

Enhancing the Use of Renewable Energy in the Transportation Sector of Nigeria

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<https://doi.org/10.18280/ijtdi.070303>

ABSTRACT

Received: 23 June 2023

Revised: 15 August 2023

Accepted: 22 August 2023

Available online: 27 September 2023

Keywords:

renewable energy, transportation, petroleum, electricity markets, electric vehicles, sustainable development, energy policy

Energy efficiency and conservation stand as pillars of sustainable economic growth, facilitating job creation and climate change mitigation. Renewable energy, a sustainable and recyclable energy form, is increasingly being integrated into several systems. However, the transportation sector, a crucial component of national infrastructure, remains heavily reliant on petroleum, particularly in Nigeria. The dependence on petroleum, a fossil fuel derivative, has resulted in escalating costs and environmental pollution due to CO₂ emissions. This study aims to assess the potential for integrating renewable energy into Nigeria's transportation sector, focusing on the environmental and economic implications. A comprehensive literature review was conducted, with sources predominantly drawn from Scopus-indexed journals. The review covers various modes of transport, including inland and ocean water transport, land-based transport, and electric vehicles. Our findings reveal a pressing need for renewable energy integration to counteract the environmental and economic challenges posed by petroleum dependency. This study also highlights the barriers to renewable energy adoption and proposes viable solutions. By transitioning to renewable energy sources, Nigeria's transportation sector could become more sustainable, cost-effective, and environmentally friendly.

1. INTRODUCTION

Energy is essential for any country's economic development, advancement, and growth [1]. The amount of energy per unit of weight or volume is the source of energy that is readily available. However, it can be challenging to extract and utilise this energy. Necessities like prepared food, a cosy home, appliances, piped water, necessary health care, etc., are made possible with the help of energy. Energy powers productive endeavours, including farming, manufacturing, construction, and mining, claims Oyedepo [2]. Nigeria is regarded as Africa's energy powerhouse, along with Libya, which supplies two-thirds of the continent's crude oil reserves [3].

Renewable energy is defined by the United Nations (2022) as energy generated from natural sources that are replenished more quickly than it is used. Examples of such are the sun and the wind. Producing renewable energy can reduce emissions because it is becoming more affordable in some nations [4]. The foundation of all economic exchanges is transportation, a crucial human activity component. A transportation system must be socially and environmentally responsible to promote economic growth and development. Maintaining robust economic and political linkages between regions with similar states requires the movement of goods and people back and forth from one location to another [5]. Thus, a country's economic development may need more infrastructure and transportation options.

Road transport is the most popular transportation in Nigeria

since it is easily accessible, readily available, dependable, and integrated. Fuels like gasoline and diesel are the main modes of transportation in Nigeria. Carrier uses energy to move people and products via pipeline, road, rail, air, and water [6]. The growth rates of the economy and the number of people of citizens driving cars affect the transportation industries significantly. From literature and experimental survey analysis, it has been proven that the petroleum product used as an energy source for vehicles has a dangerous effect on our environment. However, the application of renewable energy in transportation is very significant as it is environmentally friendly and cheap. Examining the considerable improvement of renewable energy in Nigeria's transportation system is the goal of this paper/research project.

2. RENEWABLE ENERGY IN THE TRANSPORTATION SYSTEM

Chukwu et al. [7] analysed Nigeria's transport sector's energy use. The authors used energy consumption to discuss the various transportation methods and their consumption patterns. Electricity and mobility are closely linked thanks to the proliferation of plug-in electric vehicle (PEV) charging facilities [8]. These methods will impose restrictions and have a detrimental impact on how PEV traffic flows are distributed. In this paper, the PEV routing issue on a connected power and transportation network is investigated from the viewpoint of a social coordinator. In order to reduce the system's societal

costs, we build an interdisciplinary second-order cone programming model that optimises PEV drivers' travel routes. These costs include the time PEV drivers must travel to and from work, charging their cars, power supply costs, and finding charging stations.

The model uses:

- i. A more detailed transportation network model that explains the limitations placed on it by the driving range of PEVs.
- ii. The AC power flow model is used to describe the electrical constraints of the power system.

Then, we develop an iterative column construction technique to address the problem efficiently. The authors evaluate the suggested methodology for a connected power and transportation network with distributed renewable generation. According to numerical simulation results, the direction-finding of PEV traffic flows using the proposed technique can effectively increase social welfare and encourage the integration of renewable production. Even when Nigeria's national energy demand profile includes biomass and other renewable energy sources for which data are available, the transport sector still accounted for almost one-third of the nation's energy demand in virtually all the focal years. The primary fuels used in the sector include petroleum products, petroleum motor spirit, diesel, fuel oil, and dual-purpose kerosene. The sector has been in charge of most of the petroleum fuels used in the nation over the past two decades [9]. Also, the industry has historically consumed the most fossil fuels in the country. For instance, the transportation sector used around 287.34 PJ of energy in 1990, which included all petroleum products. This accounted for almost 67% of all fossil fuels used in the nation that year (excluding fuels used to generate electricity) [10]. On a final energy and fossil fuel basis, corresponding numbers for the sector between 2000 and 2005 are shown in Table 1. Also, Figure 1: debit the transportation sector percentages of energy consumption by heavy oil, Gasoline and diesel.

Table 1. Final usage of energy and fossil fuels in the transportation sector years

Year	Final Energy, Transport Sector	Percentage of Total Energy	Percentage of Fossil Fuel	Percentage in Petroleum Product
1990	287.30	35.00	66.10	100.00
1995	278.80	20.50	75.60	100.00
2000	375.20	17.20	59.80	100.00
2005	486.30	15.60	48.20	100.00

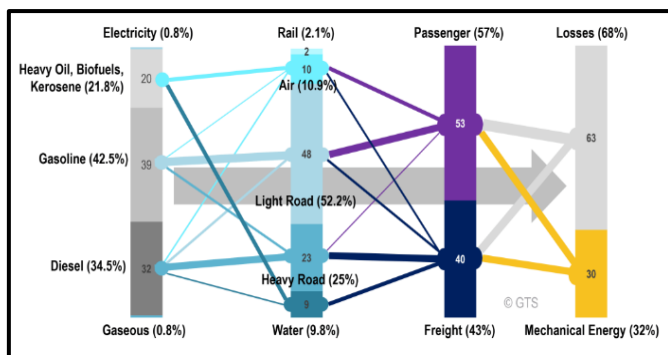


Figure 1. Debit the fuel energy consumption by the transportation sector

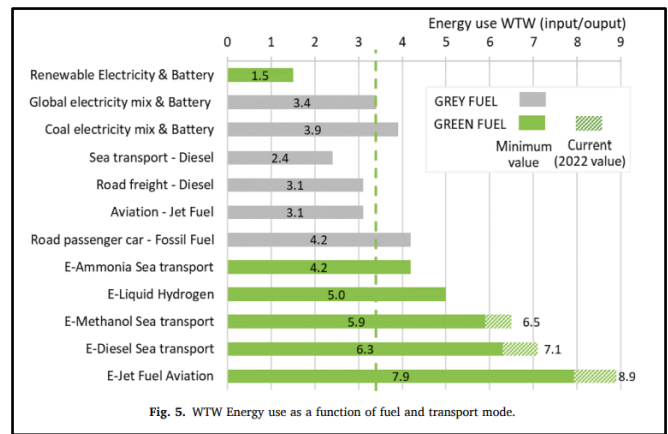


Figure 2. The energy utilised by WTW concerning the fuel and means of transportation

Green bars represent renewable options, and grey ones represent fossil fuels. In Figure 2, energy uses the Well-to-Wheel/Wake (WTW) (per kilowatt hour propulsion) chart for alternative transportation fuels. It should be emphasised that the numbers given are generally ratios of primary energy inputs to propulsion-related final energy [11]. The continued expansion of the transportation industry and the consequent increase in carbon emissions are essential to policymakers interested in sustainable mobility [12]. It is necessary to comprehend the variables that affect pollution caused by transportation. The idea of this study is to inspect the things of urbanisation, economic expansion, and the usage of renewable energy on CO₂ emissions from the transportation sector in European countries. To end this, a non-causality test and second-generation panel long-run estimates are used for the 1980–2014 dataset. Empirical statistics show that increasing the use of renewable energy lowers transportation-related carbon emissions, yet urbanisation has a statistically minor positive impact on pollution. Using more renewable power can reduce your carbon footprint by around 12%. The EKC theory is verified. In addition, emissions in the transportation industry are a direct result of urbanisation, economic growth, and renewable energy. According to the study's conclusions, the sustainable transportation system should be strengthened by encouraging energy- and environmentally-conscious modes of transportation, raising urban residents' understanding of transportation-related environmental issues, and addressing their general concerns. In particular for sector-based renewable energy initiatives, this study draws policymakers' attention to the greenhouse gas effects of the European transportation industry.

Yu et al. [13] forecast the relationship between crude oil imports and several macroeconomic indicators, including trade, industrial value added, renewable energy sources, transport services, and patents, using annual data for Germany for the years 1990 through 2020. The variables that are the focus of this study's analysis, which employs the Autoregressive Distributed Lag model, have a solid co-integration connection. This analysis also provides empirical evidence for the impact of key macroeconomic variables on crude oil imports into Germany. Findings show a significant long- and short-term positive association between transport services, industrial value added, and crude oil imports. Similarly, it has been discovered that trade only has a long-term, significant impact on lowering oil imports. However, the research reveals a significant unfavourable association between imported crude oil and renewable energy. According

to this study, crude oil consumption significantly affects industrial productivity and transportation. In addition, by alleviating the financial burden and conserving the environment, supporting renewable energy in these sectors may benefit economies in lowering their dependency on crude oil and achieving sustainability.

According to Elkamel et al. [14], the scheduling and planning of power resources significantly impact today's sustainable cities. Conventional and renewable power plants should prioritise sustainable social, technical, economic, and environmental practices. On the other hand, one of the fundamental building blocks of modern smart cities is the teletransportation electrification study plans the generation capacity to satisfy the system's load ability using a revolutionary private quick transfer scheme. This is accomplished by using a price-based unit commitment (PBUC), which optimises profit based on price signals within the parameters of a stochastic optimisation technique as the study presented is the University of West Virginia's rapid transportation system, based on several detailed planning scenarios. Wind energy is one of the most popular renewable sources for generating electricity.

The work of Tamilselvi et al. [15] says that supercapacitors and other cutting-edge electric energy generation and storage systems could considerably improve the ecological situation in large, densely populated cities. This requires the mass production of supercapacitors from abundant, sustainable resources like agricultural waste, which results from other technological cycles, using eco-friendly materials and clean, green technology. It is possible to think of a range of agricultural waste products as cheap and abundant carbon sources or making molecules that resemble graphene in large quantities. Here, we demonstrate a straightforward catalytic oxidation method that successfully employs ferrocene as a potent and eco-economic to break the available coconut trash into reduced graphene oxide. The prepared materials' structure and morphology were determined using XRD, SEM, and TEM methods. The materials' design and morphology as prepared were determined using XRD, SEM, and TEM methods. The results demonstrated that better-reduced graphene oxide may be produced. The resulting graphene oxide was then investigated as an electrode material for supercapacitor applications.

Dioha and Kumar [16] investigated the implications of five potential policy alternatives for the Nigerian transportation sector using a bottom-up optimisation model. For 2010–2050, our study considered fuel switching, increased fuel efficiency, modal shifting, enhanced logistics, and carbon pricing. According to the results, the other paths will significantly decrease energy demand and CO₂ emissions. For example, the authors found that, in 2050, a carbon tax and improved vehicle fuel efficiency may cut Nigeria's CO₂ emissions by 42.8% and 26.9%, respectively, compared to the reference case. Moreover, low-carbon routes will enhance energy security, air quality, and effective energy utilisation.

