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Electrifying Nigeria's Transport Sector: Prospects, Barriers, and Implications for Carbon Emission Reduction

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Abstract
The transport sector is a major contributor to Nigeria's carbon emissions and urban air pollution, driven by an almost total reliance on fossil fuel vehicles. This study assesses the prospects, barriers, and implications of electrifying Nigeria's transport sector as a strategy for carbon emission reduction. Employing a mixed-methods approach, the research combines quantitative data from a survey of 147 staff of the Energy Commission of Nigeria (ECN) with qualitative insights. Findings reveal a strong consensus (72.79%) that electric vehicle (EV) adoption can significantly reduce transport emissions, with statistical analysis confirming that electrification has a measurable impact on CO_2 reduction. However, critical barriers persist, including an unreliable power grid (with 63.27% of respondents doubting its readiness for widespread EV charging), high import duties on EVs (identified by 72.11% as a major market barrier), and inadequate charging infrastructure. The study concludes that while transport electrification presents a viable pathway for Nigeria to meet its climate goals and achieve co-benefits like improved public health and energy security, its success hinges on targeted policy interventions. Key recommendations include enacting fiscal incentives like import duty waivers, developing a national electric mobility policy, and investing in renewable-energy-powered charging infrastructure to enable a sustainable transition.

Keywords: Electric Vehicles (EVs), Transport Decarbonization, Carbon Emission Reduction and Sustainable Mobility, Nigeria.

Introduction

The transport sector is one of the largest contributors to global greenhouse gas emissions, accounting for nearly one-quarter of total energy-related CO_2 output (IPCC, 2022). As countries pursue pathways toward decarbonization, the electrification of transport has emerged as a critical strategy for reducing reliance on fossil fuels, improving urban air quality, and advancing sustainable mobility (Mutezo & Mulopo, 2021; Sadiq *et al*., 2025; Al-Amin *et al*., 2025) [13, 18]. Electric vehicles (EVs), coupled with renewable-powered charging infrastructure, are increasingly seen as viable tools for aligning climate action with economic modernization.

Globally, EV adoption has grown rapidly, with more than 10 million electric cars sold in 2022 alone, demonstrating both technological readiness and shifting consumer demand (IEA, 2022).

In Nigeria, transport is a major source of carbon emissions due to heavy dependence on petrol and diesel vehicles (Suleiman *et al*., 2025; Tanko *et al*., 2025) [20, 21], supported by subsidies that make fossil fuels artificially cheap (IMF, 2022). The sector also reflects the country's energy paradox: while Nigeria flares vast amounts of gas and faces persistent electricity shortages, its transport sector continues to rely almost entirely on fossil fuels, intensifying both environmental degradation and public health risks (GGFR, 2022; WHO, 2021; Umar *et al*., 2025) [22].

Electrifying transport offers an opportunity to cut emissions, improve energy efficiency, and reduce urban air pollution, which currently accounts for over 114, 000 premature deaths annually (WHO, 2021). Despite these opportunities, multiple barriers hinder large-scale adoption of electric mobility in Nigeria. Key challenges include weak charging infrastructure, high upfront costs of EVs, unreliable electricity supply, and policy inconsistencies (Adewuyi, 2020) [2]. Furthermore, the dominance of imported second-hand fossil fuel vehicles reflects socioeconomic realities that complicate rapid transitions (World Bank, 2022). Without targeted policy support and investment, electrification risks remaining aspirational rather than transformative. This study therefore explores the prospects of electrifying Nigeria's transport sector as a strategy for carbon emission reduction.

Statement of the Problem

The transport sector accounts for nearly 28% of Nigeria's energy-related CO_2 emissions, making it one of the largest contributors to national greenhouse gas output (IEA, 2021). Despite this, Nigeria's transport system remains almost entirely dependent on petrol and diesel, sustained by fossil fuel subsidies that distort the energy market and discourage low-carbon alternatives (IMF, 2022). This heavy reliance on fossil fuels exacerbates urban air pollution, which contributes to over 114, 000 premature deaths annually (WHO, 2021), while undermining the country's commitments under Sustainable Development Goal 7 (SDG 7) on clean energy and SDG 13 on climate action (United Nations, 2015).

Globally, electric mobility has emerged as a key decarbonization strategy, with over 10 million electric vehicles (EVs) sold in 2022, supported by advancing battery technologies and expanding charging infrastructure (IEA, 2022). In Nigeria, however, the adoption of EVs remains minimal, reflecting significant systemic barriers. These include inadequate charging infrastructure, unreliable electricity supply, high upfront vehicle costs, and the absence of clear policy incentives to stimulate adoption (KPMG, 2022). Current research has largely overlooked these barriers in the Nigerian context, leaving gaps in understanding how EVs could realistically contribute to emission reductions while improving mobility access.

