2022 IEEE & IET International Utility Conference and Exposition (IUCE -2022), Nov. 3 – 4, 2022, Accra, GHANA

Exploring the Barriers to Consumer Adoption and Applications of Electric Vehicles: Ghana's Experience

Ernest Agyemang
Department of Geography & Resource Development
University of Ghana
Accra, Ghana
ORCID: 0000-0003-3254-4611
Email: eagyemang@ug.edu.gh

Ebenezer Forkuo Amankwaa
Department of Geography & Resource Development
University of Ghana
Accra, Ghana
ORCID: 0000-0003-3254-4611
Email: efamankwaa@ug.edu.gh

Joseph Essandoh-Yeddu
GNPC Centre of Excellence
Institute for Oil & Gas Studies
University of Cape Coast
Cape Coast, Ghana
Email: jeyeddu@ieee.org

2022 IEEE/IET International Utility Conference and Exposition (IUCE) | 978-1-6654-5551-0/22/$31.00 ©2022 IEEE | DOI: 10.1109/IUCE55902.2022.10079349

***Abstract*— Electric mobility is gradually becoming popular in developing countries, with the potential to unlock investment opportunities and innovation for clean, safe and sustainable urban transport. However, empirical evidence on possible barriers which could frustrate the widespread adoption of electric vehicles (EVs) is lacking. This paper aims to fill the void by examining key barriers to ubiquitous EV uptake. We generated primary data through interviews among potential adopters as part of a broader EV consumer preference survey in Ghana. Results from our thematic analyses of the data identified 22 key barriers, which are sub-summed under five major categories, including social, technical, economic, policy, and infrastructural. The results further indicate that initial high purchase cost, limited driving range and general lack of supporting infrastructure are the three topmost barriers to EV adoption in Ghana. The implications of the findings and strategies to promote EV uptake among the Ghanaian populace and the national government are discussed.**

Keywords—Electric Vehicles (EVs), Internal Combustion Engine Vehicles (ICEVs), Barriers, EV Adoption, Ghana

1. INTRODUCTION

Electric vehicles (EVs) mainly comprise battery electric vehicles (BEVs) and plug-in electric vehicles (PHEVs) that run either fully or partially on electric energy. While BEVs run on electric energy charged by plugging the vehicle into a source of electricity with energy stored in batteries, PHEVs use batteries to store the electrical energy from the grid and use petroleum-based fuels to power their combustion engines. EVs are considered an alternative technology to conventional internal combustion engine vehicles (ICEVs), which burn liquid fuels, particularly fossil fuels and thus emit greenhouse gases (GHG) [1]. Therefore, the net GHG emissions of a country can be optimized when electricity generated from renewable energy sources such as solar, wind, or hydropower is used to charge EVs.

Globally, many countries are adopting EVs, with about 370 EV models comprising 235 BEV and 133 PHEV models available as of 2020 [2]. However, their diffusion rate varies widely. The acceleration in EVs uptake is expected to continue at a fast pace with the growing exigencies of combating climate change. Governments are supporting the transition from ICEVs to EVs as a fundamental action in achieving their carbon emission reduction ambitions. With EVs, cities can leapfrog to net-zero emissions, thereby reducing the carbon footprint and contributing to meeting the sustainable development goals (SDGs) for sustainable cities and a clean and healthy environment [3]. Elsewhere, several fiscal incentives and non-fiscal measures are being implemented to facilitate EV adoption [4]. These include excise duty waivers, upfront purchase price subsidies, financial support for fast charging stations, free charging, and special dedicated road lanes that reduce travel during rush hours. Through these initiatives and efforts, beneficiary cities are witnessing an increase in the volume of new and second-hand electric vehicles [5,6].