Gbadamosi and Nwulu [17] examined the generation and transmission expansion concerning the potential implications of demand response (DR) and renewable energy sources (RES) (GTEP). This is vitally essential to increase the penetration of RES in power networks to guarantee long-term energy security and emissions reduction. To help the system planner decide what investments should be made in the power system to fulfil the desired energy demand, GTEP with demand response is simultaneously considered. In order to

assess how different DR penetration levels in the planning system affect system performance, the suggested model considers these levels. Formulating a mixed integer quadratic programming problem for a multi-period, multi-objective GTEP model. The created MIQP was tested utilising the CPLEX 12.8.1 solver employing the IEEE 24-bus and the existing Nigerian Electricity system as two real-world case studies. The proposed model's system performance was subjected to sensitivity analysis, and the results demonstrate that increasing the penetration of DR resources in the planning process lowers power produced, emissions, and system costs while increasing the usage of RES in the power system.

According to Bamisile et al. [18], in Nigeria, the combined challenges of electricity generation, transmission, and distribution have long been significant. Currently, just 41% of the nation's populace has access to power. This study provides a sustainable, renewable, and economically viable strategy to electrify Nigeria by 2030 completely. The usage of hydroelectric power plants, concentrated solar power, photovoltaic power, natural gas (NG), wind onshore (WON), and offshore power was examined. The sole electricity storage system considered in this study is pumped hydro-storage. The fusion of the technologies above resulted in a total of 99 possible scenarios that were considered. Each scenario's initial investment, overall cost, proportion of renewable energy, carbon emissions, and power generation were examined. A year-long investigation using hourly time steps Energy PLAN was used to conduct time-step. The deterministic factors in this analysis are the importation of electricity for power production and crucial excess electricity production. By 2030, Nigeria's power demand is anticipated to reach 200 TWh/yr. If just one power method is used, it will take 36,000 MW of NG capacity to satisfy this demand. The most environmentally beneficial method of meeting the power demand is to use a combination of NG and PV or NG and WIN.

Ojo et al. [19] investigated using renewable energy as a viable alternative energy source and energy option from the perspective of sustainable development in Nigeria, South Africa, and the UK. In comparing the countries, the issues and factors that influence the growth and utilisation of renewable energy (RE) in different countries were identified and examined. The impact of energy policies, the influence of policymakers, their implementation and financial support, and the corresponding needs for conventional energy were the main characteristics of these countries' strategies for developing renewable energy. This article provides a conceptual framework and an explanation of how these essential aspects affect the evolution of RE. It also intends to influence policymakers' decisions, focusing on Niger, assist in formulating policies and encourage investment in the countries under review. It also attempts to add to the conversation about how to advance the Renewable Energy Master Plan (REMP).

According to Potrč et al. [20], a supportable, effective, cutthroat, and secure energy framework should be developed if the EU is to become carbon nonpartisan by 2050 and fulfil the Paris Understanding's environmental objectives. This article offers a deliberately eased energy change in the power and transportation areas to meet a carbon net impartial objective by 2050. It also outlines the EU-27's feasible, sustainable power supply organisations. A multi-period blended number programming model is created to enhance supportability net present incentive for developing biofuels, sustainable power, hydrogen, food, and other bioproducts using different sorts of innovation. The outcomes show that

with additional headway of current innovations, a carbon-unbiased EU is plausible without endangering food creation. While sun-based photovoltaics' significance has developed over the long run and will represent 43% of absolute power creation from RES by 2050, wind cultivates stand apart as the most feasible answer for the quick extension in power creation from sustainable power sources. The energy change inside the EU could decidedly affect the monetary, ecological, and social parts of manageability whenever more than 1.5 million new positions and unique open doors are laid out across the EU over the following 30 years.

In 2015 Paris plan to decarbonise the worldwide energy framework before the century's over. A reference case (REF) (ADV) and a 100 percent environmentally friendly power situation have been created [21]. ADV is in sync with patterns in the worldwide energy frameworks and will completely decarbonise the energy framework by 2050. As far as 2050 energy request expectations for essential and last energy and the requests for the structure and transportation areas, which are critical in metropolitan conditions, these discoveries appear differently about the IPCC AR5 450 ppm situations. Further examination is finished into the meaning of the discoveries for metropolitan foundations and what megacities mean for worldwide energy use. Under the reference situation, the yearly energy utilisation for structures in metropolitan regions is anticipated to ascend by 27 EJ, from 57 EJ to 84 EJ every year, because urbanisation rates will remain similar until 2050. Conversely, the elective situation predicts a decrease in the yearly energy interest for structures in metropolitan regions to 46 EJ while the populace and Gross domestic product keep expanding. By 2050, REF projects that the world's energy interest in transportation will have grown by over 60%. Nonetheless, the profound alleviation pathway decreases the interest in transport energy to 70 EJ each year, which is short of what it was in the base year. In any event, this addresses a critical decrease when contrasted with other 450 ppm situations. It may be accomplished by rapidly changing to electric versatility in light of vehicle effectiveness norms, killing ignition motors from the transportation area by 2030, and moving travel designs for metropolitan public transportation. Not precisely the requirement for transportation, the worldwide energy interest for the structure area in ADV needs to be corrected from past 450 ppm situations.

The underpinning of the crossover energy capacity framework (ECF) is the free idea of heterogeneous energy stockpiling framework (ESF) advances as far as power and energy thickness, life cycle, reaction rate, and different elements [22]. In other words, high-power ESF gadgets have quick reaction times, though high-energy ESF gadgets have slow ones. Accordingly, it may be worthwhile to consolidate the practical benefits of two unique ESF advances that are now being used. Along these lines, this hybridisation offers excellent properties that no single ESF unit could. In writing, various researchers have proposed and explored this innovation, especially in sustainable power and energised transportation. This study will examine the ECF thought, hybridisation ideas and geographies, power gadgets interface designs, control and energy the board approaches, and application spaces in this specific situation and as per a careful writing survey.

2.1 Water transportation

Water travel is the most straightforward and most traditional

mode of transportation. It runs on a natural track. Thus, unlike canals, it does not require a substantial capital investment to create and maintain its course [23]. Also, the operating costs of water transportation could be higher. Due to its large carrying capacity, it is ideal for moving heavy objects over long distances. It is crucial to global trade and has greatly aided in bringing different parts of the world closer together [24].

2.1.1 Inland water transport

They are manufactured streams created for navigation, irrigation, or both. The building and upkeep of the canal system's track, or artificial waterways, involves a substantial capital expenditure [25]. As a result, the price of canal transportation is more expensive than that of river transportation. In addition, one of the most significant issues with canal transportation is the price of providing water for the canals.

Kumari et al. [26] investigated how rivers have an advantage over roads in Kuttanad, Kerala. The study also highlights how local environmental contamination results from disregarding streams and rising road preference. The research area has been visited several times for a specific solution, and interactions with the inhabitants have been conducted to understand the issues. Waterway planning is done by gathering data from the research region under consideration. Several trips along a route were used to estimate journey durations, and Google Earth was used to calculate distance. Tracks were recorded using the GPS device while travelling in a car and a boat. After that, Google Earth was used to represent the tracks and coordinates. The study shows that waterway improvements can outperform road improvements in the study area. The study also tries to demonstrate how the creation of rivers might address the area's stagnant water issue.

According to Akpudo et al. [27], in Nigeria, the inland water transportation (IWT) system is one of the most important modes of transportation due to its simplicity of use and low operating and maintenance costs. Throughout the beginning of time, IWT played a crucial role in the growth of trade, business, and societies. Knowledge of its operational features and supplies will aid its appreciation and potential to improve the intermodal connection of the country's transportation system and network, particularly in Anambra State. To do this, the study evaluated IWT operations and supplies along current routes in Anambra State by registered operators. On-the-spot interviews and the questionnaire distribution over two weeks were assessed. Descriptive statistics were used to assess the operational aspects of the data obtained, and multiple regression was used to identify the factors affecting the supply of IWT in Anambra. According to the study, private ownership dominated the store, and most used vessels were medium-sized wooden boats. Routes that were travelled on market days were profitable. Also, it was found that the demand for IWT services was the most critical determinant in determining their availability. The study suggests that to increase the appeal of IWT, the operators should enhance the services they provide, and to change the supply pattern, the existing routes should see an increase in traffic outside of market hours. It was also proposed that boat operators explore different uses of their boats outside market days.

The arrangement of Sir Frederick Lugard to dig the Lower Niger for all-year safeness in the mid-1900s is analysed in this review [28]. The Stream Niger study focused on "Lugard's pioneer objectives" about the stream as opposed to the

difficulties of its exceptional attributes versus the elements of Nigeria's inland water transport (IWT) market in the post-autonomy period and the lousy acquirement processes for the digging efforts which, by and large, impacted its genuine and seen utility. This study also examined its politics, history of dredging, and comparisons with the Pearl and Mississippi Rivers. A qualitative analytical approach was applied with archival, primary, and secondary data sources. The results show that, despite the most recent dredging campaigns, there are still no commercial voyages or off-take cargoes, the river system has no opportunity cost, environmental challenges and host community issues, the effects of the so-called "downward march of the Sahara Desert" on the river's future, and "nearly-impossible" milestones in the capital and maintenance dredging objectives. The rejuvenate that the roundabout digging efforts ought to be deserted. Nigeria's IWT strategy was checked to stop further superfluous digging uses for better models of stream frameworks on board. It does this by looking at the functional and business issues, the monetary requirements, and the straightforwardness issues of worldwide elective-ide models.

Since the beginning of human civilisation, there has been waterborne transportation. Today, the usage of waterways is encouraged by the need for an economical and environmentally friendly means of transportation [29]. In India, waterways have much potential. Excellent inland canal networks may be found in areas like Bihar, Assam, Goa, and Kerala. These networks can meet the region's travel requirements if they are built. The 74 km stretch of inland canal in Kerala between the districts of Kollam and Thiruvananthapuram was the subject of a study to ascertain its demand and potential. To look at the essential features of the rivers that are now in Traffic, surveys were conducted to gather socioeconomic data and traveller preferences, and ArcGIS software was utilised existence. The study's main results include the need for the waterway and its social, technical, and economic viability. As the international seaport on India's southeast coast rapidly approaches completion, it was determined that if the underutilised navigation system is developed effectively and economically, it will be a turning point in the growth of sustainable transportation systems in the country, particularly in logistics and tourism. The study finds that building a waterway costs 20% more than making a road but that transportation costs and emissions are 90% and 82% lower, respectively. However, the benefit-cost analysis revealed that the project would yield 66% more benefits than existing roads in various categories, including improved safety, decreased environmental pollution, lower transportation costs, reduced traffic congestion, and increased tourism.

To energise the reception of green advances and low-outflow rehearses in the waterborne transportation area, public strategies and monetary impetuses are often used as a technique [30]. After the Paris Arrangement, countries have been asked to institute more intent to cut ozone-depleting substance outflows and increment flexibility with the impacts of environmental change on agricultural lands. This article includes a survey of the literature on laws, rules, and initiatives that serve as financial inducements to promote the decarbonisation of inland and maritime transportation in sixteen nations, including Colombia. The motivators found were isolated into three classifications: project supporting, separated port taxes, and logical articles. More than 130 wellsprings of data, including official entryways of states, port

specialists and associations, were examined, and a monetary guide to pay for coastal power administration costs. This investigation uncovered that separated port duties were the most commonplace motivation. The particular occasion of Colombia was then analysed, which offers a more inside-and-out comprehension of present strategies and drives intended to advance the decarbonisation of waterborne vehicles and differentiate them from the worldwide scene. Despite how Operations has demonstrated to be an innovation that might cut discharges in inland and oceanic ports, sending at ports and on ships has been obstructed by costly establishment and support costs, high power costs, and an absence of rules and impetuses. Most ports with this innovation are in North America, Europe, and Asia. It should be noted that the guideline on the organisation of elective fills foundation 2014/94/EU, which orders that Operations innovation should be sent in the ports of the European Association as vital before 31 December 2025 (European Commission 2014), covers the countries that make up the European Association. These variables have driven a few states to offer boats and port endowments to establish Operations and sponsorships to decrease power rates.

