transition is improving access to electricity. Nigeria's electrification rate is just over 55%, with rural areas significantly underserved (World Bank, 2020). To improve electricity access, the Nigerian government has implemented various initiatives, including the Rural Electrification Agency (REA) to champion the electrification of underserved rural communities and the Energizing Education Programme, which is geared towards providing off-grid solar power to universities and teaching hospitals across the country (Vincent & Yusuf, 2014).

Another important driver of Nigeria's energy transition is the need to mitigate the effects of global warming and climate change. To this effect, the Nigerian government has also committed to reducing the country's carbon emissions by 20% by 2030 (FMoE, 2021). In achieving this, the government is partnering with other stakeholders and investing in low-carbon energy technologies such as solar, wind, and hydropower and is committed to deploying the necessary energy efficiency management measures (FMoE, 2021).

3.1 Low-Carbon Technologies and System Integration in Nigeria

Nigeria's push in transitioning from a high-carbon to a low-carbon economy requires it to move from using fossil fuels that cause significant carbon and greenhouse gas emissions and environmental degradation towards more sustainable low-carbon alternative energy sources (IEA, 2021). To achieve this ambitious target, the Nigerian government has started investing in renewable energy technologies, such as solar, wind, and hydropower, as well as efficient energy systems integration measures (FMoE, 2021).

Furthermore, there are concerns about the country's current energy infrastructure and the ability to properly and efficiently integrate the energy outputs from various renewable energy sources. Hence, the government is implementing a national innovative grid system to ensure a comprehensive system integration strategy and to enable better monitoring and management of the power grid (FMoE, 2021).

One example of low-carbon technology and system integration implemented in Nigeria are off-grid and mini-grid solar systems. These systems provide electricity to communities not connected to the national power grid, particularly in rural communities, and they equally augment the power supply to important institutions like universities and teaching hospitals (REA, 2018). The Rural Electrification Agency (REA) has been recording success in the implementation of these systems (Vincent & Yusuf, 2014).

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4.0 POLICIES FOR ADOPTING LOW-CARBON TECHNOLOGIES AND SYSTEM INTEGRATION IN NIGERIA

Historically, Nigeria has created various policies to assist in first solving its power failure problem which had impacted its industrial capacity development, and is recently being hampered by the global energy transition and the call for sustainable, cleaner, affordable energy. These policies, in general, are complementary towards ensuring the availability, accessibility and affordability of energy while trying to solve the problem of energy poverty in the country.

The following is a review of the various energy policies in the country.

4.1 National Electric Power Policy 2000

A significant turning point in the development of Nigeria's power sector was the National Electric Power Policy of 2001. The policy laid a thorough plan for constructing Nigeria's power infrastructure to address the industry's issues. The strategy responded to Nigeria's rising demand for electricity and the requirement to update the nation's deteriorating power infrastructure.

The Nigerian Electricity Regulatory Commission (NERC) and the Nigerian National Petroleum Corporation (NNPC) were among the industry participants who helped the Federal Ministry of Power and Steel draft the strategy. The system provided a development plan for the nation's electricity infrastructure, emphasising expanding the national grid's capacity, enhancing the dependability of power supply, and encouraging the use of renewable energy sources.

One of the policy's main goals was to boost Nigeria's national grid's capacity to 10,000 MW by 2007. The strategy suggested building new power plants, renovating existing ones, expanding the transmission and distribution networks, and other measures to accomplish this goal.

Additionally, the programme mandated the privatisation of the power industry, with the government holding just a little interest.
The policy acknowledged the relevance of renewable energy sources in supplying Nigeria's expanding energy needs. Accordingly, the strategy suggested promoting renewable energy technologies, including solar, wind, and hydropower. The policy also mandated the creation of a fund to encourage the growth of renewable energy in Nigeria and a legal framework for the construction of renewable energy projects.

The subject of tariff reform in Nigeria's power sector was also covered under the National Electric Power Implementation Policy of 2001. The strategy advocated implementing cost-reflective tariffs to allow the electricity sector to function commercially. The policy also mandated the creation of the NERC, an impartial regulator, to supervise the execution of the programme for reforming tariffs and ensuring that rates were established at levels that would allow the electricity sector to run sustainably.

The plan acknowledged the need for greater investment in the power industry. As a result, it suggested creating a special purpose entity called the National Integrated Power Project (NIPP) to draw in private investment for the industry. The NIPP was designed to promote private investment in building new power plants and renovating existing ones, with government guarantees for loan repayment and the purchase of the electricity produced by the plants.

