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FOSSIL FUELS TO A LOW-CARBON FUTURE: THE ROLE OF LAW, POLICY AND TECHNOLOGY IN THE GLOBAL ENERGY TRANSITION

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This article examines Nigeria's transition from fossil fuels to a low-carbon economy through legal, policy, and technological lenses. This is primarily driven by the need to ensure the mitigation of climate change and further ensure security of energy; as energy *vis* oil and gas remains the backbone of most nations, as they thrive on the production thereof, Nigeria inclusive. However, there is the need to mention that Nigeria is still heavily reliant on fossil fuels and as such detrimental to the environment, as well as not being suitable for the sustainability policy in the long run. Consequent upon this, this paper examines the role of legal and policy frameworks as well as technological innovations to the transitions from fossil fuels to low carbon future, coupled with the viability of these legislations and policy in ensuring the drive for low carbon future. This research employed the doctrinal approach, coupled with an in-depth analysis of the existing frameworks for the energy sectors and the imbalance in ensuring the desired transition. Findings showed that despite varying legal and policy frameworks, there seems to be reluctance from regulatory authorities in ensuring this transition, which is further, compounded by the capital intensive nature of this transition, hence the lackluster. The implications for this remains an unsustainable environment, which is detrimental to mankind, hence the need for undertaking this study. This paper recommends establishing binding timelines to phase out fossil fuels while scaling up renewables, supported by decentralized systems like mini-grids. It also calls for increased public and private investments in green technology, energy storage, and grid modernization. Finally, it emphasizes the need for cross-border collaboration and public-private partnerships to share knowledge, financing models, and regulatory frameworks for an efficient transition.

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1. INTRODUCTION

The phase of transitioning within the energy sector is gradually evolving with a shift and a profound transformation as the changes continue from the use and utilization of fossil fuels to low carbon energy sources.[1] This transition which is more of the need to ensure a mitigation and reduction of climate change and ensure sustainable future calls for energy transition involving a major structural change in energy supply and consumption coupled with renewable energy sources such as solar, wind, and hydroelectric power becoming increasingly prominent on daily basis.[2]

The global energy transition from fossil fuels to low carbon is, unarguably, one of the rising issues laced with its challenges and unique opportunities in the 21st century. With the increasing rate of threats from climate change, the need for a sustainable resilient, and equitable energy system has never been more urgent.[3]

While it is apposite to reiterate the fact that fossil fuels have been instrumental to the economic growth, industrial development, technological development and human advancement, their environmental impacts cannot be fully displaced. From issues of greenhouse gas emissions, air and water pollution, as well as the degradation of the natural habitat; the non-sustainability of the fossil energy model is unlikely to stand the test of time. The increasing recognition of the impact of climate change indicates that the future of global and low-carbon energy must shaped by cleaner, renewable alternatives to reduce emissions and mitigate environmental damage.[4] As a result of the need for these transitions from

[1] DF Dongo & S Relvas, 'Evaluating the role of the oil and gas industry in energy transition in oil-producing countries: A systematic literature review' (2025) Energy Research & Social Science 1-13

[2] Enel Green Power, 'The Energy Transition' https://www.enelgreenpower.com/learning-hub/energy-transition accessed 19 February 2025

[3] NY Doumon, 'Transitioning to Renewable Energy: Challenges and Opportunities' (2024) https://iee.psu.edu/news/blog/transitioning-renewable-energy-challenges-and-opportunities accessed 26 February 2025

[4] ClientEarth Communications, 'Fossil Fuels and Climate Change: The Facts' (2022) https://www.clientearth.org/latest/news/fossil-fuels-and-climate-change-the-facts/ accessed 27 February 2025

fossil fuels to the emergence of low carbon future, the place of law, policy and technology cannot be underemphasized. These factors- law, policy and technology has not only come to reshape the trajectory of this transition, but then, it is now a determinant of the need for the shift from fossil fuels to low carbon energy.

Whilst law and policy serve as the foundational regulatory and institutional framework upon which a clean and energy development induced environment can be guaranteed, by virtue of the necessary enforcement of environmental standards, and the guide for societal and economic transformation; the use of technology facilitates such drive. Consequent on this, International Agreements such as the Paris Agreements have galvanized nations to commit to reducing their carbon footprints and investing in renewable energy sources. National and regional policies, like carbon pricing, renewable energy mandates, and energy efficiency standards, provide the legal scaffolding for transitioning to a low-carbon economy. Furthermore, the legal system is central to fostering collaboration between states, private actors, and civil society, ensuring that climate change is addressed equitably and effectively.[5]

The role of technology cannot be displaced in transitions related to energy and low carbon drives, as solar, wind and hydropower are now on top of the lists in innovations as it relates to energy storage, smart grids in energy efficiency and transformation of the energy landscape. Technologies like carbon capture and storage (CCS) and green hydrogen have the potential to mitigate the carbon impact of hard-to-decarbonizes sectors like heavy industry and transportation. However, the full potential of these technologies can only be unlocked through the alignment of laws, policies, and market incentives that encourage innovation, investment, and the scaling up of clean energy solutions.[6] Transitioning from fossil fuel based

[5] O J Olujobi and others, 'Legal Response to Energy Security and Sustainability in Nigeria's Power Sector amidst Fossil Fuel Disruptions and Low Carbon Energy Transition' (2023) 9(7) Hekiyon https://pmc.ncbi.nlm.nih.gov/articles/PMC10359868/ accessed 20 February 2025