According to Wali et al. [31], the hydro-chemistry of the surface water in the River-Rima floodplain was investigated in this study. Three surface water samples were collected from the five specifically chosen sampling locations (river). After 20 days, the sampling was done once more. As a result, 30 samples in total were obtained. Laboratory testing was performed on the water samples that were collected. Results showed that BOD, TDS, Mg^{2+} and Fe^{3+} are over the reference levels for drinking water quality set by the Standard Organization of Nigeria (SON) and the World Health Organization (WHO). The coliform bacteriological examination identified several isolates, including *Enterobacter/aerogene*, *Escherichiacoli*, *Citrobacterfreundii*, and coliform-bacteria growth above the SON limit for drinkable water (H_2O) is found in the majority of samples. As a result, the River-Rima floodplain in the Wamakko region needs better quality and is unsuitable for drinking. The hydrochemistry of surface water was found to be controlled by external factors such as impurity wash-off and rock weathering, according to the principal component analysis (PCA) results. Based on hierarchical cluster analysis, anthropogenic inputs are suggested (Cl^- , NO_3^- , and PO_4^-). Cl^- , NO_3^- , and PO_4^- are among the elements that human activities, primarily agricultural and urban sewage, rapidly add to surface water. In all samples, coliform growth was higher. The three coliform bacteria found were *Escherichia coli*, *Citrobacter freundii*, and *Enterobacter aero gene*. In this investigation, the presumptive test was positive in all five samples. Because concentrations were above the rate of 10, as advised, the entire collection of pieces was unfit for drinking. Compared to the other samples, the water (H_2O) models from Kwakwalawa show the highest contamination rate. As a result, the presence of microbial pathogens in the water poses a potential health concern. 33.33% of the population belonged to *Enterobacter aero-gene*, 11.11% to *Escherichia coli*, and 55.6% to *Citrobacter freundii*. Human and animal wastes are the principal sources of these microbial pollutants in wastewater.

2.1.2 Ocean transportation system

Foreign trade can only function with ocean transportation. It has connected all the nations into one enormous global

market and brought the various regions closer [32]. It doesn't require any money to build or maintain its track because it runs in a natural way, which is the sea. It is the least expensive kind of transportation. There are two main types of Ocean Transportation Systems: Coastal Shipping and Overseas Shipping. It is one of the most crucial modes of transportation for moving commodities across a nation. It is a more efficient and affordable means of transportation that is best suited for transporting big, bulky, and inexpensive cargo to far-off locations, such as coal, iron ore, etc. [33]. But just a small area can be served by it. Previously, foreign maritime firms controlled the majority of the coastal shipping in Nigeria. However, it is presently only available to Nigerian ships as of 2006. There are three types of vessels employed in overseas shipping:

(i) Liners are ships with a set schedule of defined routes, times, and fees. They are typically a fleet or a group of boats owned by the same person. They offer a dependable, uniform service. Whether or not the ships are loaded with cargo, liners leave on scheduled dates and times [34].

(ii) Tramps: Ships with no set routes are called tramps. No established guidelines or fee structures are present. Typically, they wait until they are fully loaded before setting sail. Exporters can charter them, and they are always prepared to set sail. They move slower than liners. Tramps are more suited to transport seasonal and large items [35].

(iii) Tankers are ships explicitly made to transport liquids like oil, gasoline, and other similar substances. They can hold much oil—between 2 and 3 lakh tons—and very soon, supertankers with a capacity of about 10 lakh tons will be available [36].

Onyema et al. [37] examined how the underutilisation of inland waterways impacts the economy of Nigeria. The difficulties preventing inland waterway transportation and their corresponding effects on the Nigerian economy were also critically examined. The Nigerian Inland Waterways Authority (NIWA) and Nigeria Port Authority staff provided the primary data (NPA). Data from 60 respondents who identified constricting variables were analysed using principal component analysis and orthogonal varimax rotation. The null hypothesis was rejected because none of the ideas passed the student t-statistical test's significance test, which was used to determine whether they were statistically significant.

According to Onokala and Olajide [38], Nigeria has a vast network of lakes, lagoons, creeks, and rivers that could serve as the foundation for creating an inland waterway transportation system. The current article examines the country's waterways' level of development into a navigable inland waterway transportation system, the government's and the private sector's roles, the significance of the waterway system in achieving urban and rural transportation goals, and the potential for further development. It concludes that the current state of development of the navigable waterways system is well below what is feasible given Nigeria's large river and creek systems. The underdevelopment of the system is primarily the result of relative neglect. Urban operations could be considerably enhanced. There is only one large city besides Lagos. If properly utilised, Lagos City's extensive network of navigable inland waterways might reduce traffic congestion and pollution on the city's roads while also offering cheap long-distance transportation options. The Ikorodu-Ebutte Ero route is the main subject of this study's analysis of inland water transport services on the Lagos lagoon. Structured questionnaires were used to collect primary data. In

contrast, secondary data were obtained from pertinent public and private organisations. Descriptive approaches, such as frequency counts, tables, and graphs, were used to analyse the data. The findings/results showed that the area has insufficient terminal facilities and vessels. Furthermore, it was discovered that most journeys made by water were mainly for business purposes (67.3%). Low patronage was also noted, and it was determined that this was primarily due to Concerns about passenger safety expressed by 67.4% and 58.7% of respondents, respectively. Furthermore, it was discovered that high-income individuals used this style more frequently than low-income workers. The high frequency of respondents using water transportation (71.3%) suggests that this mode can be broadly adopted, provided the public and private sectors pay more attention to its development. Therefore, the area's water transportation system requires more significant funding for constructing modern infrastructure and vessels. Hydrogen is a well-known important source of supply of sustainable energy options. The transportation industry is one of the most significant fuel consumers in the global energy market. Hydrogen is a prominent and vital source of sustainable energy options. The transportation industry is one of the most considerable fuel consumers in the global energy market.

Acar and Dincer [39] provided reliable, safe, dependable, convenient, user-friendly, and affordable energy. Via the hydrogen as a potential fuel for environmentally friendly transportation. The latest data is utilised in this review to lead a nitty gritty examination concerning the possibility of hydrogen being the fundamental fuel for transportation frameworks. Because of its many distinctive benefits, such as its energy thickness, overflow, simplicity of transportation, and different creation strategies from perfect and sustainable energises with nothing or negligible outflows, hydrogen gives off an impression of being an extraordinary synthetic fuel that might supplant the utilisation of petroleum products in gas-powered motors. Existing motors should be changed to stop bizarre burning before using hydrogen for gas-powered motors. Gas-powered motors that sudden spike in demand for hydrogen can increment framework effectiveness, give more power per vehicle, and produce fewer nursery poisons. Fuel cells that run on hydrogen are less polluting than internal combustion engines, although they are frequently more expensive, bigger, and heavier. Internal combustion engines that run on hydrogen are the subject of this study. It is also highlighted that hydrogen must be efficiently produced from only sustainable raw materials and energy sources if biofuels are to be sustainable and clean. In this review, Frosts that sudden spike in demand for customary, half and half, electric, biofuel, power devices, and hydrogen are additionally analysed, and their CO₂ and SO₂ discharges, the cultural expense of carbon, energy and proficiency, fuel utilisation, cost, and reach are evaluated. At the point when these factors are considered, the examination shows that energy unit vehicles have the best typical presentation rating (4.97/10), trailed by hydrogen-filled Frosts (4.81/10) and biofuel vehicles (4.71/10). However, regarding execution, regular cars come in last (1.21/10), trailed by half and half and electric vehicles (4.24/10 and 4.53/10, separately).

The energy sector, which includes power generation, transportation, industries, buildings, and households, is Nigeria's leading contributor to greenhouse gas (GHG) emissions [40]. In 2016, 77% of all GHG emissions were attributable to the energy sector. The most crucial tool for maintaining adherence to the United Nations Framework

Convention on Climate Change (UNFCCC) in Thailand is its energy rules. Energy efficiency (EE) plans attempt to increase energy efficiency while decreasing the use of fossil fuels. In contrast, renewable energy (RE) plans aim to increase the share of RE in final energy consumption. Between 2015 and 2050, reducing GHG emissions will also have several additional benefits, such as improved energy security and a decline in local air pollution, through using renewable energy sources and improving energy efficiency. The opportunities for homegrown RE and EE tasks to finish Thailand's broadly characterised commitment (NDC) are one of the outcomes. Moreover, it was found that either focus in the Rethink and the EE plan should be accomplished by something like half and 75%, separately, or focuses in the Rethink and the EE plan should be completed by no less than 75% and half, to meet Thailand's most memorable NDC of a 20% GHG discharge decrease focus in 2030. Likewise, a drawn-out assessment of Thailand's lengthy NDC situation in 2050 showed a decrease of 30.4 percent contrasted with BAU. The strategy consequences incorporate advancing energy effectiveness, rushing the take-up of inventive innovation like CCS and sustainable power sources, completing the transmission network for inexhaustible power, drafting biomass sources, and expanding public attention to environmental change.

According to rankings by Ugwoke et al. [41], Nigeria has the biggest economy in Africa and one of the highest rates of economic expansion. On the other hand, a sizeable chunk of the population—roughly 51 per cent of the total, or 96 million people in 2016—lives in utter poverty and is mainly rural. These rural areas comprise a sizable fraction of the population, characterised by underdevelopment and inadequate access to power and current energy services. The clear divide between urban and rural regions best illustrates this harsh reality. Energy availability is an essential tool that may be used to boost sustainable development, improve economic growth, and make great strides in human evolution. A review of the peer-reviewed literature on energy planning, electrification planning, rural electrification, the potential of renewable resources, the impact of energy and electricity access, and policies and reforms is provided in the current work, which also examines the state of research on Nigerian energy access studies. It defines the narrative in earlier literary works and offers a novel course of investigation. This study was made feasible by a thorough, systematic examination of the literature that analysed 90 relevant publications out of 104 papers from the 1978-2019 time periods. According to the report, there is no consensus on a framework that would bring together the current policies and methods for improving Nigeria's access to electricity. The creators of this paper offer a coordinated structure that epitomises a multidisciplinary study and fills in as the establishment for additional examination concerning the conceptualisation of a bound together guide for energy arranging, framework plan, and activity with sustainable power mix designed for upgrading limited energy access in Nigeria.

According to the study of Adewuyi et al. [42], sustainable energy transition is building strong, effective, and efficient energy sectors in a particular nation or region without jeopardising the socio-environmental security in the short- and long-term. As a result, more than a few countries have made excellent efforts or pains to achieve this vital aim by the current energy consumption and supply requirements. Sub-Saharan Africa (SSA) is home to more than half of the world's reported poor people, with a significant portion residing in

Nigeria, the continent's most populated country (up to 400 million). The health of its energy industry significantly influences a nation's social and economic development. Hence, Nigeria and the entire SSA region rely heavily on energy for the Sustainable Development Goals (SDGs) to be realised by the year 2030, as anticipated by the United Nations. Meeting the UN SDGs, this study has emphasised how important it is for Nigeria and other African countries to have an equal right to adopt sustainable energy. Based on the lessons acquired from other developing countries' successful energy transition projects, the reform measures to improve Nigeria's energy sector are addressed, and suitable recommendations are made.

Economic growth and development are both favourably connected with the availability of reliable and ample energy supplies. Elum and Mjimba [43] assessed the Nigeria's renewable energy sub-potential sectors and challenges to address an energy shortfall identified as one of the roadblocks to economic advancement. Two significant conclusions were drawn from the study's examination of several documents: In order to diversify its energy mix, Nigeria has first recognised and evaluated the potential of a range of renewable energy sources. Second, despite the presence of strategies to direct environmentally friendly power improvement drives, these endeavours need to be improved by an absence of regulative help and various primary issues.