Moreover, there is limited empirical evidence examining the socioeconomic implications of electrifying transport in Nigeria. Key questions remain unanswered: how can EVs be integrated into an already fragile grid? What regulatory and fiscal reforms are required to incentivize investment? And how can electrification support co-benefits such as job creation, health improvements, and sustainable urban development (World Bank, 2021)? The lack of context-specific analysis constrains policymakers' ability to design a feasible roadmap for transport decarbonization. This study addresses these gaps by assessing the prospects of electrifying Nigeria's transport sector for carbon emission reduction while identifying the barriers that may impede its adoption.

Conceptual Review

Electrification of the Transport Sector

The electrification of the transport sector refers to the transition from vehicles powered by internal combustion engines (ICEs), which use fossil fuels like petrol and diesel, to electric vehicles (EVs) that operate on electricity stored in batteries. This transition is a crucial component of global strategies aimed at reducing greenhouse gas (GHG) emissions, enhancing energy efficiency, and mitigating the adverse effects of climate change. As the transport sector remains one of the largest consumers of fossil fuels and a significant contributor to air pollution and carbon emissions, its decarbonization through electrification has gained increasing attention in national and international climate agendas (International Energy Agency [IEA], 2021).

At the core of transport electrification is the deployment of various types of EVs including battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and electric buses alongside the necessary charging infrastructure. These vehicles rely on electric motors rather than fuel combustion, thereby eliminating tailpipe emissions and drastically reducing the carbon footprint associated with traditional transportation systems. When powered by electricity generated from renewable sources such as solar, wind, or hydro, the emissions reduction potential of EVs is significantly amplified (International Renewable Energy Agency [IRENA], 2021).

Beyond environmental benefits, the electrification of transport also contributes to energy diversification, reduced dependency on imported petroleum products, lower operating costs for vehicle owners, and improved public health outcomes through decreased air pollution. This transformation is significant for developing nations like Nigeria, where urbanisation, population growth, and economic activities are rapidly increasing the demand for mobility and energy. However, the transition to electric mobility requires systemic changes across multiple sectors, including power generation and distribution, manufacturing, urban planning, and public policy. Key components of successful electrification include investment in renewable energy-powered charging stations, development of local EV manufacturing and assembly capabilities, policy frameworks that support EV adoption, and public awareness campaigns on the benefits of electric mobility (United Nations Environment Programme [UNEP], 2020).

Electrifying Nigeria's Transport Sector as a Means to Reduce Carbon Emissions

Globally, countries such as Norway, China, and the United States are leading in EV adoption, driven by aggressive policy mandates, fiscal incentives, and innovations in battery technology. In Africa, several countries, including Kenya, Rwanda, and South Africa, have begun taking proactive steps to electrify their transport systems. Nigeria, with its large population, extensive urban centres, and heavy reliance on road transportation, stands to gain considerably from embracing this transition. However, the country's current dependence on fossil fuels, infrastructural challenges, and weak regulatory environment pose significant hurdles.

As Nigeria strives to meet its commitments under the Paris Agreement and implement its Energy Transition Plan, electrifying the transport sector emerges as a critical pathway to achieving low-carbon development. The transportation sector in Nigeria is a major contributor to greenhouse gas (GHG) emissions and urban air pollution. Predominantly reliant on fossil fuels such as petrol and diesel, the sector is responsible for a significant portion of the nation's carbon dioxide (CO_2) emissions. According to the International Energy Agency (IEA, 2021), transportation accounts for approximately 25% of global CO_2 emissions. In Nigeria, road transport accounts for up to 40% of total fuel consumption,

underscoring its substantial environmental impact (Federal Ministry of Environment, 2021) [8]. As the nation grapples with the twin challenges of climate change and energy insecurity, electrifying the transport sector presents a viable and necessary strategy to decarbonise the economy, improve urban air quality, and promote energy efficiency.

Theoretical Framework

Energy Transition Theory is a conceptual framework that explores the shift from one dominant energy system to another, often driven by technological advancements, socio-economic pressures, environmental concerns, and policy changes. It was influenced by the work of scholars such as Arie Rip and René Kemp, as well as other researchers involved in socio-technical systems thinking. This theory gained widespread recognition during the global push for cleaner energy following the oil crises of the 1970s and intensified due to increasing awareness of climate change in the 21st century. The theory encompasses not only replacing fossil fuels with renewable sources but also a profound transformation in the production, distribution, and consumption of energy across all sectors (Sovacool, 2016).