[6] F Nwaiwu, 'Digitalisation and Sustainable Energy Transitions in Africa: Assessing the Impact of Policy and Regulatory Environments on the Energy Sector in Nigeria and South Africa' (2021) 11 Energ Sustain Soc 48 https://doi.org/10.1186/s13705-021-00325-1 accessed 10 February 2025

energy system to low carbon energy not only presents itself as an environmental necessity; this is often seen as more of an economic opportunity, as the clean energy sector has the capacity to bring about a drive in the new and emerging industries, ensure creation of jobs and enhance economic growths. On the other hands, it might bring about displacements in jobs, need for massive financial inputs, hence the need for ensuring balance *via* a structured legal and policy-oriented framework for ensuring this transitioning to include fairness, equity and inclusivity. As a result, law, policy and technology must work *in tandem* to ensure that clean technologies are integrated into energy systems in a way that is fair, secure, and equitable. Policy measures can create the market conditions necessary for the widespread adoption of low-carbon technologies while addressing the economic and social challenges posed by the transition.

2. CONCEPTUAL CLARIFICATION

The topic of this study- from fossil fuels to a low-carbon future: the role of law, policy and technology in the global energy transition- envisages some key concepts associated with this study. These include fossil fuels, low-carbon future, law, policy and technology and energy transitions. While these constitute the keywords, they shall be analyzed in light of this study. Fossil fuels are hydro-carbons which is a constituents of materials formed from the remains of ancient plants and animals which were buried deep within the earth crust over millions of years. These are inclusive of coal, natural gas, oil, shales, bitumen, tar sands and heavy oils.[7] Fossil fuels are formed from the decomposition of buried carbon-based organisms that died millions of years ago. They create carbon-rich deposits that are extracted and burned for energy. They are non-renewable and currently supply around 80% of the world's energy. They are also used to make plastic, steel and a huge range of products. There are three types of fossil fuel – coal, oil and gas.[8] With respect to fossil fuel, they contain carbon

[7]Stanford University, 'Fast Facts about Fossil Fuels' https://drive.google.com/file/d/16sIcysHQH1akqQ1IdiTWpXMxrIHOZl5s/view accessed 19 February 2025

[8] ClientEarth, 'Fossil Fuels and Climate Change: The Facts' (2022) <https://www.clientearth.org/latest/news/fossil-fuels-and-climate-change-the-facts/#:~:text=They%20create%20carbon%2Drich%20deposits,%E2%80%93%20coal%2C%20oil%20and%20gas.> accessed 19 February 2025

which were formed as a result of geologic processes acting on the remains of organic matter produced by photosynthesis.[9]

It has been posited that besides the environmental and health problems, fossil fuels are unevenly distributed, which increases the concerns about energy security due to their key role in today's energy production systems. Moreover, they are nonrenewable resources which raises the problem of their availability for this and future generations. Their complete depletion should be avoided, thus contributing to the decrease in the environmental impact in the corresponding impact category. The instability of markets and prices is also a drawback in their use, causing negative economic impacts.[10] On the other hand, low carbon future can be described can be describe a system or economy in which there is a lesser emission of a significant amount of carbon dioxide (CO_2) and other greenhouse gases into the atmosphere compared to the current levels. This future is often characterized by a shift toward clean energy sources, increased energy efficiency, and carbon-neutral technologies.[11] Flowing from this, the low carbon future is characterized by the transition from the traditional means of generating energy to renewable energy, in that there is a major shift to energy sources like wind, solar, hydro and geothermal power with little or no emission of carbon in the course of use. Energy efficiency, electrification and Carbon Capture & Storage (CCS) also forms an integral part of the low carbon future. It is then apposite to mention that low-carbon future is critical to mitigating the effects of climate change. By reducing CaO_2 and other greenhouse gas emissions, the world can slow global warming, reduce air pollution, and transition to a more sustainable and resilient economy. Achieving a low-carbon future will require global

[9] Britannica, 'Fossil Fuels' (2025) < https://www.britannica.com/science/fossil-fuel> Accessed 10th February, 2025

[10] F Martins and others, 'Analysis of Fossil Fuel Energy Consumption and Environmental Impacts in European Countries' (2019) 12 Energies 1–11 http://dx.doi.org/10.3390/en12060964 accessed 20 February 2025

[11] T Potts, 'Social and Policy Aspects of Offshore Renewable Energy' in Trevor M Letcher (ed), *Comprehensive Renewable Energy* (2nd edn, Elsevier 2022) 291–297

cooperation, innovation, and significant changes to energy, transportation, industry, and land use.[12]

The conception of law in this context would mean a system of rules, regulation and policies that are established and enforced by government, social or religious institutions to regulate behavior and relationship among people.[13] While law has been jurisprudentially described to be subject to series of definitions depending on the context and circumstances, its key characteristics are the creation of enactments to regulate human behaviors, the element of sanctions and the need to subject it to judicial interpretation, in ensuring that precedents are created to guide future legal decisions.[14] Going by the subject matter, environmental law which captures the intent of energy law ensured that there is a proper analysis of the role of law in regulating the extraction, use, and emissions from fossil fuels. It includes laws that promote conservation, reduce pollution, and mandate the transition to cleaner energy sources. Examples include carbon pricing mechanisms, emission standards, and renewable energy mandates.[15] Thus, it is correct to say that climate change legislations, energy law and carbon trading are all important parts of the legal structure which addresses fossil fuels and low carbon future.[16] This goes further for the concept of policy, as it is a course of action or set of principles adopted by an individual, organization, or government to address specific issues or challenges. It provides a framework for decision-making and guides the actions of authorities and stakeholders.[17]

