

THE ADVENT OF ELECTRIC VEHICLES AND AIR POLLUTION CONTROL IN KENYA: BUSINESS OPPORTUNITIES AND CHALLENGES

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Abstract: This study sought to establish the opportunities availed by the advent of electric vehicles and air pollution control in Kenya. This study examines the effects of electric vehicles and the integration of renewable energy sources on ecological sustainability, public well-being, and economic progress, with a particular emphasis on the context of Kenya. By using the principles of Demand Theory, the Economic Theory of a Faith-Based Approach to Global Warming, and the Environmental Kuznet Curve Theory, this study highlights the worldwide trend towards adopting cleaner alternatives in pursuit of sustainable economies. This study uses description and predictive methodology. The empirical evidence indicates a rising need for electric vehicles and clean energy solutions, which is consistent with theoretical frameworks that anticipate a heightened environmental awareness accompanying economic progress. The research highlights the significant importance of government policies, fiscal incentives, and infrastructure development in facilitating this change. The observed patterns demonstrate a significant positive association between the widespread adoption of electric vehicles, the mitigation of air pollution, and the creation of improved economic prospects.

Keywords: Electric Vehicles, Opportunities and Air pollution Control.

1. INTRODUCTION

The transportation sector, recognized as a major obstacle to carbon reduction due to the costs associated with liquid fossil fuels (Hill, Heidrich, Creutzig & Blythe, 2019), has experienced a significant increase in the number of registered vehicles in Kenya, reaching 2,095,088 units by December 2021, indicating a growth of 5.6% compared to the previous year (CEIC Data, 2021). The increase observed corresponds to a steady annual average rate of 9.6% between 2004 and 2021, indicating the continuous economic advancement of the country (CEIC Data, 2021). Nevertheless, given that more than 98% of these cars depend on fossil fuels, there is an urgent requirement for sustainable transportation alternatives to address the issue of air pollution. The ever-changing nature of Kenya's vehicle industry requires a comprehensive assessment of environmentally acceptable solutions. This study seeks to critically examine existing literature to assess the potential of electric vehicles in reducing air pollution in Kenya.

There is a notable worldwide trend in the transportation sector towards eco-friendly alternatives, specifically electric vehicles, motivated by the environmental issues linked to conventional combustion-engine vehicles (Wanitschke & Hoffmann, 2020). The shift is highlighted by a widespread agreement to tackle air pollution and decrease greenhouse gas emissions, as seen by the significant carbon reduction goals set by major economies. Electric vehicles are widely acknowledged as a significant effort in reducing carbon emissions. They have the potential to effectively address urban air pollution and play a vital role in attaining environmentally friendly transportation in the future (Bonsu, 2020; Zhao et al., 2021).

This adoption offers a global sustainable resolution to address the adverse effects of conventional combustion-engine vehicles on air quality and climate change. Based on the findings of the International Energy Agency (2021) cited in Sathiyaraj et al. (2022), it was observed that the worldwide electric vehicle fleet exceeded 10 million units in the year 2020. This milestone represents a significant decline in carbon emissions when compared to traditional vehicles. The European Union serves as a prominent example of the regional trend towards adopting more environmentally friendly modes of transportation. In 2020, the sales of electric vehicles in this region achieved an unprecedented milestone of 1.4 million units, constituting around 10% of the overall new car registrations (European Alternative Fuels Observatory, 2021).

1.1 Advent of Electric Vehicles in Kenya

National Energy Efficiency and Conservation Strategy 2020 projects that by 2030, electric-powered vehicles would account for 5% of the total number of registered vehicles in Kenya (Ministry of Energy, 2020). This percentage is much small compared to the overall registered vehicle population in Kenya. This implies significant carbon emissions from vehicles. This proportion is comparative to statistic from India where escalating environmental issues was linked to everyday transportation which accounts for 25-30% of the country's greenhouse gas emissions (Kumar *et al.*, 2023). According to Ayetor, Mashele and Mbonigaba (2023), the uptake of electric vehicles in Kenya just like other African countries has been sluggish, driven by a multitude of variables.

