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THE ROLE OF ELECTRIC VEHICLES IN ENHANCING SUSTAINABLE TRANSPORTATION IN NIGERIA

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ABSTARCT

With growing concerns about climate change and energy sustainability worldwide, electric vehicles (EVs) have emerged as viable solutions for reducing transportation-related pollutants and enhancing sustainable mobility, Nigeria is not left out. This paper explores the role of electric vehicles in enhancing sustainable transportation in Nigeria. Using a theoretical approach, the diffusion of innovation theory was used to frame, interpret, and guide the study. The DOI theory supports the study reviews from various sources such as policy papers and articles from scholarly and media sources on EV adoption in and out of the country. The study shows that there is a growing interest in electric vehicles (EVs) as a sustainable alternative mode of transportation in Nigeria, but several challenges need to be addressed such as, the current poor infrastructure, very high initial costs and inadequate government support etc. However, positive prospects could be seen in terms of renewable energy integration, local manufacturing, and focused policy efforts. The study recommends the need for multi-stakeholder collaboration to overcome all current barriers; financial incentives and increased charging infrastructure as well as supportive regulatory measures should be implemented by the Nigerian government. Affordable EVs should be manufactured; renewable-powered charging stations should be established; and manufacturing processes should be innovative. Finally, the academia should strengthen EV technology research.

KEYWORDS: Battery Electric Vehicle (BEV), Diffusion of Innovation Theory, Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicles (PHEVs), Sustainable Transportation.

INTRODUCTION

The Transportation system in Nigeria plays an important role in the development of the economy, in that it facilitates the movement of persons, carriers and services necessary for the running of businesses in different regions. The Nigerian Bureau of Statistics (NBS) observed that the sector contributes significantly to the Gross Domestic Product (GDP), especially through road and air transport, which are the dominant modes in Nigeria (NBS, 2022). Nevertheless, the International Energy Agency (IEA), (2021) warns that the transport sector is one that contributes immensely to climate change on a global scale. Movement from land, air, and sea is still profoundly dependent on polluting internal combustion engines (ICEs) which produced over 8.4 billion metric tons of carbon dioxide ($GtCO_2e$) globally in 2023. Though, transportation emissions differ by region, there is an increase at a much faster rate in developing regions when compared to developed economies, because of high incomes and car ownerships (Alda, n.d). In a similar report, Ajala (2023) avers that the transport industry in Nigeria accounts for forty-eight percent (48%) of the total annual carbon dioxide (Co_2) emissions, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), as well as carbon monoxide (CO) in the country arising from the use of combustion engine (Air Quality (AQI) 2024). The country struggles with grave air pollution and environmental degradation, particularly in major cities. This is because the sector remains intensely reliant on fossil fuels, leading to amplified greenhouse gas emissions, air pollution, and traffic congestion, principally in urban areas (Akuru & Okoro, 2020).

Electric vehicles, driven by electricity instead of traditional fossil fuels, have great potential when combined with renewable sources to provide significant reduction in greenhouse gas emission and better-quality air (Sovacool, Axsen & Kempton 2018). The rest of the world is curious about the

effect of climate change on energy consumption, and that is why the apparent solution has come in the form of electric cars as an option to reducing transportation emissions and increase safe public transport. Still, EVs are at the embryonic stages of adoption in Nigeria. Poor charging infrastructure forms one of the major challenges impeding its growth in Nigeria; the existing power grid within the country has massive strain on it currently, thus potential EV customers are reluctant to invest in electric vehicles due to unreliable power supply (Oshionameh, 2024). Additionally, electric vehicles exist in the high cost category for the average Nigerian consumer as a result of costs relating to batteries (Ogunlowo, 2022). Exorbitant interest rate, lack of technical know-how and Nigeria's status as an oil-producing country create diffidence in embracing Electric Vehicles (EVs) because of her dependence on the oil and gas sector (Lande (2023).

Nigeria's hesitation can also be explained by its economic structure, though, Nigeria is the richest economy in Africa, there are over 100 million poverty-stricken citizens (Imoleayo, 2024) which depends heavily on oil revenue. The country's status as one of Africa's largest oil producers creates both an opportunity and a challenge: while the country is heavily reliant on fossil fuel revenues, it also faces frequent energy crises, creating an urgent need for cleaner, more efficient alternatives (Onyeka, Akinbami & Ogundipe 2021). Electric vehicles have considerable potential to drive transformative change in Nigeria's sustainable transportation sector. Nigeria is also the most populous country in Africa, and her vehicle fleet makes up approximately (8.4%) of the entire vehicles in use in the continent (Deloitte, 2016). Therefore, the country needs to turn to affordable options like renewable energy powered by EVs, could offer a path toward reducing the nation's carbon footprint and enhancing energy security (Oyedepo, Adaramola & Alayande, 2023).