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[12] V Pawar & S Farooqui, 'The Effectiveness of Renewable Energy Technologies in Reducing Greenhouse Gas Emissions' (2023) South India Journal of Social Sciences 150–160

[13] L Akhirome-Omonfuegbe, 'Law in Social Context' in C C Ohuruogu and O T Umahi (eds), *Nigerian Legal Methods* (Cambridge Scholars Publishing 2013) 1–10

[14] A Ziemmermann, 'The Rule of Law as a Culture of Legality: Legal and Extra Legal Elements for the Realisation of the Rule of Law in Society' http://classic.austlii.edu.au/au/journals/MurdochUeJlLaw/2007/2.pdf accessed 19 February 2025

[15] U Outka, 'Environmental Law and Fossil Fuels: Barriers to Renewable Energy' (2012) 65(6) Vanderbilt Law Review-Barriers to Renewable Energy 1679–1721

[16] *Ibid*

[17] AR Khan, *Policy Implementation: Some Aspects and Issues* (2016) https://www.researchgate.net/publication/320549262_POLICY_IMPLEMENTATION_SOME_ASPECTS_AND_ISSUES accessed 19 February 2025

Technology, in the context of climate change, refers to the specialized tools, systems and methodology which is used to ensure innovations at the reduction of carbon emission, the improvement of energy efficiency and enabling the transition to a low carbon economy.[18] Technological innovations to the problems of fossil fuels and low carbon energy would mean to include renewable energy technologies, energy storage, and electric vehicles, smart grids and energy management, among others. It is imperative to mention that these concepts are all interwoven in the bigger picture of the need for climate change mitigation and the efforts globally to ensure a seamless transition to a more sustainable future.[19]

2.1 General Overview of the Energy Sector and Multinational Corporations in Nigeria as Compared to other European Countries

A general overview of the energy sector in Nigeria is reflective of the fact that Nigeria is a key player in the Oil and Gas industry in Africa, and significantly influenced by multinational corporations which operates within the country.[20] Nigeria is one of the largest producers of oil globally, and energy resources with emphasis on oil and natural gas. As a matter of fact, being Africa's largest oil producer and one of the top ten global oil producers; it has substantial oil reserves, estimated at over 37 billion barrels. Oil accounts for over 90% of Nigeria's foreign exchange earnings and a large portion of government revenues.[21] Further, Nigeria holds the 9th-largest natural gas reserves in the world.

However, the country faces challenges in gas infrastructure, limiting its ability to fully capitalize on its gas resources.[22] The energy sector is dominated by fossil fuels with a composition of oil and gas making up for

[18] Yogesh K Dwivedi and others, 'Are Digital Technologies and Information Management Part of the Problem or the Solution? An Editorial Reflection And Call To Action' (2022) 63 International Journal of Information Management
[19] Ibid
[20] DA Obada and others, 'A Review of Renewable Energy Resources in Nigeria for Climate Changes Mitigation' (2024) https://www.sciencedirect.com/science/article/pii/S266601642400063X accessed 20 February 2025
[21] A Elwerfelli & J Benhin, 'Oil, a Blessing or Curse: A Comparative Assessment of Nigeria, Norway and the United Arab Emirates' (2018) 8 Theoretical Economics Letters 1136–1160
[22] *Ibid*

over 80% of electricity generation and hydro power contributing about 20%.[23] On the flipside, renewable energy such as solar, wind and biomass are underutilized although they are gaining attention due to government initiatives.[24]

It is also imperative to mention that Nigeria encounters series of challenges such as insufficient generation of power, transmission losses, theft, corruption and unreliable grid infrastructure.[25]Electricity is laced with an extremely low *per capita* electricity consumption compared to global standards.[26] There is abundance of renewable resources in Nigeria which could meet nearly 60% of its energy demands by 2050 but investments in renewable is seen as more cost-effective than fossil fuel pathways, with potential savings in natural gas and oil consumption.[27] While the government has introduced policies like tax incentives and import waiver duties for renewable technologies, gas flaring and improved energy efficiency is imperative. It is also trite to state that Multinationals Corporations such as Shell, ExxonMobil, Chevron, and Total dominate Nigeria's oil and gas sector. They invest heavily in upstream activities but have been criticized for environmental degradation (e.g., oil spills) and insufficient contributions to local development.[28] As against this stand in Nigeria, European countries are composed of MNCs such as BP, Total

[23] Investment Climate Statement, 'Electricity, Power, System and Renewable Energy' (6 June 2023) https://www.trade.gov/country-commercial-guides/electricity-power-systems-and-renewable-energy accessed 19 February 2025

[24] *Ibid*

[25] OJ Olujobi and others, 'Legal Responses to Energy Security and Sustainability in Nigeria's Power Sector amidst Fossils Fuel Disruption and Low Energy Transition' (2023) 9(7) Heliyon https://www.cell.com/heliyon/fulltext/S2405-8440(23)05120-4?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS2405844023051204%3Fshowall%3Dtrue accessed 10 February 2025

[26] PriceHouse Waters Coppers (PWC), 'Powering Nigeria for the Future-The Power Sector in Nigeria' (July 2016) https://www.pwc.com/gx/en/growth-markets-centre/assets/pdf/powering-nigeria-future.pdf accessed 17 February 2025

[27] International Renewable Energy Agency (IRENA), 'Renewable can Provide Nearly 60 Per Cent of Nigeria's Energy Demand by 2050' (13 January 2023) https://www.irena.org/News/pressreleases/2023/Jan/Renewables-Can-Provide-Nearly-60-Per-Cent-of-Nigerias-Energy-Demand-by-2050 accessed 20 February 2025

[28] EY, 'Nigeria enacts Tax Incentives to encourage Development in Oil and Gas Sector' (14 March 2024) https://www.ey.com/en_gl/technical/tax-alerts/nigeria-enacts-tax-incentives-to-encourage-development-in-oil-an accessed 10 February 2025

Energies and Siemens and they are at the forefront of the global shift in ensuring clean and global energy.