At its core, Energy Transition Theory outlines a staged process through which energy systems evolve. These stages typically include pre-development, where alternative energy options are explored; take-off, where interest in new technologies grows and initial policy frameworks are developed; acceleration, marked by large-scale implementation, falling costs, and public acceptance; and finally, stabilization, when renewable energy becomes dominant and the system enters a new regime (Rotmans *et al*., 2001; Cherp *et al*., 2018) [17, 5]. Unlike traditional linear development theories, Energy Transition Theory acknowledges the non-linear, multi-actor, and dynamic nature of energy transitions, emphasising the roles of institutions, culture, technology, and governance in shaping outcomes.

Nigeria currently resides in the pre-development to take-off stages, characterised by fragmented but growing policy attention, pilot renewable energy projects, and the foundational work of national frameworks such as the Energy Transition Plan (ETP). However, challenges such as dependence on oil revenues, weak regulatory enforcement, and inadequate energy infrastructure hinder this progression. Energy Transition Theory emphasises the role of governance, financial incentives, and infrastructure planning in overcoming such barriers (IRENA, 2022). Applying this theory helps identify policy gaps, investment opportunities, and strategies for aligning Nigeria's energy transition with global low-carbon pathways

Empirical Reviews

Aba *et al*. (2023) [1] conducted an extensive analysis of Nigeria's potential transition pathways in the road transport sector, focusing on fuel alternatives and powertrain technologies under subsidy and non-subsidy regimes. The study examined compressed natural gas (CNG), electricity from renewable sources, and fossil fuels as transition options for decarbonizing the transport sector. Using a techno-economic and environmental modeling approach, the study assessed the impacts of these energy carriers on cost, energy efficiency, and CO_2 emissions.

Findings revealed that switching to natural gas would yield a 33% resource conservation and 52% emission reduction compared to conventional fuels. Moreover, dedicated CNG and hybrid CNG electric powertrains offered the lowest cost per kilometer ($0.27/km and $0.25/km, respectively). Electrification of transport—especially through renewable energy—was shown to deliver up to 98% emission reduction, although with higher operational costs in the short term. The authors concluded that while CNG serves as an efficient transition fuel, full electrification remains a viable long-term pathway for achieving carbon neutrality. They further recommended policy reforms, such as subsidy removal and incentive schemes, to promote the adoption of low-carbon transport technologies in Nigeria.

Oluwakoya (2024) [14, 15] provided a detailed assessment of Nigeria's transportation emissions, emphasizing the interplay between urbanization, population growth, and economic development. Using historical data and trend analysis, the study identified key drivers of emission growth, such as increased vehicle ownership, reliance on fossil fuels, and weak regulatory mechanisms. The study found a strong positive correlation between economic growth and transportation emissions, indicating that Nigeria's rapid development has come at the expense of environmental sustainability. It also highlighted the significant public health impacts of emissions, including respiratory diseases and reduced life expectancy in urban areas. Policy evaluation revealed inconsistencies in enforcement and limited integration of sustainable transport measures within national frameworks. The research concluded that Nigeria must urgently transition to cleaner fuels, electric mobility, and public transportation reforms to mitigate the environmental and social consequences of rising emissions. The author called for policy coherence, international collaboration, and technological innovation as essential steps toward decarbonizing the transport sector.

Shao *et al*. (2025) [19] explored Nigeria's sustainable energy transition within the context of the road transport sector, focusing on energy conservation and emission reduction (ECER) strategies. Through a multi-method approach, including scenario modeling and literature review, the authors examined the potential of integrating intelligent transport systems (ITS), renewable energy technologies, and alternative fuels such as hydrogen and biogas. The study identified major obstacles, including inadequate infrastructure, weak policy implementation, and overdependence on fossil fuels, which currently account for over 90% of the national energy mix. Findings emphasized that technological innovation and smart urban planning could significantly enhance transport efficiency, reduce emissions, and improve energy security. The authors also advocated for organizational and managerial reforms within the energy and transport sectors to ensure efficient policy coordination. Overall, the study contributes a holistic perspective by combining technological, economic, and environmental dimensions of sustainable transport planning in Nigeria.

the dominance of fossil fuels across road, air, rail, and water transport. The study observed that the transport sector is the largest consumer of fossil fuels and a major contributor to CO_2 emissions. Using energy consumption data, the authors analyzed the sector's economic contribution and environmental footprint, concluding that the transport sector accounts for about 3% of Nigeria's GDP but contributes disproportionately to carbon emissions. To achieve decarbonization, the study proposed practical measures, including revitalization of rail and water transport systems,

promotion of mass transit, incentivization of biofuels, and progressive introduction of electric vehicles. The authors warned that while decarbonization is crucial, it must be gradual and economically balanced to avoid disruptions in the national economy. Their recommendations provide a strategic framework for achieving emission reduction while sustaining economic growth.