Numerous studies in literature have explored different aspects of electric vehicles (EVs) in both developing and developed economies; Liu, Kong, Liu, Peng & Wang, (2015) studied the strategic planning of the energy system. Bellocchi, Gambini, Manno, Stilo & Vellini, (2018) investigated the positive interactions between electric vehicles and renewable energy sources in CO_2-reduced energy scenarios in Italy. Tang, Cockerill, Pimm, & Yuan, (2021) explored reducing the life cycle environmental impact of electric vehicles in Great Britain. Kühnbach, Stute, Gnann, Wietschel, Marwitz & Klobasa, (2020) examined the impact of electric vehicles on German households. Ogunlowo, (2022) investigated challenges and opportunities for electric vehicle adoption in Nigeria, Oyedepo, Adaramola & Alayande, (2023) studied renewable energy and electric vehicles and Ugwoke, Okoro & Ezugwu, (2022) explores promoting electric vehicle adoption in Nigeria, none of them explored the role of Electric vehicles in enhancing sustainable transportation in Nigeria. Therefore, the aim of this study is to examine the role electric vehicles would play towards improving sustainable transportation in Nigeria, mainly as regards their environmental benefits, economic opportunities, and policy implications. The study will also try to recommend means by which electric vehicles can be integrated into Nigeria's transport system as part of the country's comprehensive sustainability agenda by looking into existing frameworks and future ways of adopting EVs.

THEORETICAL FRAMEWORK

The theoretical framework provides the basis for extrapolating the research phenomenon. The Diffusion of Innovation (DOI) theory provides a framework for this study because it explains how novel ideas, technologies, or practices circulates within a social system in a period of time.

DIFFUSION OF INNOVATION (DOI) THEORY

The Diffusion of Innovation (DOI) theory was first conceived and published by Rogers in the year 1962 in his book entitled Diffusion of Innovations. Rogers defined diffusion to be process by which an innovation is communicated through certain channels over time among the members of a social

system (Rogers, 1962). At first, it evolved from investigations regarding rural sociology: how most agricultural innovations were adapted by farmers. It has since been applied over a wide variety of disciplines, which include technology, public health, marketing, and education (Rogers, 2003). As stated by Wejnert, (2002), the diffusion of Innovation theory describes how the society changes through the gradual adoption of a new practice, idea, or product into a society or a subgroup, eventually leading to widespread diffusion and institutionalization of that change. Nwokah and Poi, (2022) citing Sirk, (2020) opined that innovation diffusion explains the flow and implementation of new ideas, products and technologies through mindfulness, persuasion, decision, implementation, and continuation. According to DOI theory, there also exists classification of categories of individuals or organizations into different groups categorized as innovators, early adopters, early majority, late majority, and laggards based on their rate of adoption with respect to a particular innovation (Agarwal & Prasad, 1997). DOI has directed the design and implementation of health interventions such as the promotion of new health behaviors, including vaccination uptake and health screenings (Greenhalgh et al., 2004). Marketing companies exploit the concept of adopter categories as bases for tailoring their promotional strategies with the objective of influencing early adopters to influence the early majority and other categories (Valente, 1996). As new innovations penetrate the world, DOI is used to extrapolate the penetration of new inventions like mobile phones, social media networks, and other digital technologies like Electric Vehicles, indicating how peer influence and social perception could easily lead one to another.

ELECTRIC VEHICLES

The term "electric vehicles" usually referred to as a "Plug-in' Electric Vehicle" (PEV), refers to a class of automobiles powered by electricity through lithium-ion battery packs, enabling them to run efficiently without producing any direct emissions. Electric vehicles (EVs) are automobiles that operate entirely on electrical power stored within batteries, which can be recharged from an outside electric source, and accounts for lessened carbon emissions and reduced fuel consumption. Nwohu, Ambafi and Bawa, (2023) opined that an Electric Vehicle (EV) is any automobile that is power-driven partially or fully by a battery which source of charging is direct linking to the mains.