Even though Africa has not been left out of this global EV revolution, the situation is quite different due to existing challenges in the transport sector, including congestion, affordability, poor service quality, standard enforcement and lack of incentives [7,8]. In Ghana, e-mobility can catalyze the country's commitment to shift towards low carbon growth and contribute to developing a modern, sustainable, efficient, and results-driven transport sector. As EVs are being introduced in Ghana, their uptake would have to be delivered through supportive government policies, private sector partnerships, and investments from international development partners to promote the penetration of different types and models in the Ghanaian market. To accelerate uptake and avoid Ghana becoming a dumping ground for discarded ICEVs, the country first of all quickly needs to develop and enact minimum technical standards to regulate imports and entry of such discarded ICEVs as well as sub-standard EVs into the country. Also, robust and enabling policies, especially tax and other economic incentives and waivers, are obviously required to boost capacity for local assembling and production besides ensuring imports of standardized products along the EV value chain.

Against this backdrop, it is heartwarming to note that the Ghana government is already developing a policy on electric mobility that incorporates an implementation framework and market feasibility [9]. However, more partnerships and investments are required to pilot and deploy electric vehicles in the Ghanaian market. Most importantly, we contend that, for the diffusion of EVs to happen, it is crucial to understand consumer behaviour and address the barriers detrimental to EV adoption. This is because, despite the considerable benefits of EVs, studies conducted elsewhere have reported various barriers to their diffusion and wider acceptance [10,11]. The key concern relates to consumer perceptions of

EVs, as their popularity significantly depends on user acceptance [12].

These studies concluded that the inhibiting factors affecting EV uptake include high upfront cost compared to ICEVs, lack of government policies and support, driving range anxieties and longer charging times [13]. Therefore, this paper explores the intention of electric vehicles adopters and the barriers that beset the widespread uptake of electric vehicles from the Ghanaian perspective. The paper contributes to the emerging literature aimed at revealing the determinants of EV adoption in Africa by providing new empirical insights into the adoption intention of potential EV consumers.

2. CONTEXTUAL ISSUES

As in most parts of sub-Saharan Africa, cities in Ghana are fast urbanizing. Ghana's vehicular population, estimated at 2.2 million in 2020, is also steadily growing and may exceed 3 million in 2030 and reach about 7 million by 2047, when Ghana is projected to become an upper-middle-income country [14]. Even though Ghana's Transport sector accounts for about 17% of the overall national GHG emissions, it is responsible for about 48% of the Energy Sector GHG emissions. The average annual growth is estimated at 7% relative to 2012 levels [15]. The transport sector currently accounts for an average of 37% of the total energy share of the country. It is the second largest after the residential sector due to its considerable reliance on oil consumption. Presently, about 77-80% of all oil products go into transportation as fuel, culminating in the sector's high and increasing GHG emissions. Thus, this could have severe GHG emissions implications for the nation if her upper-middle income ambition by 2047 would still be based on the prevailing internal combustion engine (ICE) technology.

In conformity with the Paris Agreement, Ghana's Nationally Determined Contributions (NDC) GHG emission reduction goal is to unconditionally lower its GHG emissions by 15 per cent relative to a business-as-usual (BAU) scenario emission of about 74 MtCO2e to about 63 by 2030 [16]. An additional 30 per cent emission reduction is attainable, making it a total GHG emission reduction of 45% below the BAU emission levels to 31-41 MtCO2e by 2030, depending upon the economic growth but on condition that external support is made available to Ghana to cover the total cost of implementation [17]. Available records indicate that there are over 1000 EVs in Ghana presently through private sector importation into the country by private individuals and organizations [18]. Several EV models can be found on the Ghanaian market, including Nissan Leaf, iEV7, HongGuang Mini EV, Ora Black Cat, Hyundai Kona etc.

Fig. 1. Some imported Electric Vehicles on display at the Ghana e-Mobility conference in Accra

Subsequently, public EV charging outlets have emerged in Accra, the capital, including the Kempinski Hotel Gold Coast City and the Palace Shopping Mall. This is expected to encourage acceptance by the general public.

Fig. 2. Selected public Electric Vehicle charging units in Accra

Recently, a local car manufacturer, the Kantanka Automobile Company Limited, intends to venture into the production of Electric Vehicles to promote the uptake of the product. Currently, two EV models -a tricycle and a sedan christened *Amoanimaa* -are under pilot studies.