2.2 Comparison of the Energy Sector between Nigeria and the European Countries

S/N	ASPECT	NIGERIAN	EUROPEAN COUNTRIES
1	**Energy Mix**	Fossil Fuels dominate; renewable <20%	Diversified; renewable >40% in many European Nations
2	**Policy Framework**	Emerging Policies (E.g. REMP)	Advanced Frameworks (Eg. EU Green Deal)
3	**Challenges**	Grid Efficiency; low electrification	Balancing intermittent renewables
4	**MNC Roles**	Focus on Oil and Gas, Limited renewables	Leading clean energy transition
5	**Investment Needs**	High for Grids upgrades & Renewables	Focused on storage and advanced tech

Source: Garba Nuru[29]

2.3 Prior Studies on the Energy Sector in Nigeria

Studies within the energy sector reveal some key issues. This is characterized by the heavy reliance on fossil fuels, the potential for renewable energy and policy challenges as well as the role of MNCs within Nigeria. Olujobi in his assessment of the Energy sector and with more emphasis to the area of electricity sector and opines that low carbon energy is underutilized in Nigeria.[30] His work addresses energy challenges in Nigeria coupled with the legal and policy barriers and made recommendations. While highlighting the dependence of Nigeria on non-renewable energy sources like fossil fuels which are unsustainable and

[29] Garba, Nura & Adamu, Abdullahi & Idris Augie, Abdulrahman and Ozveren, Cuneyt, 'Sustainable Energy Policy for Africa (Nigeria) and Europe. A Comparative Study' (2022) 16 International Journal of Energy and Environmental Engineering 30–36

[30] O J Olujobi, 'The Legal Sustainability of Energy Substitution in Nigeria's Electric Power Sector: Renewable Energy as Alternative' (2020) 5(32) Protections and Control of Modern Power Systems 1–12

contribute to environmental degradation, and privatization in the electricity sector does not address the inherent issues. His work however recommends the enactment of a robust regime promoting renewable energy; and the implementation of strict regulatory policies with incentives to attracts, among others.[31]

Oyedepo addresses the conception of energy and sustainable development in Nigeria and the need for the way forward.[32] While the central argument of his work revolves around the need for diversification energy sources to embrace renewable energy technologies, the need to address energy crisis and promote sustainable development cannot be underemphasized. He addresses the Nigeria's energy crisis which has undeniably hindered socio-economic development in Nigeria as well as causing a paralysis in industrial and commercial activities; thus leading to substantial losses. He identifies energy efficiency practices and energy conservative measures in various sectors inclusive of the construction and transportation sector.

Ndukwu and others did an expose on the challenges and eco-friendly approach in reducing the energy gap, with relations to Nigeria's energy deficit.[33] They examined Nigeria's persistent energy challenges and explored sustainable solutions to bridge the gap. In their study, they highlighted the fact that over 85 million Nigerians lack access to electricity, representing a significant energy access deficit. This shortage impacts economic growth, industrialization, and overall quality of life; over-reliance on fossil fuels, particularly natural gas, for power generation; inefficient electricity generation and distribution systems, characterized by high technical losses and aging infrastructure; limited investment in renewable energy technologies and inadequate policy frameworks to support clean energy transitions; heavy dependence on diesel and petrol generators, which are costly and environmentally harmful among others. They proposed eco-friendly solutions such as the need for diversification

[31] *Ibid*

[32] SO Oyedepo, 'Energy and Sustainable Development in Nigeria: The Way Forward' (2012) 2(15) Energy Sustainability and Society https://doi.org/10.1186/2192-0567-2-15 accessed 19 February 2025

[33] MC Ndukwu and others, 'Nigeria's Energy Deficit: the Challenges and Eco-Friendly Approach In Reducing the Energy Gap' (2021) 14(3) International Journal of Sustainable Engineering 442–459

within the energy sector, adoption of decentralized energy systems and the implementation of energy efficiency measures across industries.

A detailed look at the examined studies highlights the policy frameworks and challenges as well as the roles of MNCs in the oil and gas sector which represents a large chunk of the energy sector. While these corporations are primarily focused on fossil fuels in Nigeria, some are beginning to invest in renewable energy projects globally, which could potentially expand to Nigeria as the sector develops.[34] Flowing from this, the sector presents opportunities for investments in renewable energy technologies, energy infrastructures and policy reforms.