According to Hannan, Azidin & Mohamed, (2014), electric vehicles (EV) are defined as any automobile that uses an electric motor to drive instead of an internal combustion engine, with energy supplied by rechargeable batteries or some other storage device. EVs are regarded as cars using one or more electric motors for their propulsion. They take charge from recharge batteries or are running through fuel cells. They provide a more sustainable alternative in contrast to gasoline vehicles (Chan, 2007). An EV is as an automobile using one or more electric motors, powered by onboard energy storage systems and/or replacing or supplementing traditional fossil fuel engines (International Energy Agency (IEA), 2020). Nykvist and Nilsson (2015) provide a further detailed explanation; their definition states that EVs are road vehicles that rely on electric motors powered by batteries, fuel cells, or some other energy storage devices instead of internal combustion engines. EVs are considered battery-driven vehicles because they depend on electric energy stored in rechargeable batteries and could be considered as a cleaner alternative to the conventional automobile because they do not release tailpipe pollutants (Li, Tong, Xing & Zhou, 2017).

Denton, (2020) suggests that electric vehicles can be categorized based on their average distance and mechanical or electrical configuration. They include: (i) Battery Electric Vehicle (BEV): A Battery Electric Vehicle is exclusively powered by an electric battery, with no gas engine parts. Most BEVs are able of fast charging with Level 2 charging. Zero emissions. (ii) Hybrid Electric Vehicle (HEV), A hybrid-electric vehicle is one powered with an internal combustion engine and an electric propulsion system for lower energy consumption. In other words, it cannot be plugged in to charge the battery, as an alternative, the battery is charged through recreating braking and by the internal combustion engine. Therefore, the emissions and fuel efficiency are improved compared with a conventional

vehicle. (iii) Plug-in hybrid electric vehicles (PHEVs) utilize batteries to power an electric motor and some kind of fuel, like gasoline or diesel, to power an internal combustion engine or other propulsion source. (PHEVs) batteries are charged by plugging with electricity from an outside socket through charging equipment and regenerative braking. This helps to reduce the operating costs and fuel usage, relative to traditional vehicles. Their emissions could be less than those of their g counterparts, depending on the source of electricity as well as the travel distance in all-electric mode. Finally, (iv) Fuel cell electric vehicles (FCEVs) which are powered by hydrogen. They are more efficient than traditional internal combustion EVs. Hence, they produce no destructive emissions. Hence, an electric vehicle is an automobile that primarily converts electricity stored in batteries to power electric motors for driving, presenting a sustainable emission-lowering option for transportation. And the accessibility of charging stations helps to simplify the charging process and encourage more individuals and organizations to switch to EVs.

Figure 1: An Electric Vehicle Is Plugged into A Charging Station in Bilbao, Spain
Source: Damilola, (2023)

SUSTAINABLE TRANSPORTATION

Sustainable transportation encompasses transportation systems designed to improve energy efficiency, reduce greenhouse gases, and contribute positively to urban air quality and community well-being (Litman, 2020). Sustainable transportation refers to modes of transport and facilities that meet current mobility needs of the present generation without compromising the ability of the future generation to fulfill theirs. This is done with emissions reduction, resource conservation, and a lowered environmental footprint (Black, 2010). Marsden and Reardon, (2017) observed that sustainable transportation is the mobility systems that support low carbon emissions, preservation of natural resources, and intensification of resilience to climate change. Sustainable transportation is the practice of building transportation systems to help economic development while minimizing carbon emission, pollution, and resource use (Banister, 2008). The International Energy Agency (IEA). (2021) agrees that it is form of transport that seeks to reduce the carbon footprint and improve energy efficiency by adopting cleaner technologies and promoting low-emission modes. For Zhang & Batterman, (2019), sustainable transportation is defined as transportation that produces environmental benefits, improves public health, and is economically affordable and accessible to all. Sustainable transport entails strategies, tactics, and policies aimed at reducing emissions, conserving resources, and providing fair mobility choices across all socioeconomic groups (Chester & Horvath,

2019). Thus, the sustainable mode of transport includes developing transport networks for environmental balance, renewable energy usage at all ends, and walking, cycling, and public transport instead of car dependency.

A primary measure of sustainable transportation is the reduction of greenhouse gas emissions, particularly carbon dioxide (CO_2). This is the shift from fossil fuel-propelled vehicles to low-emission vehicles like electric vehicles (EVs), hydrogen-powered transport, and increased use of public transport. This involves moving from fossil fuel-powered vehicles to low-emission substitutes like electric vehicles (EVs), hydrogen-powered transport, and improved use of public transportation. Switching to EVs and expanding public transport infrastructure could reduce GHG emissions by as much as thirty percent (30%) by 2050 according to the (International Transport Forum, 2021). United Nations Environment Programme (UNEP,) (2022) reports that minimizing GHG emission involves energy-efficient practices and transition to renewable sources of energy into the reducing emission of carbon dioxide, methane, and some other greenhouse gases release into the atmosphere. According to Stern, (2020), minimizing GHG emissions accentuates GHG emission reduction within the context of transition from carbon-intensive economic activities to low-carbon economies, which ultimately promotes sustainable development while combating climate change. The Intergovernmental Panel on Climate Change (IPCC)(2022) opined that GHG minimization is systematically reducing one individual's or organization's carbon footprint by primarily adopting low-carbon technologies and reducing fossil fuel-dependent practices. Ong, Xing and Roberts, (2023) indicate that minimizing GHG emissions in this context involves promoting the use of electric vehicles, improving fuel efficiency, and enhancing public transit to reduce vehicular emissions. This incorporates pollution prevention strategies such as reducing industrial waste, improving energy efficiency in manufacturing, and enhancing recycling processes.