Fig. 3. The Kantanka *Amoaniwaa* Electric Car under production in Ghana

3. DATA AND METHODS

Between the 10th and 27th August 2021, we undertook a broad national electric vehicle preference survey. The survey involved 1507 participants recruited from three Ghanaian metropolitan areas. These are Accra (705 participants), representing the southern sector; Kumasi (502 participants), representing the middle sector and Tamale (300 participants), representing the northern sector of the country. Fig. 4 illustrates the study locations. For the sake of brevity, readers may see Appendix 15 in a previous study which provides study participants' background details, including gender, age, education, employment status, income, city of residence and marital status [9].

During the questionnaire survey, we encouraged participants who had completed filling out the forms to verbally share further thoughts that were not directly captured in the survey instrument. Specifically, we asked the question, "*personally, what obstacle(s) do you think will prevent you from owning*

Primary data was generated through a grant support from the United Nations Office for Project Services (UNOPS).
Grant Number: GVA/UNEP-CCC/23404-001/23404-001-04/202206

or using an electric vehicle?" The researchers recorded the interviews using smartphone voice recorders.

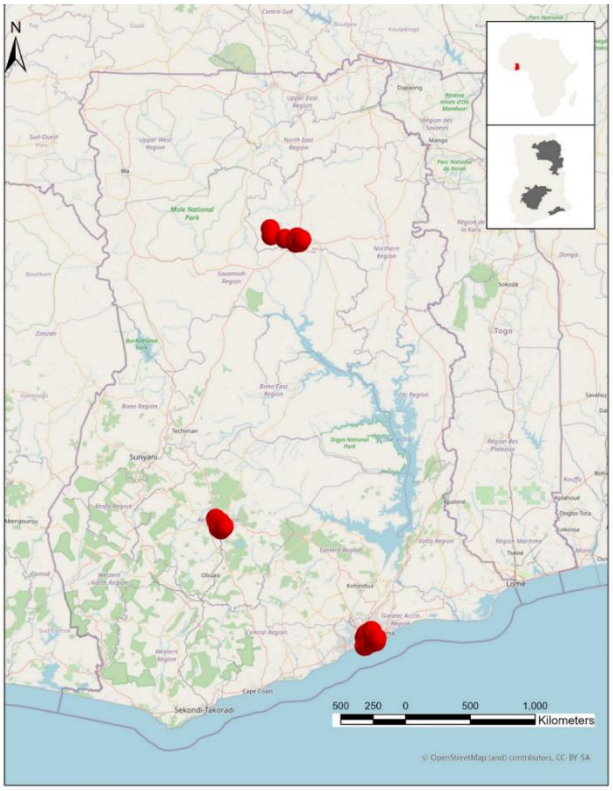

Fig. 4. National Electric Vehicle survey study locations

The interviews lasted an average of 15-30 minutes per interviewee. Data analyses were done manually by coding the responses into themes to tease out emerging patterns that shed light on how participants perceived electric vehicles. Findings from the thematic analyses were refined through further consultation with experts to contextualize and properly situate the identified barriers. The studies of the consumer preference survey and stakeholder interviews provided a better context for understanding EV uptake and the preferred enabling strategies. The findings presented in the next section are based solely on the qualitative data generated from the fieldwork.

4. FINDINGS AND DISCUSSIONS

Figure 5 shows the key barriers that beset the ubiquitous adoption of electric vehicles in Ghana, as pointed out by interviewees. In total, 22 barriers were identified and grouped under five major categories: social, technical, economic, policy, and infrastructural (see Fig. 5). This is in consonance with previous studies [1, 19, 20].

When the data is further scrutinized, the three topmost barriers to EV adoption include initial high purchase cost, limited range and general lack of supporting ecosystem for Electric Vehicles in the country. Most interviewees perceived the initial purchase price to be out of their reach, given recent economic hardships and the price parity concerns with petrol and diesel vehicles.