2.4 Problems Facing the Energy Sector in Nigeria (Government Related Problems, Individual Related Problems, International Institutions Related Problems

Associated problems and challenges within the Nigeria's energy sector will be addressed under government related problems, individual related and institutional related problems. While it is reiterated that the energy sector and the transition into low carbon future, the use of fossil fuels is still inherently faulty. Firstly, the uncertainty around regulatory framework and inconsistent enforcement of policies tops the list. This is further enhanced by the government's control over the transmission of assets in the course of privatization and distribution which creates unnecessary bottlenecks and inefficiencies in the system.[35] The inadequacy of infrastructure and lack of maintenance culture in Nigeria also constitutes a clog to the energy sector in Nigeria. Frequent system failure, grid collapse and inability to generate increased power constitute a big challenge to the energy sector.[36] Similarly, corruption and inefficiency across all levels in the energy sectors which relates to the implementation

[34] EnerData, 'Nigeria's Energy Report' https://www.enerdata.net/estore/country-profiles/nigeria.html accessed 18 February 2025

[35] C Remteng and others, 'Key Challenges and Opportunities in the Nigeria Energy Sector' (2021) https://energypedia.info/wiki/Key_Challenges_and_Opportunities_in_the_Nigeria_Energy_Sector accessed 18 February 2025

[36] O Alao and K Awodele, 'An Overview of the Nigerian Power Sector, the Challenges of its National Grid and Off-Grid Development as a Proposed Solution' (2018) 178–183

of policies, revenue allocation and ineffective management in the public sector and management of state-owned enterprises also form a larger percentage of the issues bedeviling the energy sector caused by the government. Invariably, individuals also contribute to the challenges in ensuring a low-carbon society and the prospect for one. The reliance on diesel and private generators which are costly and environmentally harmful constitutes a deal breaker in the quest for a low-carbon society.[37] The limited access to electricity and limitations to economic opportunities also constitutes a major issue.[38] In terms of international institutional related problems, it is evident that the lack of support for renewable energy is hampered by limited foreign investment and technical support for renewable projects.[39] It is also worthy of mention that the international market dynamics and Nigeria's reliance on oil exports contributes to the underdevelopment of alternative sources of energy; coupled with global economic pressures and fluctuations in oil prices which affects the stability of energy security and economy.[40]

2.5 Theoretical Framework

Theories on energy and sustainable development have been formulated. This study identifies the public private partnership theory, the recourse curse theory and the portfolio diversification theory. The public private partnership theory presupposes a collaborative arrangement between government entities on one hand and on the other hand, key players in the private sectors within the energy sector to ensure delivery of public services or infrastructure as it relates to energy use and consumption including but not limited to gas, EV, etc.[41] PPP is instrumental in

[37] AA Abdallah & O B Odeleke, 'Energy Security in Nigeria: Challenges and Prospects' (2023) 1(1) Journal of Arid Zone Economy 101–111

[38] Informa Markets, 'Why Invest in Nigeria's Energy Future? Opportunities and Challenges in Nigeria' (2024) https://www.nigeria-energy.com/content/dam/markets/emea/nigeria-energy/en/2024/NE24-Why-Nigeria-report.pdf accessed 20 February 2025

[39] World Economic Forum, 'Energy Transition - Here's how Nigeria is tackling the Barriers to its Green Energy Transition' (8 May 2023) https://www.weforum.org/stories/2023/05/how-nigeria-is-tackling-barriers-to-its-green-energy-transition/ accessed 18 February 2025

[40] AA Abdallah & OB Odeleke, 'Energy Security in Nigeria: Challenges and Prospects' (2023) 1(1) Journal of Arid Zone Economy 101–111

[41] M Itu & WE Kenigua, 'The Role of Public Private Partnership (PPP) on Infrastructural Development in Nigeria' (2021) 2(5) 23–43

addressing energy access challenges, in the need to drive renewable energy development and the transitioning to a low carbon economy. This theory admits of the inadequacies of the public sector and resources to drive a low carbon economy, and as such the involvement of the private players within the sector to manage risk sharing, ensure accountability and transparency and see that there is value for money. For instance, Nigeria has been able to leverage on PPP to expand renewable energy access in rural areas such as the Oando clean Energy Limited intended to deploy off-grid solar initiatives such as the solar power Naija.[42] On the other hand, the recourse curse theory which was introduced by Richard Auty in 1993 and further known as the Oxymoron of Abundance study sheds light on the inefficiencies exhibited by numerous resource-rich nations in harnessing their natural resources to meet the infrastructure and well-being needs of their populations.[43] The theory highlights the significance of effectively harnessing abundant natural resources, including low-carbon energy sources, to benefit the population by providing reliable power and other essential social amenities. It also emphasizes the importance of prudent utilization of the revenue generated from these plentiful natural resources.[44] The theory exposes the impact of slow economic growth, weak governance coupled social inequality in contrast with the abundance of resources in Nigeria capable of facilitating the drive for a low carbon future and era, and however, the associated economic, social and environmental challenges must be decisively dealt with. Lastly, the portfolio diversification theory posits that port-folio diversification can be adopted as a strategy which is used to reduce and mitigate risks by spreading investments across assets class. In other words, this theory within the energy sector helps to reduce the market volatility, price fluctuations and uncertainties that might be associated with global oil

[42] Y Kemp, 'Nigeria: Public Private Partnership to Expand Renewable Energy Access' (15 June 2023) https://www.esi-africa.com/industry-sectors/future-energy/nigeria-public-private-partnership-to-expand-renewable-energy-access/ accessed 20 February 2025

[43] OJ Olujobi and others, 'Legal Response to Energy Security and Sustainability in Nigeria's Power Sector amidst Fossil Fuel Disruptions and Low Carbon Energy Transition' (2023) 9(7) *Hekiyon* https://pmc.ncbi.nlm.nih.gov/articles/PMC10359868/ accessed 20 February 2025

[44] *Ibid*

pricing.[45] The associated characteristics of this theory includes risk management, correlation and diversification benefits. It therefore follows that in the course of investing in variety of assets, companies can assist in the reduction of exposure in specific risk related to any one sector or commodity such as that of oil and gas within the bigger energy sector.[46]