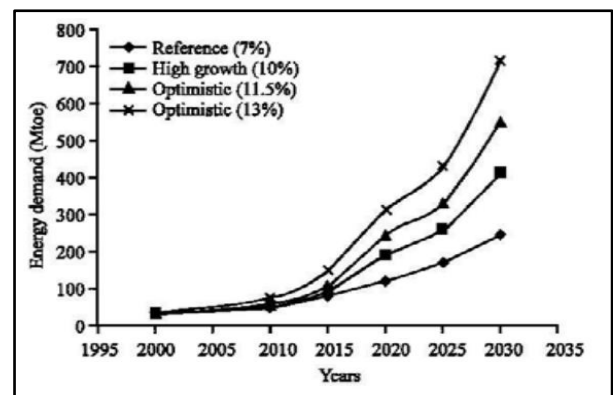


Figure 3. Projected electricity demand between 2000 and 2030

Østergaard et al. [44] investigated the current status of research into the use of renewable energy sources, with a focus on the technologies that do so, the evaluation of the availability of such sources, and the study into the many system types that is capable of using renewable energy. Regarding resources and technologies, salinity gradient technologies, geothermal energy, solar heating, cooling, electricity, and wind and wave energy resources are all assessed. The energy system's performance regarding system integration, impacts, and environmental impact is evaluated. The review or research starts with work presented at the Sustainable Development of Energy, Water and Environmental Systems (SDEWES) conference series, published in Special Issues in several journals. It situates this work from a larger perspective. Energy should be managed similarly to land, labour, and capital because it is an essential production component. Sustainable development is closely related to using energy resources and its projected demands (Figure 3). Increasing the energy efficacy of processes using sustainable energy or power sources is crucial for achieving sustainable improvement. A

sustainable power system uses the resources and networks available locally and is economical, dependable, and ecologically benign. Energy efficiency and conservation initiatives can scan with, guarantee energy access, create jobs, and enable individuals to save money. Additionally, energy efficiency will be crucial in reducing climate change. If energy is used effectively, Nigeria may save up to half of the energy it now consumes. The main issue has been Nigeria's energy policy, which has minimised the benefits of energy efficiency for the environment and economic development. This essay evaluates potential approaches to practical energy usage and conservation methods for sustainable energy development in Nigerian economic sectors [45].

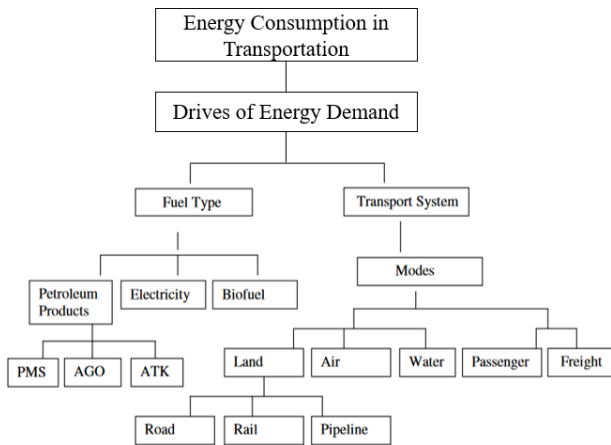


Figure 4. An analysis approach for Nigeria's transportation sector's energy usage

Transportation-related energy use includes the energy used to move a group and produce by pipeline, rail, air, and water [46]. The growth rates of the economy and the population of people who can drive will determine how much energy the transportation sector needs. Economic growth boosts industrial output, which calls for carrying raw resources to built-up facilities and finished goods to consumers. Between 2005 and 2009, Nigeria's consumption of liquid fuels for transportation increased significantly. Light-duty vehicles, buses, aeroplane aeroplanes and passenger trains all use fuels qualified as passenger transportation energy. Fuels utilised in the freight transportation industry are used by large trucks, freight trains, and both domestic and international marine vessels. Among the subjects explored in this essay are the forms of transportation and their energy usage patterns. There is also a discussion of how the country's energy consumption would be affected by the trend in energy use. Additionally, it analyses the nation's share of energy use in the transportation industry and suggests potential improvements. Figure 4 shows Nigeria's transportation sector's analytical approach to energy usage. According to estimates, the transportation sector consumes 6192.18 toes of fossil fuel overall, of which passenger urban accounts for 47% (2915.47 tons), passenger intercity accounts for 30% (1866.44 tons), freight accounts for 18% (1115.26 tons), and miscellaneous accounts for 5% (295 tons). The amount of fossil fuel consumed by cars for urban passenger transportation was 2219.65 toe or roughly 76% of the motor fuel used in urban passenger transportation in 2009. Public buses consumed about 516 tons of fossil fuel in the same year, or roughly 18%, and other vehicles, such as motorbikes, finished 180.24 tons, or approximately 6%. In

2009, 1866 toe of fossil fuels were consumed for intercity passenger transportation. Vehicles consumed 61% (1158.09 tons), buses used 30% (558.49 toes), diesel trains consumed 1% (0.156 toes), and aeroplanes used 8%, according to the percentages used by the various modes (149.68 toes). Figure 5 below also displays the motor fuel consumption by modes of freight transportation and other (miscellaneous, international, etc.) in 2009.

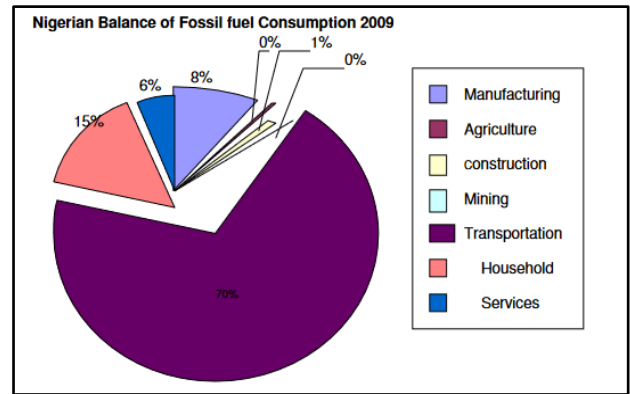


Figure 5. Nigerian sectoral consumption balance for fossil fuels in 2009

Das et al. [47] stated that freshwater scarcity and environmentally harmful electricity generation are two key issues facing isolated islands. The abovementioned challenges can be solved by implementing a 100% renewable energy supply system with regional desalination facilities. It can reduce emissions of pollutants and conserve gasoline. First, this study proposes a desalination plant and concentrated solar power (CSP) facility as part of a wind turbine-based, entirely renewable energy supply system. The flexibility of CSP plants' scheduling is used to supplement wind power generation, and islands' need for battery energy storage is lessened thanks to thermal storage technology. In contrast to the conventional strategy of seeking to reduce the levelized cost of CSP from combinations of limited capacity, an optimal planning model is created to achieve the lowest overall prices of the system using just renewable energy sources. To improve/develop the microgrid's performance, the configurable output capability of CSP is also considered a decision variable. The model generates a mixed integer linear programming problem. The simulation's findings show that the suggested supply system lowers peak load demand while increasing the efficiency of using renewable energy sources, increasing the capacity factors of generation units, and changing the capacity configuration of the generation units. A comparison with existing state-of-the-art systems shows that the suggested method is more cost-effective in areas with abundant renewable energy supplies and high fuel expenses.

2.2 Land transportation

In Nigeria, roads are the primary form of vehicular transportation [48]. Regarding distance travelled, it accounts for more than 90 percent of all passengers and cargo activities, as in passengers' goods from one place to another. Assessing the breadth and calibre of the road network concerning driving is crucial. The federal government has significantly expanded Nigeria's road network scope over the past fifteen years. The efforts of the Directorate of Food, Roads, and Rural

Infrastructure (DIFFRI), which in the late 1980s launched a drive to build over sixty thousand (60,000) kilometres of new rural roads, are one exceptional example [49].

According to Maduekwe et al. [50], "Avoid," "Shift," and "Improve" are effective ways to transform a non-sustainable transportation system into a sustainable one (A-S-I). This study will ascertain whether Lagos, Nigeria's most populous metropolis and commercial hub, could change due to the A-S-I policy or rule actions. The study forecasts future energy demand and greenhouse gas emissions using the Long-Range Energy or Power Alternative Planning (LEAP) mould to assess the optimal A-S-I alternative for the city. We develop a "business as usual" scenario or setup for Lagos and alternative policy scenarios for sustainable road transport. The results show that Lagos's high percentage of elderly vehicles is the major obstacle to the city's goal of cutting emissions. According to our analysis, the vehicle survival rate impacts pollution reduction in Lagos's road transport industry (i.e., the percentage of older vehicles still being driven). The authors conclude that Lagos may not meet its goal of a 50% reduction in emissions by 2032 unless the age restriction for vehicles is lowered from 40 to 22 years, the vehicle growth rate is reduced from 5% to 2%, and mileage increases by 2% from the year 2020 to 2032.

Ogunbodede and Olajide [51] employed effort to analyse Nigeria's urban road transportation system from 1960 to 2006. (46 years). The paper uses an exploratory method to examine and debate relevant issues of interest in the history of the Nigerian road transport system. Despite being freed from colonial rule for 46 years, Nigeria's urban road transport infrastructure could be more effective. To build the network, the study recommended building more motorable roads inside of cities; Since consumers are forced to utilise motorcycles as a form of public transportation in the towns because there are no other options, this practice should be institutionalised. To ensure that its use does not negatively affect commuters' rights to mobility and quality of life, laws governing the restrictions and use of this mode should be developed and monitored. Similarly, the government should create an atmosphere that would guarantee effective and sufficient automobile traffic in cities.

According to Chatziioannou et al. [52], transport networks can enhance a region's economic health and the standard of living for its population by providing the resources necessary for the mobility of people and goods. Yet, several negative externalities could be brought on by transportation projects that would lower people's quality of life, including noise, air and water pollution, barrier effects, and ecological harm. Given these realities, the main objective of this work is to methodologically express the interconnectedness of the negative externalities of travel to assist the advancement of sustainable mobility. In this study, the interrelationships between the negative externalities of transportation are disclosed, arranged hierarchically, and then evaluated regarding the potential of sustainable mobility solutions and the societal benefits they could produce. The results show that the negative externalities of transportation are not discrete phenomena but are connected and can be arranged hierarchically. According to their relationships, they are allowing for the prioritisation of particular public policies and the more effective mitigation of the negative effects of transportation. The most prominent negative externalities include the invasion of public space to construct new roads, traffic bottlenecks, congestion, and local air pollution. The

most important sustainable transportation strategies, however, are those that emphasise urban planning and, more specifically, transit-oriented development.

Alarima et al. [53] examined how the road transportation infrastructure affects the marketing of agricultural products in the Kajola local government region of Oyo state. In order to identify one hundred and sixty (166) rural farmers for the study or research, a multi-stage sampling approach was utilised. Primary data were collected using a pretested questionnaire, and graphic and inferential statistics or data were applied to the data to evaluate it. The findings or results revealed that the respondents' median age was 40.83 years old, and 72.7% were male. Moreover, 91.4% of the respondents grew maize, 89.8% grew tomatoes, 87.5% grew pepper, 79.7% grew yam, 76.6% grew cassava, and 21.9% grew cucumber. 60.2% of farmers use motorcycles to transport their produce through feeder roads from the farm to the market due to the poor state of the streets. Survey respondents say poor road networks lead to decreased agricultural output and a price increase. The correlation study's findings revealed a strong ($p < 0.05$) association ($r = 0.317$) between the marketing of farm products and the method of road transportation. To connect farmers to markets, the research recommends improving present highways and constructing more rural feeder roads.