Energy efficiency is another metric of sustainable transportation that involves reducing the costs associated with energy consumption by applying energy-saving technologies and approaches (American Council for an Energy-Efficient Economy, 2021). The International Energy Agency, (2021) defined energy efficiency as the amount of energy which must be converted for the provision of goods and services to attain similar or better outputs with reduced energy consumption. The United States Department of Energy, (2022) defined energy efficiency as the ratio of valuable energy output relative to the total energy input. It measures how effectually a system uses energy to perform a given task. The World Bank (2021) defined energy efficiency as the behavioral changes and technological improvements aimed at reducing energy consumption while maintaining the same level of performance. Energy efficiency aids sustainability by augmenting energy usage across industries like transportation, manufacturing, and hospitality sectors, leading to high energy savings (Intergovernmental Panel on Climate Change (IPCC), 2022). Increasing energy efficiency in transportation can significantly reduce energy consumption and fossil fuel dependency. This can be achieved via enhanced vehicle fuel efficiency, the use of renewable energy sources, and optimizing transportation routes. For example: Energy-efficient transportation systems can lessen energy demand by sixty percent (60%) in high-efficiency situations (Schiller, Bruun, & Kenworthy, 2017). Therefore, energy efficiency is about reduction in the environmental footprint of energy consumption communities. Showed below is the conceptual framework showing the variables behind the study.

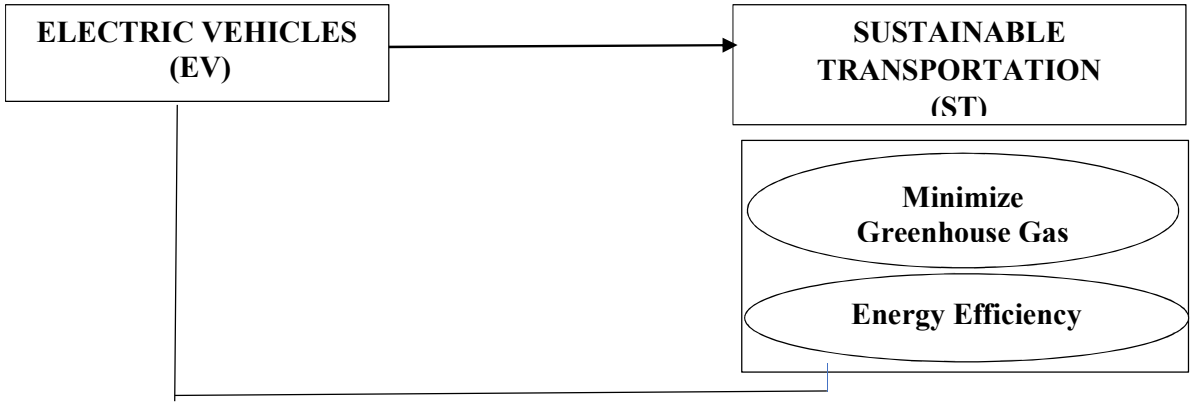

Figure 2. Conceptual Framework of The Role of Electric Vehicles in Enhancing Sustainable Transportation in Nigeria
Source: Schiller, P. L., Bruun, E. C., & Kenworthy, J. R. (2017). *An Introduction to Sustainable Transportation: Policy, Planning, and Implementation*. Routledge.

THE ROLE OF ELECTRIC VEHICLES IN ENHANCING SUSTAINABLE TRANSPORTATION IN NIGERIA

Electric vehicles (EVs) offer a fresh and different approach towards achieving sustainable transportation most especially in developing countries like Nigeria considering the growing challenges posed by urbanization and rising emissions. Electric vehicles (EVs) embody a revolutionary change for Nigerians in the pursuit for sustainable transportation, and brings multiple benefits, including environmental, economic, and social. In Nigeria, where urbanization and increasing population result in growing vehicular emissions and heavy dependence on fossil imports, EVs create a significant turnaround potential. However, this requires achieving readiness for the adoption of EVs alongside government policies supportive of it, infrastructure-on-ground facilitation, and stakeholder engagement (Akuru & Okoro, 2020). Guided by the Diffusion of Innovation (DOI) paradigm, this discourse explores the environmental, infrastructural, and societal dimensions of EV adoption in Nigeria, with emphasis on the role of government policies promoting this transition.