2.6 Methodology

This research work adopts the doctrinal legal research methodology and consequently examines the relevant keywords, literatures which have done justice to the subject matter of energy in Nigeria coupled with the legal framework for energy use, management and the transition to low carbon future within the Nigerian soil. For a better understanding of the subject matter, the energy sectors in European countries are accessed alongside the Nigerian sector. Primary and secondary sources of data were used, utilized and subjected to contextual analysis as these include statute, case laws, judicial authorities, textbooks, and peer-reviewed journals. This work, apart from the brief comparison with European countries also identifies three applicable theoretical frameworks on which the study is predicated. This study makes a significant contribution to existing knowledge in the energy sector by building upon previous research and addressing gaps in the current literature regarding the legal response to low-carbon transition in Nigeria's power sector. The findings offer valuable insights for policymakers, researchers, and practitioners in the energy field.[47]

3.0 LEGAL FRAMEWORKS FOR ADDRESSING ENERGY LAW IN NIGERIA

The legal framework for the energy sector cuts across oil and gas, electricity, environmental impact as well as environmental policy. Most

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[45] CFI, 'Modern Portfolio Theory (MPT)' https://corporatefinanceinstitute.com/resources/career-map/sell-side/capital-markets/modern-portfolio-theory-mpt/ accessed 19 January 2025

[46] *Ibid*

[47] OJ Olujobi and others, 'Legal Response to Energy Security and Sustainability in Nigeria's Power Sector amidst Fossil Fuel Disruptions and Low Carbon Energy Transition' (2023) 9(7) Hekiyon https://pmc.ncbi.nlm.nih.gov/articles/PMC10359868/ accessed 20 February 2025

recent is the Petroleum Industry Act (PIA) of 201 which is the primary legislation governing the oil and gas industry. This legislation aims to ensure transparency, enhance efficiency and encourage private sector participation in the oil and gas industry. As a matter of fact, the legislation recognizes the Nigerian National Petroleum Company Limited (NNPC Ltd) which is saddled with the creation of new regulatory agencies, the updating of licenses, ensuring licensing, contracting and fiscal provisions.[48]

The Electric Power Sector Reforms Act (ESPRA) of 2005 which is now repealed by the Electricity Act of 2023 applies to the electricity sector and establishes the Nigerian Electricity Regulatory Commission (NERC) as the main regulator in the electricity sector. The ESPRA gives the Nigerian Electricity Regulatory Commission (NERC) statutory powers to regulate the generation, transmission, and distribution of electricity. It also promotes private sector participation in the electricity market.[49]

The Energy Commission of Nigeria (ECN) Act is also instrumental in this regards. Established in 1979, the Act created the Energy Commission of Nigeria, which is responsible for planning and coordinating national energy policies and further promotes the diversification of energy resources, including renewable energy sources like solar, wind, and biomass.[50]

A similar regulatory agency is the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA) which focuses on the regulation of the oil and gas sector, focusing on upstream, midstream, and downstream operations.[51] The Rural Electrification Agency which is a statutory establishment under the ESPRA also ensures

[48] ASALAW LP, 'Energy Law in Nigeria' (29 August 2023) https://asalawpractice.org/energy-law-in-nigeria/ accessed 20 February 2025

[49] BJ Bulama & SI Nchi, 'An Examination of the Legal, Policy and Institutional Framework for the Promotion of Renewable Energy in Nigeria' (2022) 7 International Journal of International Energy and Environmental Law 14–28

[50] KENNA Partners, 'Nigeria's Renewable Energy Laws and Regulations and the Race to achieve Lasting Economic Growth' https://kennapartners.com/nigerias-renewable-energy-laws-and-regulations-and-the-race-to-achieve-lasting-economic-growth/ accessed 12 February 2025

[51] *Ibid*

the promotion of rural electrification by developing mini-grid systems and supporting renewable energy projects.[52]

Another key framework is the National Energy Policy (NEP) 2003 which outlines the guidelines for renewable energy development, focusing on increasing the share of modern renewable energy in Nigeria's energy mix.[53] Also, the Renewable Electricity Policy Guidelines 2006 aim to promote the development of renewable electricity in Nigeria; and the National Renewable Energy and Energy Efficiency Policy 2015 seeks to enhance the use of renewable energy and improve energy efficiency across the country.[54]

Going further, the National Renewable Energy Action Plan (NREAP) 2016 outlines specific targets and strategies for increasing renewable energy production in Nigeria.[55] Under the Environmental Impact Assessment Act, carbon projects with significant negative impacts on the environment must register with the Federal Ministry of Environment for an environmental impact valuation. However, weak enforcement of this requirement is attributed to a lack of resources and corruption within the regulatory bodies of the sector.[56]

The Domestic Renewable Energy and Energy Efficiency Policy 2015 provide regulations and procedures to promote renewable energy and energy efficiency, with a focus on the social and budgetary implications of inexhaustible energy. It emphasizes the need to develop appropriate measures to harness the country's energy potential and enhance ongoing energy reforms. Furthermore, the Nigerian Electricity Regulatory Commission delegates the implementation of scientific and electric-

[52] *Ibid*

[53] KENNA Partners, 'Nigeria's Renewable Energy Laws and Regulations and the Race to achieve Lasting Economic Growth' https://kennapartners.com/nigerias-renewable-energy-laws-and-regulations-and-the-race-to-achieve-lasting-economic-growth/ accessed 12 February 2025

[54] *Ibid*

[55] *Ibid*

[56] OJ Olujobi and others, 'Legal Response to Energy Security and Sustainability in Nigeria's Power Sector amidst Fossil Fuel Disruptions and Low Carbon Energy Transition' (2023) 9(7) Hekiyon https://pmc.ncbi.nlm.nih.gov/articles/PMC10359868/ accessed 20 February 2025

powered standards and guidelines to the Nigerian Electricity Management Services Agency (NEMSA) Act, ensuring the resourceful generation and circulation of safe, reliable, and environmentally friendly electricity.[57]