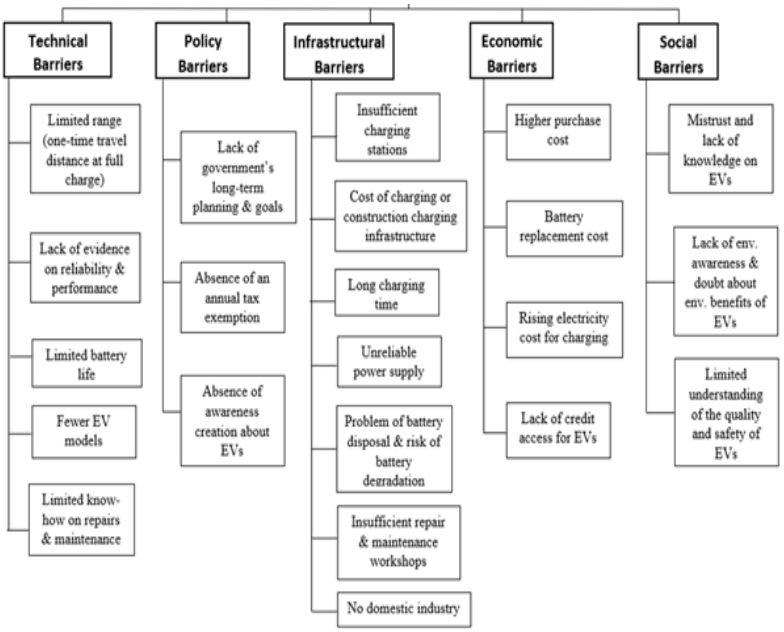

Fig. 5. Barriers to Electric Vehicle uptake in Ghana

These sentiments are captured in the statements below:

> *"Charley, honestly, I don't think I will have that much money to buy an electric vehicle. My income overtime even till pension, cannot buy the EV cars. My finances are not too good" (A 47-year-old Management Accountant, Accra).*
>
> *"The electric cars are meant for the rich. Even in the Developed World, it is not everyone who can afford it" (A 30-year-old Engineer at the DVLA office, Tamale).*
>
> *"Initial price of this car is very expensive. I could keep the balance for other better things if I were to buy a fuel or diesel [ICE] car" (A 49-year-old car spare parts dealer, Kumasi).*

Expectedly, the higher upfront cost is a deciding factor that influences EV purchase. Manufacturing costs are higher because EV is an emerging technology. High battery costs, in particular, have been singled out as a major barrier to widespread EV adoption [11]. Hence, they have a higher market price than ICEVs. This is expected to change with the expected plummeting battery prices due to economies of scale, incremental improvements in cell chemistry and engineering potentials in battery management [9, 21]. It is expected that potential cost reduction will be offset in the long run by other running and maintenance costs. Many potential users cannot afford due to their disposable income.

On the issue of Electric Vehicle range, most interviewees were apprehensive about the possibility of interruptions to their trips due to the need to charge their Electric Vehicles en-route, as seen in the comments below:

> *"So what will happen if the battery runs down at a place where there is no light [electricity] to charge it? How long can the electric car last?" (A 40-year-old car mechanic around Kaladan Park in Tamale).*

> *"Talking about driving range, in case you have an important meeting, let's say at Tamale, and you need to travel in an electric car from Accra, you may have to pause the driving at least twice and charge it before you continue. Meanwhile, when I fill my petrol car to full capacity, I can make the same journey without interruptions" (A 35-year-old Auditor, Kumasi).*

The analysis shows that driving range is the most significant technical obstacle to EV uptake in Ghana. Range is a primary concern, especially when it comes to inter-city travels. Transport operators, for example, expect EV buses to have the capacity to travel from Accra to Kumasi without any charging constraints. Users who do not need to travel long distances for their daily routines (especially intra-city) are likely to show more interest in EVs. This supports earlier empirical studies undertaken elsewhere [10, 12].

Yet still, other interviewees had concerns regarding the limited support systems in terms of charging infrastructure in the country, as seen in the comments below:

> *"When I get a shortage [of fuel], I can take a gallon and go to the [nearest] fuel station to purchase some, but this is not possible with the EV. There is no way I can leave the car behind and go looking for a charging facility" (A 38-year-old-banker, Osu, Accra).*

> *"As for me, I think that a brand-new petrol or diesel car with good exhaust equally emits fewer polluting gases into the atmosphere. In my view, the [EV] car really doesn't have any advantage over other cars [ICEs] in terms of promoting cleaner air" (A 46-year-old human resource manager, Kumasi).*

Potential users are sensitive to the charging system and cost. Thus, a higher electricity price could reduce EV uptake and demand. Aside from the cost, the quality and reliability of electricity supply is also a paramount concern raised by the surveyed public.