Abdulhafiz et al. [54] examined the spatial variation in road transport emission concentrations at particular times and their geographical and temporal concentrations (off-peak and peak traffic periods). The ToxiRAE monitor was used to test the levels of carbon monoxide (CO), nitrogen dioxide (NO₂), sulphur dioxide (SO₂), and ammonia, while the MultiRAE plus monitor was utilised to assess volatile organic compounds (VOCs) at various times and locations (NH₃). These instruments were used to measure the ambient concentration of specific gas emissions at the traffic junction corridors in the research region. 10% of the road intersections in the study region (Kawo, Ahmadu Bello Way, Yakubu Gowon Way, Sabo Junction, and NNPC Junction) were chosen as samples for the emission measurement. The findings revealed that carbon monoxide levels were above the 20ppm baseline established by the Federal Environmental Protection Agency, but the other gases (NH₃.889ppm, SO₂.0836ppm, VOCs 1.628ppm, and NO₂.203ppm) did not. The study results highlight the importance of highlighting the potential risks to urban dwellers' health from continuous exposure to these emissions. This demonstrates the necessity for deliberate measures to maintain acceptable safe levels of carbon monoxide from various road transport modalities.

Lasisi and Makinde [55] assessed the rural transportation infrastructure in Ido Local Government Area, Oyo State, and made appropriate recommendations for rural development. The objectives are to determine the various forms of transportation in the study area, assess how much the transportation network contributes to the development of rural communities, and identify the core problems that rural transit in the study area faces. A simple random selection method was utilised in the study to assign 271 questionnaires to participants. The paper is based on the interaction and gravity models. The findings demonstrate that lousy road conditions affect the cost of transferring goods and services, which affects rural inhabitants' income. To manage and maintain rural roads for adequate transportation, the report encourages the Ido Local Government Council to have the necessary resources (money, staff, and equipment). To boost rural development in the study region, the federal and state governments must

undertake various policies and initiatives addressing road restoration. People routinely face several traffic accidents that result in body dislocation and fractures. Any society's transportation infrastructure, which acts as the main artery bridging the numerous parts of society, substantially impacts its political, economic, and social development. As a civilisation grows in population and functional requirements, its various components must interact, which calls for creating dependable transportation systems. The importance of transportation to academics has increased for two main reasons. To begin with, moving is a fundamental human activity with a significant spatial component. Second, it significantly affects the extent to which other social and economic activities are spatially variable (1983, White and Senior).

2.3 Air transportation

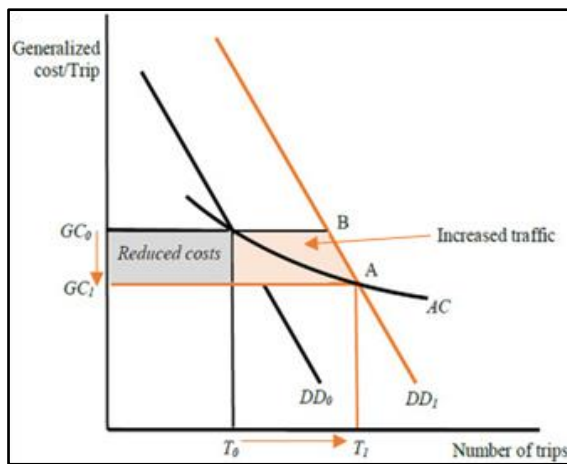


Figure 6. Cost and time savings for transportation in the CBA analytical framework (AC: Average cost)

Air travel may be a critical strategy for promoting economic development. It needs to be clarified whether air travel promotes economic growth or the opposite [56]. Both theories and empirical data support the two points of view. Air travel is crucial for launching development in some nations and regions, for instance, through luring foreign direct investment or facilitating access to lifelines. The demand for air travel is driven by economic growth elsewhere. A practical policy may be developed by understanding and using the information about the direction of causality for nations and areas divided by income level. This study examines the relationship between air travel demand and economic growth in six sub-Saharan African countries between 1981 and 2018. To find long- and short-term causal linkages, vector error correction and autoregression models are used. Their suits suggest numerous context-specific causal links. For South Africa, Nigeria, and Kenya, long-term causality flows from economic growth to demand for air travel; for Ethiopia, it travels in the opposite direction, with higher air travel demand supporting economic growth; however, the association is too weak for Senegal and Angola to infer any causal relationships. This heterogeneity is caused by several reasons, including significant domestic airlines, variances in per capita income, the share of national aviation markets held by low-cost carriers, and comparative geographic advantage as a natural hub. Demand for transportation is increased by several variables, including decreased transportation costs, higher income, the relocation

of businesses (or public services), and modifications to surrounding transportation markets. As traffic volume increases, as seen in Figure 6, the transport demand curve swings to the right (from DD0 to DD1). Increased transport facility capacity and economies of scale will result from this. Therefore, as a result of advancements in transportation, such as new or expanded airports, more flights, new routes, the growth of low-cost carriers, new roads, and intelligent transportation systems, the generalised cost per trip may decline (from GC0 to GC1) and the overall number of trips may rise (from T0 to T1). There are methods to choose the best time to increase capacity and to justify it using cost-benefit analysis (CBA).

Adedoyin et al. [57] investigated the causal and long-term links between air travel and economic growth. The tourism-led growth theory was tested for the US from 1981 to 2017 and includes information and communication technologies (ICTs) and coal rents. This paper presents a novel strategy for future research by considering the relevance of the fourth industrial revolution (Industry 4.0), particularly in the US. To substantiate its claim, this study considers how ICTs alter the impact of FDI on GDP as additional explanatory factors. The empirical finding supports a relationship between the Industry 4.0 era and the function of ICTs in fostering significant changes in the way of life. This has resulted in a significant technological advance comparable to but moving more quickly than the technical development of earlier revolutions. The paper offers pertinent policy recommendations based on empirical findings about how natural resources, new technologies, and tourism affect US GDP. It also proves the advantages of ICTs over FDI in the Industry 4.0 era.

Until now, most research on the growth and effects of air travel has been conducted in wealthy nations, and less developed countries in the Global South receive comparatively little attention compared to the Global North. This disparity is addressed by the seven studies that make up this Special Issue of the Journal of Transport Geography, as well as dodging further research into the expansion of air travel in the Global South [58]. Recent developments in the Global South's air transportation networks and rules have essential ramifications for regional development, economic growth, and airline business plans. This Special Issue looks at some of the challenges that countries in Africa, South America, the Middle East, and Asia are facing as air travel in the Global South develops. Additionally, it looks at the links between aviation and economic growth, the rise of low-cost carriers, the development of the sector as a whole, its primary drivers, and the dispersion of passenger airline networks in space. It also identifies prospective topics in this developing discipline for additional research.

Olapoju [59] studied the impact of various transit strategies on the arrival and dissemination of the 1918–19 influenza virus and the newly discovered COVID–19 coronavirus in Nigeria. The research examines the methods employed to introduce the two pandemics into the country and the contributions made by those modes of transportation to the local transmission of the epidemics over each period. The study found that although seaports and railroads, the country's newly constructed modes of transportation, air travel was essential for the importation of the current COVID-19 pandemic, just as they were vital for the importation and local spread of 1918-19 influenza, respectively. The government's efforts to support the aviation sector in the wake of the coronavirus disease (COVID-19) epidemic are assessed from

two perspectives in this essay. It starts by looking at the elements that affect how ready governments are to support airlines. The various assistance options and how country-specific considerations impact the choice of actions are next covered. Next, it looks at how government support has affected three critical aspects of air transport policy: airline ownership and control, competition and liberalisation, and environmental sustainability. According to the report by Abate et al. [60], sustaining air transport connections is a top priority for most governments to preserve economic activity, jobs, and related industries like tourism. After the COVID-19 breakout, maintaining connectivity and competitiveness has been challenging for various political and economic reasons. The pandemic-induced shift in public policy may have diminished the relative weight of the policy priorities that influenced the expansion of the aviation industry previous to the crisis, especially those about climate change and the environment. The involvement of government and public authorities at all levels, particularly the type and duration of measures influencing transportation operations, will significantly impact the aviation industry's future expansion.

Ejem et al. [61] proposed a multi-dimensional user-oriented performance metrics technique for assessing the performance of the terminal airspace system to support airport and airspace planning and decision-making. The analytical approach is supported by predictability, safety, and delay metrics. According to the research, air incidents are more likely to occur during the flight's take-off and landing phases and are more likely to happen in the radar room. Many of these incidents were caused by malfunctioning equipment or the inadequacy of the airspace infrastructure as a whole. Also, there needs to be a better correlation between the amount of traffic complexity and the frequency of mishaps in the Lagos terminal airspace. Overall schedule arrival delays range from 1 to 392 minutes, or 7.8 to 17.9 minutes per aircraft, during that time. Also, the total duration of the approach contact is 1 to 57 minutes or 4.6 to 7.1 minutes per aircraft. However, the time gap between the reported airline arrival schedule and the actual arrival time is often between 1 and 5 minutes. Similarly, regular aircraft approach contact periods are within 1 to 5 minutes. Another source of data on departure time variations above 30 minutes is the ATC clearance time for the various routes under investigation. However, estimating departure times from when ATC approval was obtained may not be precise because there is a 25% or more significant variation of more than 15 minutes. Most importantly, departure times at the Lagos airport are less reliable than arrival ones. This could indicate a problem with Lagos airport's air traffic control or crowded skies if interpreted literally. This demonstrates that consumers need more confidence in Nigeria's aviation industry to deliver just-in-time service.

In this study, Bouraima et al. [62] analysed the development plan for the West African Economic and Monetary Union's railway transportation infrastructure. Rail transportation is crucial to any country's economy. The region's severe infrastructure deficit, however, presents a problem. Through a questionnaire study of the central and controlling authorities of several countries, fourteen SWOT elements were discovered. The priority variables were assessed and employed in developing plans using a collective SWOT medium and analytical hierarchy process (AHP). The study's findings indicate that road competition and sporadic state involvement are the primary threats. The infrastructure's age, lack of functionality, and persistent lack of funding are the

most significant disadvantages of their sources. Additionally, the findings demonstrated that while future market expansion represents an enormous opportunity, large-capacity rail transportation over considerable distances represents a critical strength. Initiatives that will aid the governments in advancing regional integration, bolstering intraregional trade, balancing national and regional development, and significantly reducing poverty have been based on the findings. SWOT analysis: strengths, weaknesses, opportunities, and threats, as well as the analytical hierarchy process (AHP), as shown in Figure 7.

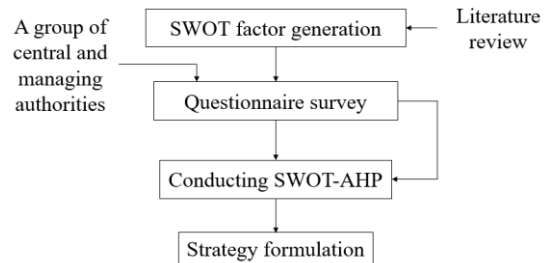


Figure 7. SWOT-AHP execution methodology for the paper review

According to Higgoda and Madurapperuma [63], it is widely known that air travel helps both industrialised and developing countries' economies advance. Thus, employing air travel is a policy tool to promote economic growth. Air travel supports the country's economy and long-term economic prosperity through trade and tourism. However, this occurrence has received comparatively little study. Objectives: This study set out to analyse the rapport between aviation and profitable expansion and examine the aviation-centric growth hypothesis for Sri Lanka. This study used Granger's causality tests after applying Johansen cointegration test methods to time series data collected over 37 years (1983–2019). Results: The study's conclusions show no consistent relationship between air travel and Sri Lanka's economic growth. The results do, however, suggest a short-run unidirectional Granger causation linking total passenger movements to economic expansion. Conclusion: The results indicate that air travel does not significantly contribute to developing Sri Lanka's economic growth, refuting the aviation-centric growth theory. Additionally, the government and policymakers would be guided by the unidirectional causality between economic growth and air travel and the acknowledged time lags of two to three years in managing resources and allocating them effectively for the sectors that speed up the Nigerian economic growth.