EVs present extensive environmental advantages over traditional internal combustion engine vehicles (ICEVs), particularly because they tend to create fewer greenhouse gas emissions during the operational life span of the motor vehicles. As price and cost reduction in EVs has seen governments adopt these vehicles from other parts of the world, Hawkins *et al* (2013) show that the production of EVs lowers urban air pollution and contributes to GHG reductions. Though, if EVs in Nigeria are powered by renewable energy sources such as solar and wind, the long-term environmental benefits would outweigh blockades like, high costs of EVs batteries translating into the high production and high prices for the average Nigerian, lack of dedicated EV charging stations and inadequate road network, unstable power supply to support the adoption of EVs in Nigeria. The adoption of EVs will definitely improve air quality in cities such as Jos, Kaduna, Osogbo, Calabar, Maiduguri, Warri, Birnin, Abuja, Benin City, Aba, Lagos and Port Harcourt in Nigeria because they are among the regions where very high air pollution is experienced (AQI (2024). The Nigerian government's National Renewable Energy and Energy Efficiency Policy (NREEEP) glamour for renewable energy integration into various sectors such as transportation for sustainable development purposes due its environmental advantages such as decreased greenhouse gas emissions and lower levels of air pollution. This fits in with Rogers' (2003) Diffusion of Innovation (DOI) Theory; innovation will be adopted more readily in scenarios where the advantages are apparent.

Robust infrastructure has been perceived as a precondition for the success of EV adoption, which, in Nigeria, remains quite a gap. According to a study conducted by Sovacool, Axsen, and Kempton (2017), accessible charging networks must be established to overcome adoption barriers. This resonates with the DOI theory under the "compatibility" dimension, which asserts that innovations should fit in with the criterion of already established infrastructures and societal norms. Major obstacles to the adoption of EVs in Nigeria include her poor power grid and inadequate charging infrastructure. Government investments in renewable energy charging stations will therefore be required to close the gap in Nigeria. Collaborative public-private partnerships, however, could be very instrumental in scaling up infrastructural development. Addressing these issues requires targeted investments in grid infrastructure and innovative solutions, such as solar-powered charging stations (Ugwoke, Okoro & Ezugwu, 2022). Government initiatives like the Electric Vehicle Development Plan (EVDP) are steps in the right direction (National Automotive Design and Development Council (NADDC). 2021). This plan encourages partnerships between public and private sectors to expand charging infrastructure and improve energy access. By focusing on both urban and rural areas, these efforts can ensure equitable access to EV technology, reducing disparities and supporting nationwide adoption.

Consumer acceptance of EVs could be determined by factors such as cost, reliability, and convenience perceptions in Nigeria. According to Carley, Krause, Lane & Graham, (2013), while the environment and cost effectiveness act as driving forces for the consumption of EVs, charging convenience and system reliability seem to negate the adoption of EVs by prospects in Nigeria. The "observability" and "trialability" constructs in the DOI theory accentuate the need for first-hand experience with the visible benefits to drive the adoption. This calls for intensive well-researched and educational persuasive campaigns on the economic and environmental benefits that accrue to the use of EVs. Consumers' trust could be enhanced via demonstration programs that show reliability of EV, complemented with economic incentives for early adopters. The government of Nigeria should develop some targeted tax incentives and grants to lower the initial cost of EVs for the wider public (National Automotive Design and Development Council (NADDC). (2021). For example, import duty exemptions on EVs and charging infrastructure would promote EV uptake while addressing some of the affordability issues facing many Nigerians.

Policies like these are all geared towards encouraging indigenous electric vehicle manufacturing and minimizing reliance on imports as part of the initiatives by the Nigerian government, including the National Automotive Industry Development Plan (NAIDP). Tax rebates for manufacturers of EVs and importers of EV components could help foster a vibrant local EV marketplace. Fit in the establishment of low-carbon zones in urban areas to prioritize EVs and ensure reduction in congestion and pollution while increasing its uptake. Integrating EV infrastructure in smart city projects like the Smart City Initiative in Abuja catches the eye of urban planners to develop a seamless environment for EVs. This type of integration is compatible, according to DOI, meaning that policy infrastructure and urban development have to maintain harmony among all possible resistant factors in propulsion of EV adoption.