5. CONCLUSIONS

The paper set out to identify barriers to EV wide adoption and applications in Ghana. This is underpinned by the fact that to accelerate the diffusion and widespread uptake of EVs in Ghana, it is essential to understand consumer behaviour and address the barriers that militate against EV adoption. Findings made in the paper lead us to conclude that Ghana's e-mobility agenda would have to be delivered through supportive government policies, private sector partnerships, and strategic investments from international development partners. This would help address barriers and provide the necessary resources required to accelerate EV adoption.

Against this backdrop, the paper proposes key enabling strategies to the three major barriers that underpin consumer adoption intention, i.e., initial high purchase cost, relatively short driving range and lack of standards for EVs. First, consumers view the higher purchase price of EVs as the most significant barrier. This makes government-supported credit facilities, tax waivers, subsidies etc., critical in the successful deployment of EVs in Ghana. These fiscal interventions could be done progressively. The incentives should include import duties and other vehicle taxes because EVs have zero emissions and pollute less. The banks and related institutions should play a vital role by facilitating EV purchases via subsidized interest rate credit mechanisms for potential users. This will address the difficulty in obtaining credit access due to a weak or absent credit mechanism and potentially provide a competitive edge to EVs over ICEVs. A combination of tax incentives such as reduction/exemption in customs duty, value-added tax (VAT) and registration charges, have the potential to achieve price parity for EVs.

Secondly, EVs with longer ranges should be encouraged, especially for long-distance travels. Some EV models have a range of 580 miles (about 930kms). This could be used for inter-city mobility. Increasing the number of charging stations can reduce the limited range challenge. Driving range and battery capacity could directly affect charging time though depending upon the charging technology, and long charging time could consequently affect travel time [9].

Thirdly, consumers emphasized the need to invest, develop charging infrastructure, and promote renewable energy to ensure an efficient transition to EVs. Given that EVs are a relatively new technology, consumers are unlikely to invest in them unless the supporting infrastructure exists. Thus, the government should work closely with the relevant stakeholders to facilitate the development and maintenance of the required infrastructure, including charging, battery handling etc. Providing sufficient public charging outlets is a crucial enabler for EV diffusion. The current fuel pump stations in the country can be redesigned to install e-charging outlets. Thus, adequate space at fuel stations to accommodate vehicles will likely reduce waiting time for e-charging. This implies that standards should be put in place to ensure that fast-charging systems are deployed equitably. Also, minimum vehicular standards would be necessary to avoid Ghana becoming a dumping ground for inferior EV components and discarded ICEVs being imported from developed partner countries. The Ministries of Transport and Energy, and their related agencies should therefore work collaboratively and innovatively to address broader energy challenges to guarantee a reliable, affordable and sustainable electricity supply for charging EVs. This should be done within the broader framework of improving the transportation and productivy nexus [22], as well as providing sustainable and inclusive public transportation.

REFERENCES

[1] O. Egbue, and S. Long, "Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions". Energy Policy, vol. 48, pp. 717–729, 2012.

[2] International Energy Agency "The global EV outlook 2021: Accelerating ambitions despite the pandemic", pp. 1-101. https://www.iea.org/reports/global-ev-outlook-2021

[3] D. Essel, and J.V. Spadaro, "Health and economic impacts of transport interventions in Accra, Ghana". Geneva: World Health Organization, pp. 1-28, 2020.

[4] J. Akumu, "Promoting cleaner and more fuel-efficient vehicle in Africa". UN Environment Air Quality and Mobility Unit, pp. 1-23

[5] N. Fearnley, P. Pfaffenbichler, E. Figenbaum, and R. Jellinek, "E-vehicle policies and incentives-assessment and recommendations",

Institute of Transport Economics (TOI) Report 1421, pp. 1-123, August 2015.