Finally, the National Electric Power Implementation Policy of 2001 marked a crucial turning point in the growth of Nigeria's power industry. The programme outlined a thorough strategy for constructing the nation's electrical infrastructure, focusing on boosting the national grid's capacity, enhancing the security of the power supply, and encouraging the use of renewable energy sources. In addition, the policy recognised the need for more industry investment and addressed the tariff reform issue. Although there have been significant difficulties with the policy's execution, it continues to be a crucial guide for the growth of Nigeria's electricity sector.

4.2 National Energy Policy 2003

Nigeria's National Energy Policy (NEP) was adopted in 2003 in response to the nation's rising energy needs and the requirement for sustainable energy development. The policy aims to support the growth of Nigeria's energy industry, provide energy security, and increase the sector's contribution to the nation's socioeconomic development.

One of the NEP's main goals is to give all Nigerians access to dependable and affordable electricity. Renewable energy sources, including solar, wind, hydro, and biomass, will be developed, while the country's enormous natural gas reserves will also be utilised. The policy also intends to enhance the nation's capacity for producing power to 10,000 MW by 2020.

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The NEP suggests creating a diverse energy mix combining traditional sources like oil and gas with non-conventional ones like renewable energy to reach its goals. The policy also emphasises raising energy conservation and efficiency standards across the board. The NEP recognises the significant contribution made by the private sector to the growth of the energy sector and promotes its involvement in all facets of the industry. It covers the construction of energy infrastructure and the discovery, production, and distribution of energy resources.

The strategy also suggests creating an impartial regulatory organisation to monitor the energy industry and guarantee honest competition among market participants. Creating and enforcing laws, rules, and regulations that support the efficient and effective operation of the energy sector is the responsibility of this regulatory agency. The NEP also suggests creating a national energy fund to finance the creation of projects that improve energy efficiency and rely on renewable energy sources. A board of trustees will oversee the fund's management and ensure that funds are distributed to initiatives that advance the goals of the policy.

The NEP also acknowledges the value of regional and global collaboration in the energy sector's growth. Therefore, to facilitate the transfer of technology and experience in the energy sector, the strategy suggests creating regional energy integration initiatives and forming relationships with international organisations.

Overall, Nigeria's National Energy Policy is a comprehensive policy framework that offers a road map for the growth of the nation's energy sector. It is anticipated that its emphasis on advancing the use of renewable energy sources, enhancing energy efficiency and conservation measures, and encouraging private sector involvement will result in the sustainable development of the energy sector and support the nation's socioeconomic development.

4.3 Renewable Energy Policy Guidelines 2006

An important policy document in Nigeria that attempted to encourage the use of renewable energy was the Renewable Energy Policy Guidelines of 2006. The strategy was created in response to Nigeria's need to diversify its energy mix, which had previously been heavily reliant on fossil fuels, and the country's rising energy demand. The policy guidelines gave the nation a framework for the growth and promotion of renewable energy technologies, focusing on boosting biomass, solar, wind, and hydropower use. The goals of the guidelines were to contribute 10% of renewable energy to the country's energy mix by 2025.

The policy guidelines suggested various methods and tactics to accomplish this goal, including creating a Renewable Energy Fund that would finance renewable energy projects and R&D. To enhance access to electricity in rural regions, the policy also supported the creation of rural electrification projects based on renewable energy.

The policy guidelines also aimed to encourage the production and use of biofuels to boost the use of renewable energy in the transportation sector. The regulations promoted the development of renewable energy sectors and opening positions in the field.

The policy guidelines also acknowledged the necessity for capacity building and public awareness efforts to encourage the usage of renewable energy. The recommendations included the creation of programmes to train technicians in renewable energy as well as the integration of renewable energy education into curricula at colleges and universities.

The importance of cooperation and coordination across sector stakeholders, including the government, corporate sector, civil society organisations, and international development partners, was also emphasised in the Renewable Energy Policy Guidelines of 2006. The policy also Acknowledged the private sector's crucial role in creating and carrying out renewable energy projects. As a result, it suggested creating a supportive climate for personal sector involvement.

The Nigerian government's 2006 Renewable Energy Policy Guidelines was a major milestone in developing and promoting renewable energy. The goal of the strategy was to create a sustainable energy future for the nation by providing a comprehensive framework for supporting renewable energy technology and system integration. However, the policy's implementation could have been done more quickly, and more progress needs to be made in reaching the goals that have been stated.

4.4 Captive Energy Generation Regulations 2008

The Nigerian Electricity Regulatory Commission (NERC) created the Captive Energy Generation Regulations 2008 to control the production, transmission, and distribution of captive power in Nigeria. In contrast to being supplied by the national grid, captive management refers to energy production for use by a single user or a group of consumers inside a building or other structure. These

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rules were created to make it easier for captive power generation to grow in Nigeria and to improve the efficiency and dependability of power supply to commercial and industrial consumers. The Captive Energy Generation Regulations of 2008 offer a framework to establish and operate captive power plants in Nigeria.