The Kenyan government, acknowledging the potential of electric vehicles, has implemented efforts to establish a conducive investment climate. The Energy and Petroleum Regulatory Authority has assisted this shift by implementing regulations for the advancement of electric vehicles (George *et al.*, 2019). In addition, the government provides incentives, such as excise duty rates ranging from 10% to 20%, for electric vehicles, which enhances their financial appeal in comparison to fossil fuel vehicles (Ministry of energy, 2020). Notwithstanding these efforts, the adoption of electric vehicles has been sluggish, primarily due to factors such as lack of awareness, inadequate charging infrastructure, ineffective government incentives, misconceptions about electronic vehicles capabilities, high upfront costs, limited availability of models, economic considerations, and the lack of a strong policy framework (Adjei-Ampomah, 2020; Dixon *et al.*, 2023). However, emerging companies that strategically position themselves for commercial prospects indicate a considerable potential for expansion in the electric vehicle industry in Kenya (Galuzka, 2021).

1.2 Air Pollution Control

Implementing electric vehicles is a vital approach to reducing air pollution, providing an eco-friendly substitute for conventional combustion-engine vehicles. The worldwide transition to electric vehicles is apparent as major economies pledge to substantial carbon reduction goals, acknowledging electronic vehicles as a possible remedy for enhancing urban air quality (Bonsu, 2020; Zhao *et al.*, 2021). The worldwide electric vehicle fleet exceeded 10 million units in 2020, resulting in a significant reduction in carbon emissions compared to traditional vehicles (IEA, 2021). In 2020, the European Union reached a significant point in its shift towards electric vehicles, as evidenced by the sale of 1.4 million EVs, which accounted for around 10% of new car registrations (European Alternative Fuels Observatory, 2021). The evolution of electric vehicles has a rich history, originating in the late 1800s. Over time, there have been significant advancements in technology, particularly in battery technology, leading to a notable decrease in maintenance costs. As a result, electronic vehicles have experienced a rise in popularity and sales since the mid-2010s, as evidenced by studies conducted by Moratori *et al.* (2021) and the International Energy Agency (IEA, 2020). This transition has not only tackled the issue of air pollution but has also created significant business opportunities, resulting in progress in battery technology, charging infrastructure, and renewable energy sources, which in turn contribute to economic expansion (Wolf & Korzynietz, 2019; Jones, Nguyen-Tien & Elliott, 2023).

The incorporation of data from the Energy and Petroleum Regulatory Authority (EPRA) underscores the substantial impact of the transportation industry on carbon dioxide emissions, a primary catalyst of global warming (Opiyo & Njenga, 2023). Voumik, Ridwan, Rahman and Raihan (2023) maintain that currently Kenya's dependence on fossil fuels in the transportation system is a significant factor in the generation of these emissions. Kenya's substantial electric power generation from renewable sources such as hydro, wind, geothermal, and solar puts the country in a favorable position to switch to electric vehicles without relying on fossil fuels for charging (Ituru, Maina & Muthomi, 2019). The nation's dedication to decreasing carbon emissions by 2030 coincides with the potential advantages of advocating for electric mobility, offering a chance to tackle environmental issues and improve sustainability in the transportation industry.

1.3 Business Opportunities and Challenges

In 2019, the global market for electric vehicles had significant growth, with sales exceeding 2.1 million units. As a result, the total number of EVs on the road reached 7.2 million, representing a considerable portion of the market (IEA, 2020; Rietmann *et al.*, 2020). The paradigm shift mentioned here corresponds to a deliberate movement in policy towards implementing extensive regulatory measures instead of providing direct subsidies. This highlights the significant impact of government aid in creating sustainable transportation solutions (IEA, 2020). In addition to the positive impact on the environment, the increase in electric vehicle adoption has led to progress in battery technology, charging infrastructure, and renewable energy sources. This has created profitable prospects for business expansion and economic development (Wolf & Korzynietz, 2019; Ziegler and Abdelkafi, 2022; Murotari *et al.*, 2021). The current progress has not only created jobs but has also stimulated advancements in smart grid technology and energy storage solutions, opening up new opportunities for investment and entrepreneurial pursuits (Jones, Nguyen-Tien & Elliott, 2023). The electric vehicle industry, supported by strategic partnerships and sustainable business models, is a prominent and influential participant in the changing field of environmentally friendly transportation.