In a complementary study, Oluwakoya (2024) [14, 15] explored how technological innovation can drive Nigeria's transport decarbonization agenda. The study highlighted key innovations—Electric Vehicles (EVs), renewable energy integration, Intelligent Transportation Systems (ITS), and advanced emission-reduction technologies—as transformative tools for emission mitigation. The research argued that EVs powered by renewable energy, particularly solar power, could significantly cut carbon emissions and improve air quality in urban centers. ITS technologies were shown to optimize traffic flow, reducing fuel consumption and idling emissions. The author further noted the importance of policy support, regulatory enforcement, and multi-sector collaboration in achieving the desired transition. The paper concluded that Nigeria's transport decarbonization requires not only technological advancements but also institutional capacity-building and stakeholder cooperation, ensuring that innovation translates into measurable environmental and economic outcomes. The reviewed studies collectively reveal that achieving a sustainable and low-carbon transport system in Nigeria hinges on technological innovation, renewable energy integration, and strong policy support. Transition fuels such as compressed natural gas (CNG) and biogas serve as short-term solutions, while electrification and hydrogen technologies offer long-term pathways toward carbon neutrality.

Methodology

This study employs both qualitative and quantitative approaches to examine Nigeria's transition to renewable energy for decarbonization comprehensively. The rationale for this design stems from the need to capture both numerical trends and contextual insights across technical, policy, and socio-economic dimensions of energy transition (Creswell & Creswell, 2018) [6].

The study focuses particularly on three key geographical zones based on their renewable energy characteristics. Northern Nigeria, comprising states such as Kano, Kaduna, and Sokoto, serves as the focal point for solar energy analysis due to its high solar irradiation levels, averaging 5.5-7.0 kWh/m²/day (ECN, 2022).

A Krejcie & Morgan (1970) [12] table (Appendix C) is used to determine the sample size from the population (N=285 staff in the first six departments). For a 95% confidence level and 5% margin of error, the required sample is 150 respondents, distributed proportionally across departments. To comprehensively address the research objectives, data will be collected through a mixed-methods approach that incorporates both quantitative and qualitative tools, ensuring robust and reliable findings. Primary data collection focuses on gathering firsthand information from the staff of the Energy Commission of Nigeria (ECN) through structured questionnaires, semi-structured interviews, and focus group discussions. Secondary data is obtained from official ECN documents, national energy reports, and international publications to provide contextual background and support primary findings (Creswell & Creswell, 2018) [6].

This section outlines the statistical and analytical techniques to be used in examining both quantitative and qualitative data gathered during the study. For data obtained from the structured questionnaires, descriptive and inferential statistical techniques are applied. The responses are first cleaned and coded using IBM SPSS Statistics (Version 27) to ensure data integrity. Descriptive statistics, including frequencies, percentages, means, and standard deviations, are computed to summarise staff perceptions on renewable energy adoption, policy effectiveness, and institutional barriers (Pallant, 2020) [16].

Data and Analysis

This section presents the data collected and analysed using descriptive statistics. The data analysed was collected using the research instrument.

Results

As the global push for clean mobility accelerates, the electrification of the transport sector has become a central pillar in national decarbonization strategies. In Nigeria, the integration of free carbon dioxide technology a zero-emission fuel produced using renewable energy is gaining attention. Table 1 captures the views of the Energy Commission of Nigeria (ECN) on the economic viability, renewable capacity, and international cooperation needed to advance electrification and transport decarbonization.

Table 1: Transport Electrification Integration

Item	Statement	SD	D	N	A	SA	Total
1.	The adoption of electric vehicles would significantly reduce Nigeria's transport sector emissions.	19 (12.93%)	21(14.29%)	-	42(28.57%)	65(44.22%)	147(100%)
2.	Nigeria's power grid can support widespread EV charging infrastructure.	34(23.13%)	59(40.14%)	-	31(21.09%)	23(15.64%)	147(100%)
3.	Import duties on EVs are currently too high to enable market growth.	29(19.73%)	12(8.16%)	-	49(33.33%)	57(38.58%)	147(100%)

Source: Field survey, 2025.