S/N	LEGISLATIONS/ POLICIES/ REGULATIONS	YEAR OF ENACTMENT	CONTRIBUTIONS TO ENERGY SECTOR IN NIGERIA
1	Electricity Act 2023[Electric Power Sector Reform Act (EPSRA) 2005]	2023	It repealed the Electric Power Sector Reform Act (EPSRA) 2005; which regulates the generation, transmission, distribution, and trading of electricity and establishes the Nigerian Electricity Regulatory Commission. This New Act Replaces EPSRA 2005, providing a comprehensive framework for the electricity sector, including generation, transmission, distribution, and integration of renewable energy
2	Petroleum Industry Act (PIA) 2021	2021	Consolidates all existing petroleum laws into one legislation, aiming to improve transparency and efficiency in the oil and gas sector
3	Nigerian Electricity Management Service Agency Act (NEMSA Act) 2015	2015	Regulates safety standards in the electricity sector
4	Nigerian National Petroleum Corporation Act 2004	2004	Governs the operations of the Nigerian National Petroleum Corporation (NNPC)
5	Energy Commission of Nigeria Act 1979	1979	Established the Energy Commission of Nigeria to coordinate national energy policies and oversee the development of various energy resources

[57] *Ibid*

6	National Environmental (Energy Sector) Regulations, 2014	2014	Focuses on preventing pollution and promoting energy efficiency in the energy sector
7	National Energy Policy (NEP) 2003	2003	Provides a framework for energy sector development, emphasizing renewable energy
8	National Renewable Energy and Energy Efficiency Policy (NREEEP) 2015	2015	Guides renewable energy development and energy efficiency
9	NERC Regulation		Various regulations issued by NERC, such as Embedded Generation, IEDN, and Metering Asset Provider Regulations
10	National Electric Power Policy 2001	2001	Preceded EPSRA, focusing on restructuring the electricity sector
11`	National Renewable Energy Action Plan (NREAP) 2016	2016	Outlines strategies for increasing renewable energy production
12	Energy Transition Plan 2021	2021	It provides a detailed pathway for details pathways for significant low-carbon development of energy systems across 5 key sectors: **Power, Cooking, Transport, Industry, and Oil and Gas**.
13	Renewable Energy Master Plan (REMP) 2005	2005	Increase the share of renewable electricity in Nigeria, from 13% of electricity generation - mainly met by large hydro- in 2015, to 23% in 2025 and 36% by 2030.
14	Climate Change Act 2021	2021	Provision of a framework for the mainstream of climate change action and for the provisions of a system of carbon budgeting, establishment of the National Council on climate change

15	National Renewable Energy and Energy Efficiency Policy (NREEEP) 2022	2022	Integrates into the Revised National Energy Policy and sets binding targets on energy use and efficiency
16	Policy Guidelines on Renewable Electricity 2023	2023	NERC directives which seeks to operationalize the Electricity Act 2023
17	Nigerian Gas Flare Commercializati on Programme 2016	2016	Aimed at eliminating routine flaring by 2030
18	Energy Transition Plan (ETP) 2021	2021	Ensuring universal energy access by 2030, 60% renewable power generation, 50% EV penetration in public transport

Source: Author

4.0 TRANSITIONING FROM FOSSIL FUELS TO LOW CARBON ENERGY SYSTEMS IN NIGERIA: LEGAL, POLICY AND TECHNOLOGICAL EFFECTS, IMPLICATIONS *CUM* CHALLENGES

There seems to a reasonable level of commitment on the part of Nigeria in a bid to achieving net-zero emissions by 2060 through its Energy Transition Plan (ETP) as the ETP aims to reduce greenhouse gas emissions by 45% by 2030 and 90% by 2050 while addressing energy poverty for over 92 million citizens lacking electricity and 175 million without clean cooking solution.[58] The transitioning from fossil fuels to low carbon energy involves an intricate interplay of legal reforms, policy incentives, technological innovation, and socio-economic restructuring. However,

[58] UKNIAF (United Kingdom Nigeria Infrastructure Advisory Facility), 'What you need to know about Nigeria's Energy Transition Plan' (19 March 2024) https://ukniaf.ng/2024/03/19/what-you-need-to-know-about-nigerias-energy-transition-plan/ accessed 10 February 2025

challenges such as a $1.9 trillion funding gap, reliance on imported renewable technologies, and regulatory fragmentation threaten to derail progress.[59] The examination of the legal nuances in the course of transition reflects the fact that although it is premised on the 2021 Energy transition plan which has been approved by the Federal Executive Council, the PIA further introduced critical reforms by establishing the Nigerian Upstream Petroleum Regulatory Commission (NUPRC), which now mandates decarbonization compliance for oil license applicants. From January 2025, operators must submit methane management programs, energy efficiency plans, and renewable energy integration strategies under the Upstream Petroleum Decarbonisation Template.[60] This position shows the alignment of Nigeria with global climate agreement, however there is the persisting issue of enforcement challenges and weak institutional capacity to make this come into fruition. Several legal tussle still springs up between the oil rich region and communities as a result of gas flaring, and oil-producing states like Rivers and Delta resist abrupt phase-out policies, advocating for gradual gas commercialization until 2030 as outlined in the ETP. Constitutional ambiguities regarding resource control between federal and state governments could spark legal disputes, particularly as onshore oil assets account for 60% of government revenues.[61] As a signatory to the Paris Agreement and the Global Methane Pledge, Nigeria faces mounting pressure to align domestic laws with international obligations. The NUPRC's 2025 licensing requirements directly implement Article 4.19 of the Paris Agreement, which urges fossil fuel-dependent economies to diversify energy systems. However, conflicting priorities emerge: while the ETP prioritizes gas as a transition fuel, the International Energy Agency's 2050 Net Zero Scenario demands immediate reductions in gas investments. This creates legal risks for Nigeria's planned $23 billion gas