All captive power plants must register with the NERC and get an operating licence to comply with the requirements. The laws also outline captive power producers' technical and safety criteria, including environmental compliance and connectivity requirements with the national grid. The Captive Energy Generation Regulations of 2008 include an important regulation regarding power wheeling. Wheeling uses the national grid infrastructure to move electricity from a captive power plant to another place or facility. In addition, the rules include a procedure for resolving disagreements between captive power generators and the national grid operator and the payment of transmission and distribution fees for moving electricity.

The Captive Energy Generation Regulations of 2008 also create captive power associations, which are collections of captive power generators that cooperate to increase the effectiveness and dependability of power delivery to their constituents. The regulations stipulate that all captive power associations must register with the NERC and specify guidelines for these groups' operations. The need for captive power providers to adhere to the government-set renewable energy targets is another significant feature of the Captive Energy Generation Regulations 2008. The regulations mandate that captive power generators obtain a minimum portion of their energy needs from renewable sources, such as solar, wind, and biomass, and also provide for certifying these resources.

A legal foundation for creating and running captive power generation in Nigeria is provided by the Captive Energy Generation Regulations of 2008. In addition to encouraging the use of renewable energy sources and the creation of captive power associations, the regulations seek to improve the efficiency and reliability of the power supply to industrial and commercial consumers. The rules thus played a significant part in the growth of Nigeria's captive power industry and helped improve the nation's electricity supply.

4.5 National Renewable Energy Efficiency Policy 2013

The Nigerian government introduced the National Renewable Energy Efficiency Policy (NREEP) in 2013 to promote renewable energy sources and enhance national energy efficiency. The policy was created as part of the nation's initiatives to address the problems posed by climate change and achieve sustainable economic development. NREEP aims to support adopting renewable energy technology in various economic sectors while fostering growth. Additionally, the strategy seeks to promote energy-saving practices to lower the nation's overall energy demand. In doing so, Nigeria will be able to lessen the effects of climate change and cut greenhouse gas emissions.

The policy provides a framework for developing renewable energy technologies in Nigeria. It lists different renewable energy sources, such as solar, wind, hydro, geothermal, and biomass, and presents plans for utilising and developing them. However, the policy also lists several obstacles to using renewable energy technology in Nigeria, such as their high cost, lack of funding, and insufficient regulatory frameworks.

The creation of proper legal frameworks, the construction of finance channels, and the encouragement of public-private partnerships are only a few of the initiatives suggested by NREEP to overcome these obstacles. The strategy also aims to foster capacity building in pertinent industries and raise stakeholders' understanding of the advantages of energy efficiency and renewable energy initiatives.

The NREEP also specifies a number of goals for implementing Nigeria's energy efficiency and renewable energy measures. Among these are plans for a 10% share of renewable energy in the nation's energy mix by 2025 and a 20% decrease in energy use by 2030. Additionally, the strategy includes particular goals for several industries, including buildings, transportation, and energy.

The National Renewable Energy and Energy Efficiency Authority is a suggestion by NREEP to ensure that the programme is implemented efficiently and effectively. This organisation would oversee policy implementation and offer stakeholders technical assistance. Furthermore, to finance the development of renewable energy technologies and energy efficiency measures, the strategy also suggests the creation of a fund for renewable energy and energy efficiency.

Globally speaking, Nigeria's National Renewable Energy Efficiency Policy is a significant step toward creating a sustainable energy system. It offers a comprehensive framework for building energy efficiency and renewable energy technology and explains tactics for removing obstacles to their adoption. The strategy could significantly contribute to Nigeria's efforts to lessen the effects of climate change and achieve sustainable economic development.

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4.6 National Energy Efficiency Action Plans (2015–2030)

Nigeria's National Energy Efficiency Action Plan (NEEAP) was created in 2015 to address the nation's energy efficiency issues. The strategy was developed according to the National Renewable Energy and Energy Efficiency Policy of 2013 and the National Energy Policy of 2003. It attempts to advance energy efficiency to lessen energy waste and GHG emissions, enhance energy security, and support sustainable economic growth.

The NEEAP lists several goals and tactics to accomplish its objectives. One of the main goals is to lower energy usage in the nation by promoting energy-efficient behaviours and innovations. This will be achieved by creating minimum energy performance requirements for equipment and appliances, promoting energy-efficient building codes and standards, and implementing energy management and systems in the industrial and commercial sectors.