Adjei-Ampomah (2020) and Opiyo and Njenga (2023) argue that the adoption of electric vehicles in Kenya has the potential for rapid improvements in public health by mitigating the prevalence of diseases linked to air pollution, including respiratory and cardiovascular ailments. Opiyo and Njenga (2023) point out that this change is anticipated to generate fresh commercial prospects for entrepreneurs venturing into the electric vehicle industry, hence fostering economic expansion. The private sector can also leverage this transition by investing in infrastructure, such as installing charging plug-in systems for residential properties and specified locations, thereby facilitating the growth of the electric vehicle ecosystem. Additionally, the government has the potential to decrease healthcare costs associated with illnesses caused by pollution, while also generating additional income through taxation on electric vehicles (Ampah *et al.*, 2022).

Conversely, there are expected difficulties in executing policies to promote the adoption of electric vehicles (Altoumi *et al.*, 2021). In order to promote universal adoption, the government should offer incentives, such as tax reductions, to those who choose to utilize zero-emission battery automobiles (Opiyo & Njenga, 2023). Significant governmental assistance is essential for the development of infrastructure, especially in the establishment of a pricing system, which may need a large amount of resources. Extended return on investment timeframes in the private sector may result in a sluggish adoption of investment potentially diminishing its appeal to investors (Opiyo & Njenga, 2023; Briceno-Garmendia, Qiao & Foster, 2023). Studying successful deployments in other areas can provide Kenya with valuable insights to overcome these problems and effectively shift to electric vehicles.

2. EMPIRICAL LITERATURE REVIEW

There are key drivers moving societies from fossil fuel to clean energy a study done for BRICS countries which members are Brazil, Russia, India, China and South Africa (Gerasimchuk *et al.*, 2019). These driving forces include international treaties and agreements on need to reduce the greenhouse gases under United Nation conventions; there is reduction in the cost of green energy technologies-and this is encouraging investors in the sector and government initiative to make fossil fuel costlier through tax impositions ; health benefits, fossil fuel emits noxious gas and smog which have caused death in countries, there have been diseases associated with pollution and there are direct cost on saving on import when countries relies on other source of energy they can save on fossil fuel used to power their Generator to feed the Country National Grid (Gerasimchuk *et al.*, 2019).

The city of the Edmonton was the first city in Alberta to adopt electric vehicle innovation to mitigate on Green House Gases emission to manage global warming effect. Interviews contacted did show that many people are willing to adopt to Battery electric vehicles for low carbon emission but the biggest barrier have been the capital cost and the lack of charging stations. In other cities of Toronto, Montreal support from government comes inform of financial supports, charging infrastructures, and consumer awareness toward the uptake (Lee & Morales, 2020).

India have been accelerating gradual shift from fossil fuel to encourage uptake of clean energy. India cut out subsidies in Fossil fuel which is a vote to adopt to clean energy like electric vehicles. Government have adopted policy to shift from power generated from fossil fuel to renewable energy. Clean energy would feed grid which would then feed the charging station for electric vehicles. The government is aiming to supports loans for those willing to adopt to green energy (Bridle, Sharma, Mostafa & Geddes, 2019).

California it was noted the biggest contribution of air pollution was from transportation leading to global warming. There has been disproportionate exposure to air pollution more to people of colors Africa America and Latinos and people of low income compared to whites and Native America. There have been efforts to reverse this through polices and incentives encouraging use of cleaner energy such as Battery electric vehicles. Exposure to pollutants particulates matters of smog have been attributed to negative health effects including chronic heart and lung diseases and Death (Reichmuth, 2019).

Society of American Engineers adopted Jacob's innovation theater; smart installation, which work on principle to maximize resilient in future installation aimed at cleaner energy to compact negative climate change. This system got Artificial Intelligence system which communicate to deliver working and feeding processes to green energy power generation including charging the Electric vehicles which is then directed to Battery storage. This system advocate for use of high efficiency and performing gadgets. The United States Military is the highest institutional consumer of Energy worldwide (Society of American Engineers, 2021)

Collaboration between United States of American and Japan on development of Lithium-ion battery technology leading to increased adoption to electric vehicles and for home supplementing the Grid through Battery storage. Electric vehicle adoption increased by 40% in 2019 and surpassing two million one hundred the same year this seen as positive move benefiting to achieving clean energy and the demand for these raw materials is expected to grow astronomically (Blackhore & Yellen, 2020). Another study in India shows an accelerated uptake of lithium mineral which is key to making battery for electric vehicles (Goel, Moerenhout, Sharma, Raizada, & Kumar, 2023).