[6] E. Figenbaum, "Perspectives on Norway's supercharged electric vehicle policy", EIST, vol. 25, pp. 14-34, 2017.

[7] E. Agyemang "Uber is here to stay: Exploring the policy implications of the Uber-Local taxis turf war in Accra, Ghana", Case Stud. Transp. Policy., vol. 8 (1), pp. 59-66, 2020.

[8] G.K. Ayetor, D.A. Quansah, and EA Adjei, "Towards zero vehicle emissions in Africa: A case study of Ghana". Energy Policy, vol. 143, 111606, 2020.

[9] E.F. Amankwaa, E. Agyemang, S. Dhar, T. Munshi, and P. Jyoti, "National Electric Mobility Roadmap in Ghana", UN Environment Programme and Climate Technology Centre & Network, pp. 1-38, 2022.https://unepccc.org/publications/national-electric-mobility-roadmap-in-ghana/

[10] L. Noel, G.Z. de Rubens, B.K. Sovacool, and J. Kester, "Fear and loathing of electric vehicles: The reactionary rhetoric of range anxiety". Energy Res. Soc. Sci., vol. 48, pp. 96–107, 2019.

[11] ZY She, S. Qing, JJ Ma, and BC. Xie, "What are the barriers to widespread adoption of battery electric vehicles? A survey of public perception in Tianjin, China". Transp. Policy, 56, 29–40, 2017.

[12] T. Schneidereit, T. Franke, M. Günther, and JF Krems, "Does range matter? Exploring perceptions of electric vehicles with and without a range extender among potential early adopters in Germany". Energy Res. Soc. Sci., vol. 8, pp. 198–206, 2015. 10.1016/J.ERSS.2015.06.001

[13] I. Vassileva, and J. Campillo, "Adoption barriers for electric vehicles: Experiences from early adopters in Sweden". Energy, vol. 120, pp. 632–641, 2017.

[14] Grantham Research Institute. "Ghana Infrastructure Plan 2018-2047". Climate Change Laws of the World database, Grantham Research Institute on Climate Change and the Environment and Sabin Center for Climate Change Law, 2022. https://www.climate-laws.org/geographies/ghana/policies/ghana-infrastructure-plan-2018-2047#

[15] Environmental Protection Agency, "Ghana's 4th National GHG Inventory Report", pp. 1-318, February, 2019. https://unfccc.int/sites/default/files/resource/gh_nir4-1.pdf

[16] United Nations Climate Change, "The Paris Agreement", undated. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[17] MESTI, "Ghana: Updated Nationally Determined Contribution under the Paris Agreement (2020 - 2030)", Environmental Protection Agency, Ministry of Environment, Science, Technology and Innovation, Accra November 2021. Available at: https://mesti.gov.gh/wp-content/uploads/2021/12/Ghanas-Updated-Nationally-Determined- Contribution-to-the-UNFCCC_2021.pdf

[18] GhanaWeb, "TotalEnergies Marketing Ghana PLC commissions first ever Electric Vehicle charging unit", September 15th 2022.TotalEnergies Marketing Ghana PLC commissions first ever Electric Vehicle charging unit (ghanaweb.com)

[19] P. K. Tarei, P. Chand, and H. Gupta, "Barriers to the adoption of electric vehicles: Evidence from India", J. Clean. Prod., vol. 291 (125847), pp. 1-19, 2021.

[20] D. Browne, M. O'Mahony and B. Caufield, "How should barriers to alternative fuels and vehicles be classified and potential policies to promote innovative technologies be evaluated?" J. Clean. Prod., vol. 35, pp.140-151, 2012.

[21] L. Mauler, F. Duffner, W.G. Zeier, and J. Leker, "Battery cost forecasting: a review of methods and results with an outlook to 2050", Energy Environ. Sci., vol. 14 (4712), 1-28, 2021.

[22] J. Esson, K. V. Gough, D. Simon, E. F. Amankwaa, O. Ninot, and P. W. K. Yankson, "Livelihoods in motion: Linking transport, mobility and and income-generating activities". J. Transp. Geog., 55, 182-188, 2016.