Additionally, regulatory frameworks act as catalysts to fast adoption of electric vehicle (EV). Research by Hardman, Shiu, and Steinberger-Wilckens, (2017) reflects the fact that incentives combined with stringent emissions regulations can advance transportation towards a sustainable future. In Nigeria, part of the policy activities found on the National Automotive Industry Development Plan (NAIDP) is meant to encourage local EV manufacturing while reducing importation dependency (National Automotive Design and Development Council (NADDC), 2021). Tax rebates to EV manufacturers and importers of EV components could be an avenue for entrenching a strong local EV market, and policies such as low-emission areas in cities could again prioritize EVs for use instead of congestion and pollution reductions. Also, integrating EV

infrastructure into smart city projects like Abuja's Smart City Initiative (Federal Ministry of Communications and Digital Economy 2020). is in line with the diffusion of innovation (DOI) theory, especially on the aspect of compatibility, which pertains to the degree that new technologies can fit and work with other existing systems. This supports that policy, infrastructure, and urbanization converge into a seamless, sustainable ecosystem for urban mobility: the adoption of EVs.

CONCLUSION

Investigation of prevailing studies indicates that electric vehicles (EVs) are a crucial solution to very positively sustainable transportation in Nigeria-giving huge environmental, economic, and social benefits. This can only be harnessed through a synergistic approach that considers environmental, infrastructural, perceptual, economic, and regulatory aspects. Use of Electric Vehicles by Nigerians implies confronting serious challenges like insufficient infrastructure, high prices, and limited consumer knowledge. This study, which uses the principle of diffusion of innovation (DOI), reiterates the need for government policy interventions, extensive spending on infrastructure, and public-private partnerships for EV adoption. By addressing the various barriers to EV adoption such as constant power supply and charging infrastructure deficits, Nigeria will be positioned to maximize the benefits of environment-friendly vehicles in terms of emission reduction and quality improvement of air. Tax reliefs, duty-free imports, and inclusion of the EV infrastructure in smart city initiatives to establish a promising pathway for boosting consumer acceptance and supporting local production facility for EVs. With continuous progress and partnerships with government, industry and the academia Nigeria can witness a new direction in cleaner and equitable transportation systems, becoming a good example for sustainable urban mobility in developing countries.

REFERENCES

Agarwal, R., & Prasad, J. (1997). The role of innovation characteristics and perceived voluntariness in the acceptance of information technologies. *Decision Sciences*, 28(3), 557–582.

Air Quality (AQI) (2024). *Nigeria Air Quality Index (AQI) | Air Pollution*. Retrieved from: https://www.aqi.in/dashboard/nigeria on 22nd December, 2024.

Akuru, U. B., & Okoro, O. I. (2020). Energy transition in Nigeria: Policies, politics, and development in the African giant. *Renewable and Sustainable Energy Reviews*, 133, 110267.

Alda, M. (n.d). *Transportation Emissions Worldwide - Statistics & Facts*. Retrieved from: https://www.statista.com/topics/7476/transportation-emissions-worldwide/#topicOverview on 20th December, 2024.

American Council for an Energy-Efficient Economy (ACEEE) (2021). *The Role of Energy Efficiency in the Economy.* Retrieved from: https://www.aceee.org/ on 31st October, 2024.

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy*, 15(2), 73-80.

Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management,* 17(1), 99-120.

Barney, J. B., & Arikan, A. M. (2001). The resource-based view: Origins and implications. *Handbook of Strategic Management*, 124-188.

Barney, J. B., Wright, M., & Ketchen, D. J. (2001). The resource-based view of the firm: Ten years after 1991. *Journal of Management*, 27(6), 625-641.

Bellocchi, S., Gambini, M., Manno, M., Stilo, T., & Vellini, M. (2018). Positive interactions between electric vehicles and renewable energy sources in CO2-reduced energy scenarios: The Italian case*. Energy,* 161, 172-182.

Black, W. R. (2010). *Sustainable Transportation: Problems and Solutions.* New York: Guilford Press.

Carley, S., Krause, R. M., Lane, B. W., & Graham, J. D. (2013). Intent to purchase a plug-in electric vehicle: A survey of early impressions in large US cities. *Transportation Research Part D: Transport and Environment*, 18, 39–45. https://doi.org/10.xxxx/yyyy

Chan, C. C. (2007). The state of the art of electric and hybrid vehicles. *Proceedings of the IEEE,* 95(4), 704-718.

Chester, M., & Horvath, A. (2019). The environmental impacts of passenger transportation. *Transport Research Part D,* 74, 151-163.