In United States of America Transportation, the biggest contributor of greenhouse gases. There has been policy to encourage clean energy. This comes at a cost since governments' losses tax. The policies encouraging clean energy has seen good uptake of Electric vehicle including long distance trunks (Dosh & Metcalf, 2023). In the city of Alberta there has been raise in electric vehicles and hybrid vehicles this aid in the carbon reduction. The developments for infrastructure to support plug in charging at home, workstation and at existing sites for gas station. There will be opportunities for developers and homeowner to work with Electrical engineers to provide reliable and safety on charging sites (Han & Wang, 2023).

Research conducted on cities implementing low emission zones; Analysis of global data reveals that cities in Sweden, Germany, Rome, France, London, and China witnessed a decline in carbon dioxide and other greenhouse gas emissions following the implementation of clean technologies such as electric vehicles and hydrogen fuel vehicles (RoyChowdry, Das & Bandela, 2023). In Sweden, there was a notable enhancement in public health, resulting in a decrease in mortality rates and a decline in hospital admissions. To ensure the successful implementation of this adoption, several strategies were employed. These included imposing taxes on fossil fuel vehicles entering designated low zone cities and restricting the entry of older vehicles into the country. This is because as vehicles age, their emission control mechanisms become less effective (RoyChowdry *et al.*, 2023). It is noted that despite the valuable contribution made by this study, it did not incorporate mortality statistics in comparison to cities that did not have zero emissions. The emission quantity was not specified.

Another study conducted in Canada demonstrated that addressing climate change caused by fossil fuels can be achieved by implementing a plan that promotes the increased sales of zero emission automobiles, hence reducing carbon emissions (Thorn & Mcbain, 2023). The anticipated reduction in greenhouse gas emissions of 40% is crucial for the process of decarbonization. The survey also indicated that the private sector is making positive investments in infrastructure for plug-in charging systems for electric cars, which will enhance market efficiency. The Canadian Government must formulate a comprehensive plan and establish regulations aimed at aiding for achieving zero emissions. Furthermore, these initiatives should be seamlessly integrated to provide a synergistic effect (Thorn & Mcbain, 2023). However, this study is limited because it did not provide the quantitative data on the number of vehicles. Instead, it focused on presenting the percentages of predicted carbon savings. It also did not include information on the existing rules, which would have been important to demonstrate the potential benefits.

According to Shankar (2023), although the adoption of electric cars in India is currently slow, the most effective approach would be to initially focus on implementing electric motors for two and three-wheeled vehicles, as well as light trucks. Electric public fleet cars are crucial for decarbonization efforts. Anticipated growth is projected for the electric car industry, with batteries playing a significant role as a key component. The private sectors will be incentivized to get carbon credits and create zero-emission automobiles within designated economic zones. Additionally, the establishment of

infrastructure for battery charging plug-ins will present additional commercial opportunity (Shankar, 2023). It would have been beneficial to compare the adoption rates of light vehicles with heavy-duty vehicles or provide specific percentages of the anticipated adoption rates. The shortcoming of this study is that it did not provide information about the raw materials used and other components that are anticipated to have economic worth, apart from the battery.

Sobelman and Myersdorf (2022) argues that there is intense competition between the United States of America and China in the battery sector, particularly regarding the technology and raw materials utilized for battery manufacturing. They argue that Israel has gained a significant advantage in battery technology. Chinese investors have made investments in an Israeli company that specializes in battery technology. This has put Israel in a difficult situation because the United States is currently engaged in a trade war with China, and Israel has traditionally been aligned with the United States. There is a forecasted shift in demand towards electric vehicles, making investment in the infrastructure for battery-powered vehicles a significant driver of economic development. This study is limited since it does not indicate specific raw materials and materials utilized in predicting sales figures.