According to Akindoju [64], Nigeria's interest in homegrown air travel was pattern examined utilising yearly traveller interest from 2010 to 2017. Utilising Conventional Least Square (OLS) relapse, Nigeria's interest in homegrown air travel was conjectured for over twelve years (2018 to 2030). The estimate contrasted with Nigeria's homegrown air travel interest between 2010 and 2017. The interest in homegrown air a trip in Nigeria has varied on occasion somewhere in the range of 2010 and 2017, as most consider it normal to affect conjectures for homegrown air travel significantly. Notwithstanding the expectation that homegrown air traveller requests will decrease from now on and the way that the gauge is questionable and, in this way, uncertain, as displayed in the estimations, government offices ought to be delicate to the conjecture and attempt to take on

new approaches and methodologies that will work on the interest for homegrown air traveller travel in Nigeria [65]. Over the past twenty years, Nigeria's civil aviation industry has experienced enormous growth. This sector's vast growth is a byproduct of globalisation. We are all aware that most advancement has a price tag. In Nigeria, where there are hundreds of thousands of consumers, the fundamental rights of those who use air transportation are routinely violated. For these reasons, it is necessary to examine the numerous consumer protection laws, the legal framework established by the Nigerian government to safeguard the rights of persons who use air transportation services, and how the application of these laws affects the aviation sector. Consequently, a study of our fundamental jurisprudential statutes, such as the Consumer Protection Council (CPC) Act 2004. The Warsaw Convention of 1929, the Montreal Convention (on the carriage of goods and persons by air) of 1999, the Nigerian Civil Aviation Act of 2006, and the Nigerian Civil Aviation Regulations of 2015, and the degree to which these laws have an impact on the consumer protection framework for Nigeria's aviation industry.

2.4 Electric vehicle

Ten years ago, there was a critical development in how much insightful exploration on the subject of electric vehicles, yet there have yet to be any extensive examinations that combine and coordinate these discoveries. Kumar and Alok [66] utilised an incorporated survey strategy using an integrative audit process, including a coordinated appraisal of 239 articles aggregated from diaries distributed during the Scopus Q1 period. The five principal factors remembered for this investigation are socio-socioeconomics, arbiters, arbitrators, outcomes, and the go-between-between-siew approach, which prompted many exciting revelations about research strategies and neighbourhood progressions. The audit features unstudied viewpoints like showroom experience, charging framework flexibility, advertising methodologies, and widely explored ones like setting foundation improvement, the complete expense of possession, and buy-based motivating force plans. Also, it enlightens the components supporting the reception of electric vehicles by featuring significant go-betweens and modifiers. The outcomes would be necessary to the two researchers and policymakers as few previous assessments have simultaneously and thoroughly investigated all maintainable result factors. Improving an extensive nomological organisation of electric vehicle reception gave our review another viewpoint. Partners have a great deal of data to assess electric portability because of the section's explicit key strategy proposals.

Zhao et al. [67] investigated the energy usage and comparable emissions for electric cars (EV). This research offers a practical and scientific way of creating a representative driving cycle for EVs. To design a test route, it is necessary first to assess the topology and traffic flow of the roads in Xi'an. The onboard and pursuit car technologies are combined in an integrated strategy to acquire data on vehicle driving habits. Data on speed and acceleration are divided into micro-states using the velocity-acceleration (V-A) grid method. Third, the suggested driving cycle design methodology includes the Markov chain and Monte Carlo (MCMC) simulation approach. After that, the most representative driving cycle is eliminated using a filtering

procedure. The designed EV driving cycle is correct, and estimating the EV's energy consumption per kilometre, driving range, and comparable emissions under official driving cycles yields astronomical relative errors, according to a simulation and test data comparison. Therefore, real-world driving cycles for particular cities or regions must assess EVs' energy consumption, driving range, and equivalent emissions.

According to Das et al. [47], renewable energy sources and electric vehicles are being developed as synergistic intelligent grid applications. Smart electric car charging and vehicle-to-grid technologies are viewed in this context as a way to gain economic, technological, and environmental benefits. The support of the purchaser of electricity, the owner of a stimulating car, the system operator, and decision-makers is necessary for deploying these technologies. These parties involved seek various, occasionally at odds goals. Multi-objective, technological, economic, and environmental optimisation is put out in this study as a method for planning out the charging and discharging of stimulating vehicles, the energy usage costs, for the first time, in the context of a residential micro-grid, battery deterioration, grid interaction, and CO₂ emissions are predicted and simultaneously optimised while supplying frequency management. Compared to uncontrolled electric car charging, the suggested strategy reduces energy costs, battery deterioration, and grid utilisation by 90%, 67%, 34%, and 88.2%, respectively, as did CO₂ emissions. To promote participation in energy services and achieve a 41.8% increase in grid utilisation, the system operator also needs to compensate the end-user of electricity and the owner of an electric car for their respective benefit losses of 27.34% and 9.7%.

According to Yao et al. [68], Electric Buses (EBs) must be efficiently scheduled for a range of vehicle types for public transportation to be sustainable. Based on a predetermined multi-vehicle-type timetable, this paper suggests a new solution for the electric vehicle scheduling problem with multiple vehicle types (MVT-E-VSP) in public transit. The first step is developing an optimisation model that explicitly considers changes in the driving range, recharging time, and energy consumption of EBs for different vehicle types. This optimisation model seeks to lower annual total scheduling costs, including EB and charger fees and operating costs for deadheading, timetabled trips, etc. Next, the optimal solution uses a heuristic approach that considers charging trips and replacing various electric vehicle (EV) types. The optimisation result provides transportation authorities with advice on how to set up fees and when and where to purchase EBs for various vehicle types. The proposed technique, which considers EV-type replacement, reduces annual overall scheduling expenses by 15.93% compared to the conventional approach, according to comparative research.

The results from the awareness investigation of the study conducted by Zhang et al. [69] show that the current releasing profundity (80%) and re-energizing power (240 kW) are monetarily feasible. The essential variables influencing EV charging load demonstrating and determining are the movement propensities for EV clients and the precision of their likelihood appropriation models. Most of the prior examinations depended on trip information for a scope of populaces yet disregarded the impact of individuals' social qualities on their movement conduct, which brings down the exactness of the charging load model. This study proposes an upgraded EV charging load reenactment approach that records for individuals' segment and social attributes, like orientation,

age, and instructive fulfilment, to exhibit how the day-to-day EV charging burden profiles fluctuate of the different parts and social qualities. To work on the precision of fitting individuals, travel designs, new probabilistic models with various characterised spatial-worldly factors are first made (for example, area, day type, and so on.). Second, extra factors (such as charging inclination, power utilisation rate, and so on) are considered to reenact the day-to-day profile of EV charging load, utilising the updated probabilistic models and Monte Carlo strategy. The Public Family Travel Review information is used to approve the recommended method. The discoveries show that the size and busy time of the EV charging load profile is fundamentally impacted by the client's segment and social qualities, especially those connected with typical business days and the working environment.

The suggested probabilistic models can expand the accuracy of information fitting and reenactments of charging loads [70]. The fame of electric vehicles (EVs) has developed throughout recent years as innovation has progressed and costs have diminished. Furthermore, support for clean transportation has helped the accessibility of charging stations and empowered EV reception. Appropriately, a significant group of writing has been composed that looks at various EV-related points, remembering their capability for the transportation and energy areas. This article offers an exhaustive and convenient examination of logical investigations looking at different EV-related subjects, including:

- a. a market outline of light-obligation EVs and current reception projections.
- b. market open doors past light-obligation EVs.
- c. a survey of the expense and execution development for batteries, power hardware, and electric machines, which are vital to the progress of EVs.
- d. the condition of the framework for charging, with an emphasis on examinations and models utilised to conjecture the requirement for a foundation for charging and the financial matters of public charging.
- e. an outline of the impacts of EV charging on power frameworks at different scales, from mass power frameworks to dissemination organisations.
- f. insights into investigations of life-cycle expenses and emanations that explicitly centre around EVs and
- g. expectations for the future and how EVs will cooperate with other arising patterns and mechanical headways.

This paper gives peruses an outline of the cutting edge at the time it was composed and assists them with exploring this enormous writing by dissecting and cautiously contrasting investigations and incorporating general comments. This in-depth analysis provides a positive picture for EV use in on-road mobility; by gradually addressing remaining technological, legislative, sociological, behavioural, and business model issues, a shift to cleaner, more efficient, and inexpensive transportation solutions for everyone can be encouraged.

According to Lü et al. [71], the fuel cell-powered hybrid electric vehicle is the most practical solution given the severe lack of fossil fuels and environmental problems. The answer to this issue is the development of electric vehicles powered by clean new energy. Numerous academics have discovered that the hybrid system's output performance is key in determining the fuel cell's lifespan. The unreasonable output will impact the drive system's control characteristics, which will have several adverse effects, including a shorter lifespan

in favour of the energy unit mixture control method. Therefore, the energy management strategy and performance optimisation are essential to ensure the hybrid system's smooth operation. Many outstanding researchers have currently conducted pertinent studies in this area. A heuristic approach with superior optimisation performance is the genetic algorithm. According to the optimisation objectives, it can quickly select satisfactory solutions and compensate for these drawbacks by employing its traits. Genetic algorithms benefit significantly from these characteristics while iteratively optimising an energy management strategy. To assess and choose the optimisation rules and parameters, optimisation objects, and optimisation targets, this study analyses and condenses the optimisation impact of genetic algorithms in various energy management strategies. This article offers recommendations for the finest structural and control designs for fuel cell hybrid power systems and additional suggestions for optimising energy management in the future. Additionally, it advances the study of prolonging the fuel cell's lifespan and improving the fuel cell hybrid power system's energy use efficiency.

These days, lithium-ion batteries (LIBs), whose cost and performance have substantially increased, are the primary technology for electrical energy storage [72]. Li-ion batteries with well-proven battery chemistries and cell architectures (LIBs) may have good power and energy density. Still, they are likely to only meet some of the performance, cost, and scaling requirements for energy storage, especially in large-scale applications like electrified transportation and grids. The development of so-called "beyond Li-ion" technologies has been sped up by the goal of further lowering cost, improving energy density, and the growing concern over the demand for natural resources for Li-ion. This overview will cover multivalent and lithium batteries and four critical "beyond Li-ion" technologies: Na-ion batteries, K-ion batteries, and all-solid-state batteries. The science behind each technology's difficulties and potential solutions is thoroughly examined to achieve the aims of a low-cost and high-energy-density future. Even though it is doubtful that any new technology will completely replace Li-ion soon, "beyond Li-ion" technologies should be viewed as chances for energy storage to grow into mid- to large-scale applications.

Notwithstanding, this high-energy battery's fire chance and danger have become a top issue for EV security [73]. The appraisal's principal concern is the latest dangers presented by EV fires, especially warm control and fire in Li-particle batteries. Outrageous utilisation conditions, which might be welcomed by breaking down activity or fender benders, could bring warmth out of control or fire. At the point when a battery kicks the bucket, possibly risky gas, fire, blast, and fly flares could be in every way delivered. Battery fire in battery EVs, crossover EVs, and electric transports will be contemplated. This study offers a subjective comprehension of EVs' dangers, fire risks, and the sudden spike in battery demand. Analysed are vast parts of a battery fire tested and seen in different EV fire situations. At the point when PHRR=2E0.6B, the deliberate pinnacle heat discharge rate (PHHR in MW) differs from LIBs' energy limit (EB in Wh). Restricted information has shown that an EV fire's intensity delivery and risk are equivalent to a non-renewable energy source vehicle fire for the full-scale EV fire test. It is more challenging to extinguish an EV fire once the locally available battery has set fire since the consuming battery pack inside is distant to a remotely applied silencer and can re-light without sufficient cooling. It

takes that much concealment specialist to cool the battery, put out the fire, and hold it back from the beginning again. By resolving these issues, this survey means to help specialists in batteries, electric vehicles (EVs), and fire well-being design. Also, it needs to animate more noteworthy innovative work into impending upgrades to the overall well-being of EVs. Society will only become adjusted to Evs once it has been acclimated with customary vehicles, and really at that time.