As revealed in Item 1 of Table 1, a clear majority of 107 respondents (72.79%) agreed or strongly agreed that the adoption of electric vehicles would significantly reduce emissions from Nigeria's transport sector. This high level of agreement underscores a strong institutional awareness of EVs as a climate mitigation tool, particularly in urban areas with high traffic-related emissions. On the other hand, only a combined 40 (27.22%) strongly disagreed and disagreed, suggesting some lingering concerns, possibly over implementation costs, consumer adoption, or grid capacity. Overall, however, this indicates strong support for policies that promote EVs as a central strategy in Nigeria's low-carbon transport roadmap.

In Item 2, despite optimism on emission reduction, opinions

around the readiness of Nigeria's electricity grid to support EV infrastructure were more critical. A combined respondent (63.27%) strongly disagreed and disagreed that the current power grid can support widespread EV charging, while 54(36.73%) agreed and strongly agreed, respectively. These responses highlight deep concerns about grid reliability, load shedding, and insufficient transmission infrastructure, which pose real barriers to scaling EV adoption in Nigeria. This finding supports the argument that grid modernisation must accompany EV policies to ensure technical feasibility and public confidence in EV usage.

In Item 3, it reveals concern over fiscal and regulatory barriers to EV penetration. A majority of 106 respondents (72.11%) agreed and strongly agreed that current import duties on EVs are too high, thereby inhibiting market growth. In contrast, only 41 (22.89%) strongly disagreed and 22 (12.22%) disagreed, respectively. This feedback highlights the need for tax reforms, import duty waivers, and incentive schemes to promote the local adoption of EVs. These fiscal adjustments are especially vital given that Nigeria lacks significant local EV manufacturing capacity and must rely on imports in the near term.

Transport Electrification

The electrification of Nigeria's transport sector, particularly through electric vehicles (EVs), has been recognised as a vital yet complex pathway for reducing emissions. Respondents emphasised the need for targeted policy interventions, such as local EV assembly incentives and investment in charging infrastructure. A senior ECN official emphasised:

"Without fiscal incentives and infrastructure readiness, EVs will remain elite commodities rather than mainstream alternatives."

Concerns were also raised about the resilience of Nigeria's power grid, with stakeholders noting that EV charging could overwhelm current distribution capacities. This underscores the urgent need for grid modernisation and energy storage systems as prerequisites for electrification.

Test of Null Hypothesis

H_0: Electrification of Nigeria's transport sector has no measurable impact on CO_2 emission reductions.

To test this hypothesis, the One-Way Analysis of Variance was also used because the data m*et al*l the assumptions. The result of the analysis is presented in Table 2.

Table 2: Result for Electrification of Nigeria's transport sector on CO_2 emission reductions.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Value	P-Value
Between Groups	7.124	5	1.421	2.540	0.025
Within Groups	468.134	915	0.523		
Total	475.258	920			

(F-critical= 2.540, P<0.05)

Table 2 demonstrates that the F-value is 2.540 and the P-value is 0.025. Since the P-value is less than the critical value ($P < 0.05$), the null hypothesis is rejected. This result indicates that the Electrification of Nigeria's transport sector has a measurable impact on CO_2 emission reductions. This finding implies that transitioning from fossil fuel-based to electric-powered transportation systems has a tremendous impact on decarbonising Nigeria's energy sector.

Conclusion

The electrification of Nigeria's transport sector presents a transformative opportunity to address the dual challenges of climate change and sustainable development. This study confirms that transitioning from internal combustion engine vehicles to electric vehicles (EVs) can significantly reduce carbon emissions, improve urban air quality, and enhance energy security.

The strong consensus among stakeholders, particularly from the Energy Commission of Nigeria (ECN), underscores the potential of EVs as a viable decarbonization tool. However, the study also highlights significant systemic barriers that must be overcome. These include an unreliable power grid, inadequate charging infrastructure, high upfront costs of EVs, and a lack of coherent policy frameworks. The statistical analysis further reinforces that while transport electrification can measurably reduce CO_2 emissions, its success is contingent on complementary investments in energy infrastructure, fiscal incentives, and regulatory support.

In the context of Nigeria's Energy Transition Plan and international climate commitments, electric mobility should be prioritized as a cornerstone of the nation's low-carbon strategy. A coordinated, multi-stakeholder approach is essential to transform the transport sector from a major emitter to a leader in sustainable mobility.

Recommendation

Based on the findings of this study, a critical and immediately achievable recommendation is for the Nigerian government to introduce a targeted package of fiscal incentives, including the significant reduction or full waiver of import duties on fully assembled electric vehicles (EVs), their components, and charging equipment. This single action would directly address the primary barrier of high upfront costs, stimulate market demand, and encourage private sector investment in EV sales and charging infrastructure, creating a foundational push for the electric mobility ecosystem without requiring immediate, large-scale capital expenditure from the government.

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