The empirical evidence suggests a notable global transition from fossil fuels to renewable energy, with a special emphasis on electric vehicles. The rise in popularity of electric vehicles, solar photovoltaic, wind power, and hydropower can be seen as evidence of the application of demand theory, which suggests that the economy will shift away from fossil fuels as more cost-effective alternatives become available (Covert et al., 2016). The growing desire for cleaner and more sustainable solutions among individuals can be attributed to the improved availability and affordability of these clean energy sources. Government support plays a significant role in supporting the transition to electric vehicles and the establishment of strategically located charging stations. This support is mostly manifested through tax cuts, subsidies, and infrastructure development, as seen in several cases.

The empirical research supports the Economic Theory of a Faith-Based Approach to Global Warming, highlighting the intricate nature of global climate change concerns and the imperative nature of making difficult choices to address carbon emissions. The theory posits that the shift towards green energy, exemplified by the production and acceptance of electric vehicles, is in accordance with its endorsement of a proactive approach to green energy alternatives such as hydrogen fuel (Banks, 2014). The aforementioned transformation, which is propelled by governmental policies that endorse tax reductions and subsidies, underscores the dedication to attaining environmental sustainability. The utilization of this theory within the realm of research underscores the importance of ongoing governmental backing for the production of electric vehicles through policies that foster a transition towards sustainable energy sources.

The theory of the Environmental Kuznet Curve posits a pattern in which developing nations undergo a phase of heightened environmental degradation and pollution, followed by a subsequent shift towards environmental preservation as per capita income reaches a certain threshold. This phenomenon is evident in the observed patterns within countries such as India. The transition from fossil fuels to renewable energy, facilitated by governmental policies and initiatives, signifies a positive association between economic progress and ecological consciousness (Karsch, 2019). With the attainment of economic stability by developing nations, there has been an increased emphasis on comprehensive environmental conservation, corroborating the predictions of the theory. The inclusion of India's policies and activities within the setting provides support for the underlying idea, thereby shedding light on the intricate relationship between economic development and the adoption of environmentally sustainable practices in emerging nations.

In addition, it is expected that the implementation of electric vehicles will result in significant benefits, encompassing enhancements in public health as well as the creation of economic prospects. The potential social benefits of shifting to electric vehicles are evident in the reduction of medical expenses related to heart and lung problems, as well as the favorable influence on climate change resulting from decreased greenhouse gas emissions (Nealer, Reichmuck & Anair, 2015). The electric vehicle market offers several economic opportunities, such as the sale of electric vehicles and related components, along with potential job prospects in electrical and mechanical engineering. These factors highlight the diverse advantages associated with the ongoing revolution in electric vehicles. Moreover, the presence of economic prospects in charging infrastructure, encompassing both home and public domains, amplifies the profound influence of electric vehicle adoption across many industries. Nevertheless, it is imperative to acknowledge prospective obstacles, such as the potential decrease in government income derived from conventional sources like petroleum, while underscoring the wider benefits of cleaner and more sustainable transportation choices.

This study through empirical review underscores a pervasive worldwide pattern towards more environmentally friendly energy sources, with a specific emphasis on the widespread use of electric vehicles. The observed patterns are consistent

with established theoretical frameworks. Demand Theory highlights a natural economic transition, Economic Theory A Faith-Based Approach to Global Warming emphasizes the importance of proactive government commitments, and the Environmental Kuznet Curve Theory elucidates the positive relationship between economic advancement and environmental preservation. Collectively, these research and theories shed light on the complex dynamics that shape the worldwide shift towards more sustainable energy sources. They underscore the significance of economic principles, policy interventions, and environmental awareness in driving this transformation.

3. CONCLUSION

The research findings demonstrate that the introduction of electric vehicles and the enforcement of air pollution mitigation strategies offer significant economic prospects. These opportunities encompass a positive outlook for the EV market, the generation of employment for electrical and mechanical engineers, and the emergence of profitable ventures in the development of charging infrastructure. Moreover, the environmental advantages stemming from the reduction of air pollution and greenhouse gas emissions contribute to improved public health, potentially leading to a decrease in healthcare expenses. While acknowledging the economic difficulties, such as the decline in income tax revenue resulting from petroleum products, the study underscores the broader societal benefits associated with the transition to electric vehicles. This transition aligns with global endeavors to combat climate change and enhance the overall well-being of the Kenyan population. Benefits of green energy will be great for cleaner environments and for economic developments.

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