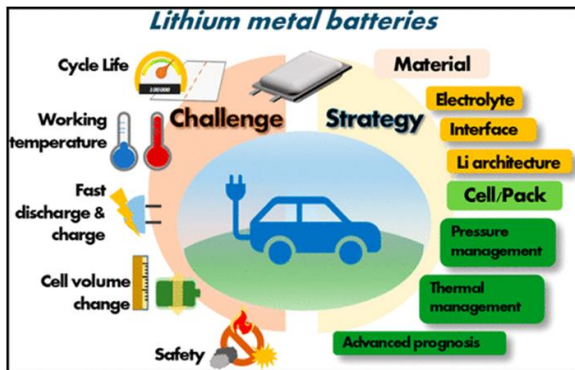


Figure 8. Lithium metal batteries

Chen et al. [74] mention that lithium-metal batteries are far superior to modern lithium-ion batteries regarding energy content and price. It creates a variety of future opportunities for long-range and inexpensive electric automobiles. The automobile sector has tight criteria for some battery cell characteristics, such as cycle life, working temperature range, capability to discharge and recharge quickly, volume change, safety, etc. In this Focus Review, we examine the requirements and challenges of high-energy-density lithium metal batteries for prospective electrical vehicle applications (Figure 8) and some significant recent advancements in these areas. Our main goal is to pinpoint effective solutions for these problems to spur additional research and development work and hasten the use of lithium metal batteries in real applications.

According to Hoang et al. [75], the Coronavirus pandemic considered an overall crisis, has guaranteed various lives and jeopardised livelihoods and business ventures. Especially

under extreme strain because of the pandemic in the energy area. The production of feasible assets and a foundation for environmentally friendly power has been demonstrated to be a promising and fruitful answer for such a difficulty. Transient strategy needs should be flexible, while mid-term and long-haul activity plans ought to be created to accomplish the characterised environmentally friendly power targets and move towards a more reasonable energy future to address the effect of Coronavirus on sustainable power improvement systems satisfactorily. The Coronavirus pandemic's chances, challenges, and critical impact on current and future feasible energy methodologies were analysed exhaustively in this audit. Strategy suggestions on the direction of economic energy were likewise referenced [76] alongside leanings from distinguishing sensible ways of behaving and arranging suitable activities. The genuine inquiry is whether the Coronavirus pandemic will kill us or give us a treasured example of creating environmentally friendly power from now on. As an overall well-being crisis, the Coronavirus pandemic adversely affects the world economy, especially the energy area. Individual vehicles and other essential transportation methods have been fundamentally shortened because of control endeavours, remembering boycotts for all movements put something aside for important outings [77]. The end of worldwide boundaries, the change to remote learning and business, and so on because of the lower generally speaking interest, which was evident in the diminished result from atomic offices in Europe and the US during the principal quarter of 2020, the degree of energy creation has been definitely brought down Figure 9(a-b). Moreover, Figures 9(c) and 9(d) showed a prominent decrease in the worldwide interest in coal and oil. Specialists have noticed the predictable ascent in environmentally friendly power utilisation throughout recent years (i.e., by as much as 1.5%) because of the development of new wind and sun-based offices regardless of the further decrease in worldwide energy interest (Figure 9(e)) [78]. The extent of sustainable assets on the planet's power age blend has persistently expanded thanks to enormous commitments from the EU, US, China, Japan, Southeast Asia, and Africa.

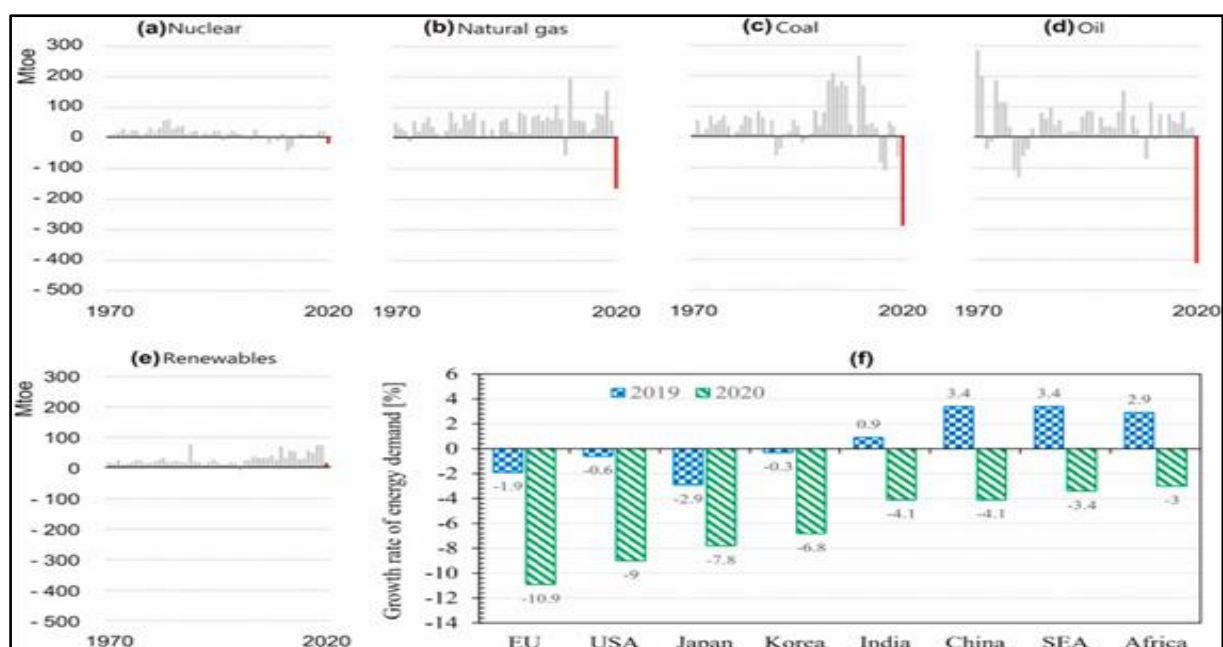


Figure 9. The analysis of four energy sources, nuclear, natural gas, coal and oil, for eight nations

The Worldwide Energy Survey in 2020 shows the adjustment of the world's energy interest by fuel from 1970 to 2020 contrasted with the Second Great War (even pattern relating to nothing); the red vertical line addresses the world's energy interest in 2020 [79]. Figure 9(f) shows the development paces of the energy interest for specific countries and locales in 2020 contrasted with 2019. (The peruse is coordinated to the Internet adaptation of this article to translate the references to variety here.

Oyekale et al. [80] provide a concise overview of the real-world effects of grid integration of renewable energy sources on the performance of power networks, as well as commonly used cutting-edge solution approaches. Solar, wind, biomass, and geothermal energy are among the renewable energy sources being concentrated on. Renewable hydrogen and fuel cells are also crucial for long-term energy sustainability, although not being strictly considered renewable energy sources. Although some global energy outlooks have stated that renewable energy sources already exist enough to meet the world's energy needs in multiples of thousands, the various difficulties frequently involved with practical exploitation have rendered this claim untrue. Therefore, the nature of these issues and workable solution techniques must be synthesised through more research, which is why this review study is necessary. First, quick summaries of each investigated renewable energy source are included. Then, concerning power grid integration, difficulties and associated solution techniques at the generation phase are discussed. Then, issues and standard resolution methods at the grid/electrical interface are covered for each renewable resource. At last, proficient decisions are given, including various sayings from the survey concentrating on that feature information holes nearby and could act as an aide for future exploration. These sentiments underline the essential jobs that sustainable hydrogen will play in future energy frameworks, the need for multi-sectoral coupling, especially by empowering the utilisation of electric vehicles and coordinating them with inexhaustible based power lattices, the requirement for more affordable energy stockpiling gadgets, which could be accomplished by involving disposed of electric vehicle batteries for electrical capacity, and by propelling the improvement of cutting edge nuclear power stockpiling frameworks. Table 2 summarises the creation of force overall from different sustainable power sources, with figures up to 2040 given expressed arrangements that other partners have consented to execute.

Table 2. Use of renewable energy for electricity production worldwide

Generation by Resource Type	2000	2018	2030	2040
Hydro	2613	4203	5255	6098
Bioenergy	164	636	1085	1459
Wind	31	1265	3317	5226
Solar PV	1	592	2562	4705
Geothermal	52	90	182	316
CSP	1	12	67	196
Marine	1	1	10	49
Renewable electricity generation (TWh)	2863	6799	12,479	18,049
Share of total electricity generation	19%	26%	37%	44%

According to Al-Shetwi [81], the monstrous economic and green worldwide energy change is fundamentally affected by

the continuous expansion in worldwide energy interest and the related natural impacts. Besides, the electrical power industry is critical to carbon dioxide discharges. Subsequently, the mix of sustainable power (RE) into the power framework has recently gotten a ton of monetary, ecological, and specialised consideration. Even though it is believed to be less harmful than power created from petroleum derivatives, RE can adversely affect the climate. It could likewise bring about functional, social, and specialised issues. Accordingly, additional consideration and legitimate protections are expected to be followed. Known as the new skyscraper in RE use and its proceeding with impacts on the worldwide energy or power industry, breaking down what it will mean for the climate and manageable turn of events is essential. This study expects to portray how the RE mix upholds supportable turn of events. The latest worldwide pattern in combining different RE into the power area is given alongside an ongoing examination. Every RE source's adverse outcomes are painstakingly thought of, as well as the job and impacts of this elevated degree of incorporation on the environment. These issues incorporate specialised and functional ones (like voltage soundness, recurrence steadiness, and power quality), mixed strategy and guidelines issues, RE natural worries, asset problems of determination and area, and social ones. They are entirely surveyed, examined, and broken down in this paper. From 2010 to 2021, a survey of the writing was finished. All through this strategy, 712 distributions were sorted, and 177 papers were sifted for an introductory survey or examination. The report's assessment uncovered that RE coordination had developed and enjoyed various benefits. However, more accentuation should be given to decreasing its adverse consequences because new troubles have, as of late, arisen. To empower future examinations to distinguish the essential answers for green and feasible energy, the new issues brought on by the development of the RE age and its association with the electric lattice were counted. Ultimately, the review gives ideas for future examination headings toward a manageable power framework.

According to Akram et al. [82], clean and energy-efficient energy sources must be used if greenhouse gas emissions are to be reduced. The study examines the various impacts of energy efficiency (EE), renewable energy (RE), and other variables on carbon emissions in 66 developing countries between 1990 and 2014 within the context of the environment Kuznets curve (EKC) hypothesis. This study considers EE's role in creating the EKC theory, which was disregarded in earlier studies. Using panel ordinary least squares and fixed-effect panel quantile regression (PQR), we find that the effects of the significant factors affecting emissions vary across different quantiles. In particular, EE lowers emissions at all quantiles, but the 90th quantile has the most considerable mitigation effect. Using nuclear energy reduces emissions, but only at the 50th quantile does it have a meaningful impact on carbon emissions. GDP (Y) causes an increase in emissions, but at higher quantiles, Y's rising influence becomes more pronounced. When the square of GDP reduces emissions, the most significant mitigating effect is visible at the highest quantiles. The quantile coefficients of Y and, which are highly positive and negative, respectively, support the existence of the EKC hypothesis in emerging countries. Finally, EE and RE contribute to reducing carbon emissions in underdeveloped countries. In addition to confirming the significance of EE in the evolution of the EKC hypothesis in developing countries, our findings offer some critical recommendations for creating

and implementing efficient economic and energy policies in these countries to achieve environmental sustainability.