Promoting renewable energy sources across the nation is another goal of the NEEAP. By 2030, the strategy wants to see a 30% proportion of renewable energy in the country's energy mix. This will be accomplished by creating policies and regulations for renewable energy, encouraging investments, and offering financial incentives for renewable energy projects.

The programme attempts to raise public understanding of renewable and efficient energy sources and usage. The NEEAP also recommends that energy education and awareness programmes, energy efficiency and renewable energy centres, stakeholder training and capacity building, are all needed.

The plan specifies several tactics and steps stakeholders must adopt to implement the NEEAP. These include the creation of laws and policies that support energy efficiency and renewable energy, providing funding and incentives for energy efficiency and renewable energy projects, and creating centres dedicated to these topics that offer technical assistance and knowledge. To track the plan's development and guarantee its efficacy, the NEEAP also provides a structure for monitoring and assessment. The framework comprises indicators and targets to gauge renewable energy adoption, greenhouse gas emission reductions, and energy savings.

The National Energy Efficiency Action Plan 2015–2030 is an important policy document regarding Nigeria's efforts to address its energy efficiency and renewable energy issues. The strategy includes various tactics and initiatives to advance renewable energy and energy efficiency nationwide. It also offers a framework for tracking and assessing progress toward these objectives. As a result, Nigeria can save energy, lower greenhouse gas emissions, and encourage sustainable economic growth by implementing the NEEAP.

5.0 DISCUSSIONS AND RECOMMENDATION

The role of policies cannot be overstated, especially in a country where the accessibility of energy is minimally low, with a significant population without access to electricity and often having to rely on fuelwood for its energy source (Isah, 2023). In 2021, the total Electricity generated by the Generation Companies (GenCos) stood at 36,397.92 (Gwh), while 35,654.43 (Gwh) was transmitted (NBS, 2022), which is below the national demand. The government's various efforts to meet these demands are reflected by the multiple policies from 2001 to 2015, indicating the need for a more robust approach to implementation to ensure that Nigerians do not continue to be energy poor. In addition, while various recent policies and plans have been instituted to address the need to embrace cleaner and cheaper energy, the starting cost is usually massive, which hampers the adoption, especially in rural economies where fuel is scarce.

It is essential to note that different policy interventions can influence the spread of low-carbon technologies in different ways, including enabling it, accelerating it, delaying the beginning or distribution, or having no impact. Hence, while formulating policies, appropriate measures should be taken to ensure that those policies do not hurt the economic and technical viability of their adoption. A single policy instrument frequently affects several technologies; it takes a combination of approaches to impact the dissemination of a single technology significantly.

To ensure the adoption and usage of low-carbon technologies, governments and technology developers should concentrate on the following factors:

1. **User-centered approach:** To create low-carbon solutions that satisfy consumers' needs and preferences, policymakers and technology developers should utilise a user-centred design and development strategy.
2. **Contextualization of technology:** To guarantee that the technology is adopted and used, policymakers and technology developers consider the institutional and cultural context. There is a need for significant investments, robust policies, and collaborations across all stakeholders, including governments, businesses, and individuals, to achieve this.

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3. **Considerations of social norms:** The significance of social norms in influencing users' behaviour and practises is emphasised. Policymakers and technology developers should use social norms to encourage adopting and using low-carbon technologies, especially in rural communities
4. **Role of intermediaries:** This demonstrates the crucial function of intermediates, such as community organisations and energy consultants, in promoting the adoption and use of low-carbon technologies, and it advises policymakers to encourage the development of intermediary services.

In general, implementing low-carbon technologies involves many different aspects and complexity. As a result, to encourage the adoption and use of low-carbon technologies, policymakers and technology developers should adopt a user-centred approach, take the institutional and cultural context into account, capitalise on social norms, and support the development of intermediary services.

5.1 Conclusion

Nigeria's energy transitions demand a thorough strategy considering various elements, such as institutional and cultural environment, social norms, and intermediary services. To promote the adoption and use of low-carbon technologies, policymakers and technology developers must concentrate on a user-centred design and development strategy that prioritises customers' requirements and preferences. In order to ensure that the technology is embraced and used, it is also critical to consider the cultural and institutional background. Social norms have a powerful impact on how users behave and conduct themselves. Furthermore, it is important to recognise the role of intermediaries in promoting the adoption and use of low-carbon technologies, including community organisations and energy consultants. Government officials should support the growth of intermediate services. In the end, putting low-carbon technologies into practice is difficult and necessitates various strategies to have a meaningful impact on the spread of a single technology. To encourage sustainable energy usage and advance a more environmentally friendly future, policymakers and technology developers in Nigeria must take a comprehensive approach to the country's energy transition.

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