Coffman, M., Bernstein, P., & Wee, S. (2017). Electric vehicles revisited: A review of factors that impact market penetration. *Transportation Research Part D: Transport and Environment,* 56, 149-158.

Damilola, A. (2023). *FG Plans Local Manufacturing of Electric Vehicles*. Retrieved from: https://punchng.com/fg-plans-local-manufacturing-of-electric-vehicles/ on 24th December, 2024.

Denton, T. (2020). *Electric And Hybrid Vehicles*. Routledge.

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy*, 48, 717-729.

European Commission (2020). *The European Green Deal: Energy and Climate Objectives.* Available at: https://ec.europa.eu/clima/policies/eu-climate-action on 31st October, 2024.

Federal Ministry of Communications and Digital Economy. (2020). *Abuja Smart City Initiative.* Retrieved from: https://fmcide.gov.ng/ on 24th December, 2024.

Federal Ministry of Power. (2015). *National Renewable Energy and Energy Efficiency Policy.*

Grant, R. M. (1991). The resource-based theory of competitive advantage: Implications for strategy formulation. *California Management Review*, 33(3), 114-135.

Hannan, M. A., Azidin, F. A., & Mohamed, A. (2014). Hybrid electric vehicles and their challenges: A review. *Renewable and Sustainable Energy Reviews*, 29, 135-150.

Hao, H., Wang, H., & Ouyang, M. (2014). Fuel consumption and life cycle GHG emissions by China's on-road trucks: Future trends and policy implications. *Energy Policy*, 62, 678-686.

Hardman, S., Shiu, E., & Steinberger-Wilckens, R. (2017). Comparing high-end and low-end early adopters of battery electric vehicles. *Transportation Research Part A: Policy and Practice*, 88, 40-57.

Hawkins, T. R., Singh, B., Majeau-Bettez, G., & Strømman, A. H. (2013). Comparative environmental life cycle assessment of conventional and electric vehicles. *Journal of Industrial Ecology,* 17(1), 53-64.

Helfat, C. E., & Peteraf, M. A. (2003). The dynamic resource-based view: Capability lifecycles. *Strategic Management Journal*, 24(10), 997-1010.

Imoleayo, O. (2024). *Nigeria's Poverty Rate Will Surpass W'Bank 104 Million Estimate Soon – Economists.* Retrieved from: https://punchng.com/nigerias-poverty-rate-will-surpass-wbank-104-million-estimate-soon-economists/ on 13th December,2024.

Intergovernmental Panel on Climate Change (IPCC) (2022). *Climate Change 2022: Mitigation of Climate Change. IPCC Sixth Assessment Report.* Retrieved from: https://www.ipcc.ch/report/ar6/wg3/ on 28th October, 2024.

Intergovernmental Panel on Climate Change (IPCC) (2022). *Climate Change 2022: Mitigation of Climate Change.* Retrieved from: https://www.ipcc.ch/report/ar6/wg3/ on 31st October, 2024.

International Energy Agency (IEA). (2020). *Global EV Outlook 2020*. IEA.

International Energy Agency (IEA). (2021). *Global energy review: CO2 emissions in 2021*. https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021

International Energy Agency (IEA). (2021). *Global EV Outlook 2021*. IEA

International Transport Forum (2021). *Decarbonising Transport: Achieving Zero-Emission Vehicles by 2050.* OECD Publishing.

Kühnbach, M., Stute, J., Gnann, T., Wietschel, M., Marwitz, S., & Klobasa, M. (2020). Impact of electric vehicles: Will German households pay less for electricity? *Energy Strategy Reviews,* 32, 100568.

Lande A. (2023). *Here's How Nigeria Is Tackling The Barriers To Its Green Energy Transition* Retrieved from: https://www.weforum.org/agenda/2023/05/how-nigeria-is-tackling-barriers-to-its-green-energy-transition/ on 28th October, 2023.

Li, S., Tong, L., Xing, J., & Zhou, Y. (2017). The market for electric vehicles: Indirect network effects and policy design. *Journal of the Association of Environmental and Resource Economists,* 4(1), 89-133.

Litman, T. (2020). *Evaluating Transportation Equity: Guidance for Incorporating Distributional Impacts In Transportation Planning*. Victoria Transport Policy Institute.

Liu, L., Kong, F., Liu, X., Peng, Y., & Wang, Q. (2015). A review on electric vehicles interacting with renewable energy in smart grid. *Renewable and Sustainable Energy Reviews,* 51, 648-661.

Marsden, G., & Reardon, L. (2017). *Sustainable Mobility Transitions: Policy and Governance.* Routledge.