Furthermore, Ugwu et al. [83] say that due to fossil fuels' threat to human survival, several nations have shifted their attention to renewable energy sources to minimise greenhouse gas emissions and halt the ozone layer's thinning. This has led to a growth in the use of renewable energy sources, such as hydro, biomass, solar, geothermal, and wind, in many wealthy nations. Yet, most African countries have not realised this new reality or truth. This work or research presents a thorough analysis of the renewable (RE) energy or power capacity that is currently available in Nigeria, the utilisation of renewable energy in Nigeria relative to other nations, comparisons of renewable (RE) energy or power scenarios among African countries, factors impeding the development of renewable energy in Nigeria, the nation's stance on renewable (RE) energy or power and strategies to raise awareness of it there. The best papers from an extensive collection of grey literature and peer-reviewed journal publications were chosen for review. A questionnaire was also used to get opinions from people around the nation and abroad regarding the use of renewable energy in Nigeria. It has been discovered that Nigeria has a wealth of diverse renewable energy sources. However, because of various circumstances, including the non-implementation of renewable energy legislation, financial or fiscal difficulties, unfriendly government policies, and a lack of sufficient research, the level of use has been relatively low. Nigeria installed renewable energy capacity in 2019 compared to South Africa, Kenya, Egypt, and Morocco (IRENA S., 2020). Figure 10 shows that Nigeria, with a total

installed capacity of 2152 MW in 2019, is still falling short of other African nations like South Africa, Kenya, Egypt, and Morocco, which have established abilities of 6167 MW, 2179 MW, 5973 MW, and 3267 MW, in that order. Nigeria outperformed South Africa, Kenya, and Morocco in terms of installed hydropower capacity that same year with 2111 MW.

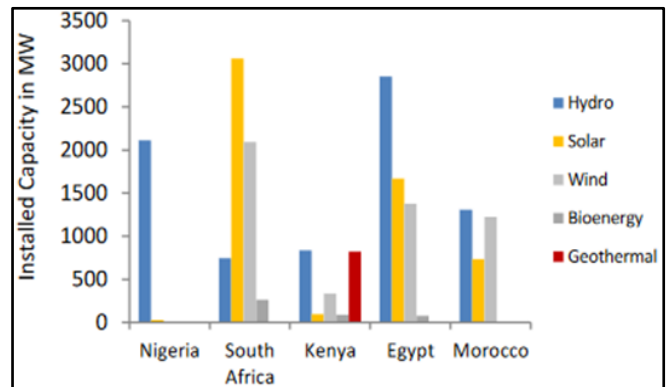


Figure 10. The installed capacity of Nigeria, South Africa, Kenya, Egypt, and Morocco is compared graphically for 2019

However, compared to other countries under study, other sources such as solar, wind, bioenergy, and geothermal experienced little to no increase in capacity. Therefore, Table 3 summarises the literature regarding the significant effects of renewable energy on transportation in Nigeria.

Table 3. Summary of Selected Studies of renewable energy supply in transportation system

Authors Details	Area of Implementation	Classification of the Renewable Energy	Findings
Lund [84]	Renewable energy strategies for sustainable development.	The perspective of renewable energy (wind, solar, wave, and biomass) in formulating plans for sustainable development is discussed in this study. Such methods typically require three significant technological changes: energy savings on the demand side, increased energy production efficiency, and substitution fossil fuels with diverse renewable energy sources.	This article uses the example of Denmark to explore the challenges and opportunities of transforming the current energy systems into a 100% renewable energy system. This advancement is, therefore, predicted to be feasible. The required renewable energy sources are already available, and a renewable energy system might be established with future technology advancements in the energy sector. Adopting flexible energy system technologies and technology for transforming the transportation industry is particularly important. Investigate the current energy structure and analyse potential future sustainable energy policies. A simulation model for Hong Kong's energy system is constructed in this article. First, a reference model is created and verified using data from 2009. Three possibilities are secondarily modelled. We propose and simulate the BAU (business as usual) scenario for Hong Kong's energy system in 2020.
Ma et al. [85]	An energy system model for Hong Kong in 2020. <i>Energy</i> , 68, 301-310.	Hong Kong is forced to transition from a fossil fuel-based to a clean and low-carbon energy framework for climate change and energy security.	The study examines the potential for alternative energy sources in the worldwide power industry and the prospects for the growth of the global energy sector. We identify the directions and potential for using alternative energy sources and the potential to accelerate the development of alternative energy to diversify the energy supply.
Dyatlov et al. [86]	Prospects for alternative energy sources in the global energy sector.	The report analyses the production and transportation of oil and gas (natural, liquefied, and shale) during the next several years. We outline the prerequisites and critical elements for ensuring energy security and eradicating energy poverty in national economies.	One main objective of this study is to determine the jobs created in the renewable energy sector while assessing the impacts of local clean energy production. The selected methodology
Blanco et al. [87]	Evaluation of the renewable energy plan's effects on regional	A broad objective outlined in the Renewable Energy Plan for 2011 through 2020 is to ensure that at least 20% of final energy consumption in 2020 will come	

Authors Details	Area of Implementation	Classification of the Renewable Energy	Findings
Østergaard et al. [44]	production and employment in Spain. Sustainable development using renewable energy technology.	from renewable sources, with a minimum contribution of 10% for transportation. Wind and wave energy resources, wind technology, geothermal energy, solar heating, cooling, electricity, and salinity gradient technologies, are assessed in terms of technologies and resources.	was the shift-share analysis, which researchers often use to evaluate territorial disparities. This article offers a review of the state of research into the use of renewable energy sources, with a particular emphasis on the technologies that do so, the assessment of the availability of such authorities, and the research into the different kinds of systems that can incorporate renewable energy sources. The World Health Organization claims that COVID-19 has put the health of vulnerable populations, particularly older people, in grave danger. There is still some debate regarding the origin of the virus and its intermediate host. However, due to the disease's growth, most nations now impose stringent curfews and shutter most commercial and recreational areas. This study aims to demonstrate the potential advantages of COVID-19 for the environment and the expansion of renewable energy production in Malaysia.
Naderipour et al. [88]	Effect of COVID-19 virus on reducing GHG emission and increasing energy generated by renewable energy sources	The global impact of the 2019 coronavirus (COVID-19) on human mortality rates and economic development in the modern era.	Electric mobility and renewable energy are the pillars of the modern transition by 2050. This transition necessitates adaptation to accommodate demographic and economic expansion while reducing pollution and traffic congestion. The contemporary world requires infrastructure and services that are accessible, safe, inclusive, sustainable, and focused on the demands of the customer. To achieve its goal of a long-term transition to a low-carbon economy, the road transportation sector must undergo a significant fundamental change.
Lakshmi Priyadarsini and Suresh [89]	Renewable Energy Generation and Impacts on E-Mobility.	This essay discusses renewable energy production and how it affects electric vehicles.	To better understand what this Strategy meant in terms of the kinds and numbers of renewable energy (RE) systems that would need to be installed, as well as the support systems that would need to be put in place to make this possible, the project's goal was to do further research.
Oniszk-Popławska et al. [90]	Renewable-energy developments in Poland to 2020.	The "Development Strategy for Renewables" in Poland, approved by the Council of Ministers in 2000 and the Parliament in 2001, set development goals for renewable energy of 7.5% in 2010 and 14% in 2020, respectively.	Only 7.8% of Ecuador's energy comes from renewable sources, with fossil fuels comprising most of the country's energy mix. According to the scenario analysis, Ecuador would expand its energy sector sustainably by following the lead of global renewable energy regulations. The nation's biggest problem is reducing its reliance on fossil fuels and decentralising the electrical industry away from thermoelectric facilities.
Arroyo M. and Miguel [91]	Renewable energies' role in sustainable energy governance and environmental policies for mitigating climate change in Ecuador.	This article compares Ecuador's energy governance practices regarding renewable energy sources. Utilising renewable energy sources improves energy security and helps nations meet their objectives for climate mitigation.	The hybrid fuel station (HFS) is described in this article as a fuel source for electric and natural gas automobiles. We include an energy hub and provide a detailed explanation of the architecture and parts. Renewable energy sources (RESs), a power-to-gas unit (P2G), a natural gas distributed generator (NGDG), an energy storage device, a compressor, and a gas storage device are all included in the planned HFS's configuration.
Faridpak et al. [92]	Toward small scale renewable energy hub-based hybrid fuel stations: Appraising structure and scheduling.	The portfolio of road cars has seen a fast shift in recent years. Fuel stations need to be redesigned to enable this shift. Adapting the current infrastructure to provide different vehicle kinds while employing renewable energy sources is possible.	

3. THE CHALLENGES FACED IN RENEWABLE ENERGY AND THE WAY FORWARD

Energy is fundamental for the financial turn of events and the annulment of destitution, yet the African mainland faces impressive obstructions to approaching current, clean energy administrations. Somewhere between 60 and 70 percent of

Nigerians prefer to avoid coming power and excellent transportation right now, starting with one local area and then onto the next. Only when it forestalls energy waste and sets aside cash can the public authority broaden the energy sources utilised in the private, business, and modern areas, and there is little uncertainty that Nigeria's ongoing transportation issue will continue. This evaluation looks at various transportation

energy strategy changes that could fundamentally support accomplishing reasonable development on all fronts - monetary, ecological, and social exercises of Nigeria, the landmass' most crowded country, have driven the way. The social advantages of sustainable power transportation effectiveness incorporate diminished energy consumption for low-pay vehicles. Therefore, the application of wind, energy batteries, and solar energy can provide a sustainable means of renewable energy for the nation's transportation system is highly needed. This application will enable the sustainability of electric vehicles in Nigeria [93-95].

Inadequate research on solar initiatives, a lack of technological proficiency, short-term policies, a lack of awareness, and political instability are the main obstacles that have made it nearly impossible to implement solar initiatives in Nigeria [96]. Also, Given the lack of policies on electric vehicles, inadequate infrastructure and energy sources (wind energy generation), poor technology adoption, and a lack of flexible financing, the Nigerian governance system should stand out in promoting sustainable transport policies [97].

Experts say Nigeria is determined to be highly endowed with various renewable energy sources. Still, consumption has been relatively low due to several causes, including the non-implementation of renewable energy legislation and financial difficulties [98]. Unfriendly government policies and a lack of proper research, according to a recent study by the International Renewable Energy Agency (IRENA) mapping renewable energy capacity in the previous year, Nigeria's capacity for renewable energy climbed marginally to 2154 Megawatts (MW) in 2021 from 2150 MW in 2020. Therefore, developing nations may lessen their reliance on fossil fuels like oil and gas by fostering the development of such renewable energy sources for transportation sectors. And build energy portfolios more resistant to price increases. These investments in renewable energy as a source for sustainable transportation may frequently be more affordable than fossil fuel energy systems [99].

4. CONCLUSION

A feasible solution to Nigeria's energy issues regarding transportation, particularly in the country's rural areas: as well as the limitations imposed by the rising cost of conventional energy, it is believed to be renewable. In this article, it is highlighted how useful renewable energy technology is in tackling energy-related issues. The factors influencing the enlargement of the renewable energy sector have also been considered. Efforts have been made to ensure that renewable energy capacity is built, the private sector is stimulated, the markets for renewable energy are developed, the necessary financing for renewable energy projects is obtained, and multilateral institutions are enlisted to help advance via transportation renewable energy technologies in the nation. The following conclusions can also be drawn in light of our goals.

- i. By 2050, Nigeria's transportation sector will use more energy and emit more greenhouse gases.
- ii. Transport sustainability goals in Nigeria will require structural and demand-side policies that can encourage technological advancements for better fuel economy and the development of alternative fuels.
- iii. Additionally, it will need substantial transformational efforts and strong political will from local

communities to the federal. Implementation of renewable energy transportation should be encouraged.

5. RECOMMENDATION

The nation's economic success as a maritime nation is intimately correlated with our investments in navigational infrastructure. The ability of future generations to succeed and grow will depend on the choices made now regarding infrastructure investment in Coastal Cities, just as current generations benefit from investments made in the past. These features will be present in a 21st-century maritime and inland waterway transportation system that is globally competitive. Therefore, this study will recommend that Nigeria's current transportation with the following:

- i. The current trend towards renewable energy utilisation, such as incorporating wind and solar energy, which Nigeria has abundant to power our water and land system transportation, should be considered extensively.
- ii. Also, the Nigerian government encourages industries to fund research involving renewable energy in transportation.
- iii. The hybrid formulation of wind and solar energy can successfully utilise Nigeria's transportation sector. And this will boost the economic stability of Nigeria.
- iv. The public-private partnerships have to come into play, as the private sector needs to support the government to transition from petroleum products to renewable energy sources.

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