[59] MC Ugwu and AO Adewusi, 'Navigating Legal and Policy Challenges in the Energy Transition: Case Studies from the United States and Nigeria' (2024) 6(4) *International Journal of Applied Research in Social Sciences* 506–517

[60] Offshore Technology, 'Nigeria requires Oil License Applicants to Demonstrate Low Carbon Emissions' (2 January 2025) https://www.offshore-technology.com/news/nigeria-oil-licence-carbon-emissions/ accessed 20 February 2025

[61] CC Nweke-Eze, 'Nigeria's Energy Transition' (18 November 2024) https://www.kas.de/en/sustainability-monitor/detail/-/content/nigeria-s-energy-transition accessed 10 February 2025

commercialization projects, potentially exposing them to future climate liability claims.[62] Policy frameworks and mechanisms from the Energy Transition Plans shows 5 key areas to be addressed *vis a;* power; which involves the transitioning from 80% fossil based generation to 60% renewable, cooking which involves 95% of households from firewood/kerosene to LPG and electric stoves; transportation involving the achievement of 50% electric vehicle (EV) penetration in public transport fleets by 2035; industrialization involving the implementation of carbon capture systems in cement plants and steel mills and oil and gas entailing the reduction of flaring by 95% through gas commercialization infrastructure.[63] Technology wise, Nigeria's renewable potential remains underutilized, with solar contributing <1% of the energy mix despite 2,300–5,000 kWh/m² irradiation levels.[64] This is as a result of the dependency on import; as 8% of solar panels, inverters, and batteries are imported, inflating costs by 40–60% compared to regional peers; the national grid's 5.3 GW operational capacity cannot integrate variable renewables, necessitating $135 billion in transmission upgrades and the lack of utility-scale battery systems restricts solar penetration to <15% of grid capacity, forcing continued reliance on gas peaker plants.[65] Whilst gas dominates the transition journey for Nigeria; with 23GW of new gas-fired plants planned by 2030 to replace diesel generators. The Nigeria-Morocco Gas Pipeline project exemplifies this approach, aiming to supply 3 billion scf/day to domestic industries and export markets.[66] While gas emits 50% less CO_2 than coal, methane leakage rates of 3.8% from pipelines negate

[62] *Ibid*

[63] SEforAll [Sustainable Energy for All], 'Nigeria's Energy Transition Plan' https://www.seforall.org/our-work/initiatives-projects/energy-transition-plans/nigeria accessed 23 February 2025

[64] HN Amadi and others, 'Renewable Energy in Nigeria: Prospects and Challenges' (2024) 11(4) European Journal of Advances in Engineering and Technology 51–60

[65] Clean Technology Hub, Energy Innovation Center, 'Nigeria's Energy Transition Plan Review Series: The Power Sector' (May 2023) https://cleantechnologyhub.com/wp-content/uploads/2023/05/CTH-ETP-Review-Series-Power-Sector-new.pdf accessed 10 February 2025

[66] CC Nweke-Eze, 'Nigeria's Energy Transition' (18 November 2024) https://www.kas.de/en/sustainability-monitor/detail/-/content/nigeria-s-energy-transition accessed 10 February 2025

climate benefits, requiring $12 billion in leak detection systems per ETP stipulations.[67]

5.0 CONCLUSION AND POLICY RECOMMENDATIONS

Mitigating climate change and enhancing energy security as well as the promotion of sustainable development all requires the need for a swift transition from fossil fuels to a low carbon energy future. It is however imperative to mention that this transition requires a multifaceted approach in that the interplay of the legal, policy and technological frameworks have to be carefully considered and integrated. Whilst international agreements like the Paris Agreement and national commitments have set ambitious goals, the pace of the transition remains insufficient to avert catastrophic climate impacts. It is on this note that various legal and policy frameworks, apart from inclusivity and equity must be clear, enforceable and provides incentives for renewable energy adoption. Technological dynamisms must be embraced as it applies to renewable, energy storages and efficiency and it must be adequately supported by robust governance structures and public-private collaboration.

To accelerate a low carbon future, timeline involving transitions must set clear deadlines which are legally binding in a bid to ending the phasing out of coals, oil and gas while scaling up renewable. Second, where there is promotion of access to energy and development of policies targeting rural electrification through decentralized renewable systems like mini-grids and solar home systems, this will make the transition seamless. Investment in research and development is also an important part of the transition process. There is the need for allocation of public funding into research for advanced renewable (e.g., green hydrogen), energy storage technologies, and grid modernization. The need for fostering public-private partnerships cannot be underestimated. It is proposed that collaborations between government and private entities be enhanced to scale renewable projects efficiently. Facilitation of cross border knowledge

[67] SEforAll [Sustainable Energy for All], 'Nigeria's Energy Transition Plan' https://www.seforall.org/our-work/initiatives-projects/energy-transition-plans/nigeria accessed 23 February 2025

for the exchange of regulatory frameworks, technological innovations and financing models will further enhance the transitioning process.