National Automotive Design and Development Council (NADDC). (2021). *Electric Vehicle Development Plan for Nigeria.* Abuja: NADDC.

Hardman, S., Shiu, E., & Steinberger-Wilckens, R. (2017). Comparing high-end and low-end early adopters of battery electric vehicles. *Transportation Research Part A: Policy and Practice*, 88, 40–57. https://doi.org/10.xxxx/yyyy

National Automotive Design and Development Council (NADDC). (2021). *National Automotive Industry Development Plan (NAIDP): Strategic Framework for EV Adoption in Nigeria. Abuja:* NADDC.

Nwohu, M. N., Ambafi, J. G., & Bawa, A. (2023). Electric Vehicle: Prospects and Possibility in Nigeria. *In 2023 2nd International Conference on Multidisciplinary Engineering and Applied Science (ICMEAS)* (Vol. 1, pp. 1-5). IEEE.

Nykvist, B., & Nilsson, M. (2015). Rapidly falling costs of battery packs for electric vehicles. *Nature Climate Change*, 5(4), 329-332.

Ogunlowo, B. O. (2022). Challenges and opportunities for electric vehicle adoption in Nigeria. *Journal of Energy and Transportation*, 14(2), 102-112.

Ong, G., Xing, H., and Roberts, C. (2023). Sustainable transport: Approaches to reduce GHG emissions in the mobility sector. *Journal of Environmental Management*, 324(1), pp. 18-27. U.S. Department of Energy (DOE) (2022).

Onyeka, I. K., Akinbami, J., & Ogundipe, A. A. (2021). Oil, energy security, and climate change in Nigeria: The role of electric vehicles. *Sustainable Energy Technologies and Assessments*, 45, 101123.

Oshionameh, A. (2024). *Green Wheels: Nigeria's Road to a Sustainable EV Future.* Retrieved from: https://theelectricityhub.com/accelerating-electric-vehicle-adoption-in-nigeria-challenges-and-opportunities/ on 27th October, 2024.

Oyedepo, S. O., Adaramola, M. S., & Alayande, A. W. (2023). Renewable energy and electric vehicles: Pathways for sustainable development in Nigeria. *Renewable Energy Focus*, 38, 45-53.

Rogers, E. M. (1962). *Diffusion of Innovations.* New York: Free Press.

Rogers, E. M. (2003). *Diffusion of Innovations* (5th ed.). New York: Free Press.

Schiller, P. L., Bruun, E. C., & Kenworthy, J. R. (2017). *An Introduction to Sustainable Transportation: Policy, Planning, and Implementation*. Routledge.

Sovacool, B. K., Axsen, J., & Kempton, W. (2017). The future promise of vehicle-to-grid (V2G) integration: A sociotechnical review and research agenda. *Annual Review of Environment and Resources,* 42, 377-406.

Sovacool, B. K., Axsen, J., & Kempton, W. (2018). The future promise of electric vehicles: A critical review of literature. *Transportation Research Part D: Transport and Environment*, 63, 132-153.

Stern, N. (2020). *The Economics of Climate Change: The Stern Review*. Cambridge University Press.

Tang, Y., Cockerill, T. T., Pimm, A. J., & Yuan, X. (2021). Reducing the life cycle environmental impact of electric vehicles through emissions-responsive charging. *Iscience,* 24(12).

Ugwoke, E. O., Okoro, O. I., & Ezugwu, C. A. (2022). Promoting electric vehicle adoption in Nigeria through renewable energy integration. *Renewable Energy and Environmental Sustainability*, 7(1), 35-47. https://doi.org/10.xxxx/yyyy

United Nations Environment Programme (UNEP) (2022). *Emissions Gap Report 2022.* Retrieved from: https://www.unep.org/resources/emissions-gap-report-2022 on 28th October, 2024.

United Nations Environment Programme (UNEP) (2022). *Global Status Report for Buildings and Construction 2022.* Retrieved from: https://www.unep.org/resources on 31st October, 2024.

Wejnert, B. (2002). Integrating models of diffusion of innovations: A conceptual framework. *Annual Review of Sociology*, 28(1), 297-326.

Wolfram, P., & Lutsey, N. (2016). Electric vehicles: Literature review of technology costs and carbon emissions. *International Council on Clean Transportation*. Retrieved from ICCT Publications.

World Bank (2021). *Energy Efficiency as a Key Driver for Sustainable Development*. Retrieved from: https://www.worldbank.org/en/topic/energy on 31st October, 2024.

Zhang, Y., & Batterman, S. (2019). Air pollution and health risks due to vehicle traffic. *Science of the Total Environment*, 668, 1256-1268.