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Department of Renewable Energy

School of Energy

Evaluation of Potential Impacts of the Introduction of Electric Vehicles in The Transportation Sector in Ghana



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**EVALUATION OF POTENTIAL IMPACTS OF THE INTRODUCTION OF ELECTRIC
VEHICLES IN THE TRANSPORTATION SECTOR IN GHANA**

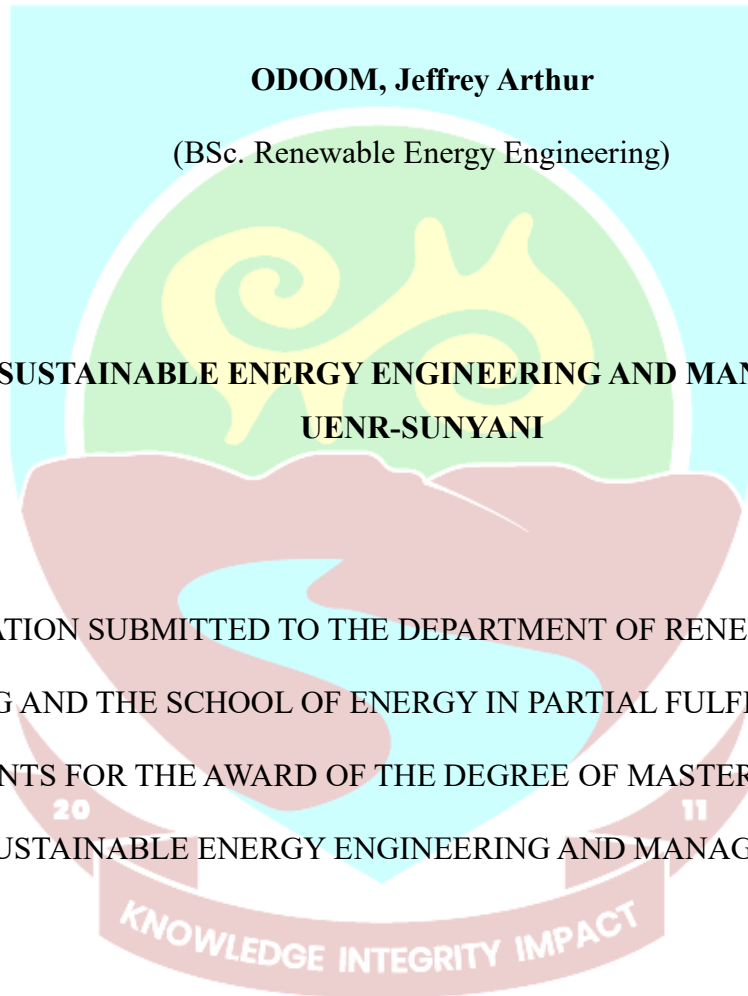
By

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(BSc. Renewable Energy Engineering)

**MSc. SUSTAINABLE ENERGY ENGINEERING AND MANAGEMENT
UENR-SUNYANI**

A DISSERTATION SUBMITTED TO THE DEPARTMENT OF RENEWABLE ENERGY
ENGINEERING AND THE SCHOOL OF ENERGY IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN
SUSTAINABLE ENERGY ENGINEERING AND MANAGEMENT.



DECLARATION AND CERTIFICATION

Student Declaration

I, ODOOM, Jeffrey Arthur (UEMS0200721), hereby declare that, except for the references cited, which have been duly acknowledged, this submission is my work toward a Master of Science degree in Sustainable Energy Engineering and Management, and that to the best of my knowledge, it contains no materials previously published by another person. I also declare that this has not been presented either in whole or in part for another degree in this University or elsewhere.

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ABSTRACT

This study evaluated the potential environmental, economic, and socio-technical impacts of adopting electric vehicles (EVs) in Ghana using well-to-wheels analysis, cost comparison, and policy review. Findings reveal that substituting internal combustion engine vehicles (ICEVs) with EVs could reduce lifecycle CO₂ emissions by 30–45%, equivalent to 2.5–3.2 tonnes of CO₂ avoided per vehicle annually. Local air pollutants such as NO_x and PM_{2.5} could decline by 25–40% and up to 30%, respectively, improving air quality and public health. Although EVs currently cost 30–50% more than ICEVs, their lower operating costs yield annual savings of US\$800–1,200, translating into lifetime savings of US\$8,000–12,000 per vehicle. These benefits make EVs economically viable in the long term, especially with supportive government incentives. Policy implications emphasize the need for a coherent national EV framework integrating fiscal incentives, renewable-powered charging infrastructure, and public–private partnerships. Policymakers should prioritize EV integration into Ghana’s transport and energy systems through tax reforms, import duty waivers, and local manufacturing support. Electrifying commercial transport fleets could further enhance emission reductions and energy security.

The study contributes to existing literature by providing context-specific empirical evidence on EV adoption in Ghana, addressing gaps in environmental, economic, and policy analysis within developing economies. It extends the Diffusion of Innovations and Sustainable Development theories to assess socio-technical readiness and institutional feasibility in low- and middle-income contexts. Overall, EV adoption represents a viable pathway toward Ghana’s sustainable transport transition and national emission reduction goals.

Keywords: Electric Vehicles, Ghana, Greenhouse Gas Emissions, Economic Feasibility, Sustainable Transport, Energy Transition

DEDICATION

With love and admiration, I dedicate this thesis to my late parents, Chief Inspector Charles Adu Kwabena, and Mrs Rebecca Bondzie, who have contributed enormously to my ability to reach this level.



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Without God, I would not have gotten this far. As a result, I am obliged to God Almighty for His sustaining grace and knowledge. I would like to express my sincere gratitude to several individuals and organizations for supporting me throughout my Graduate study. First, I wish to express my sincere gratitude to my supervisors, Dr Benjamin Batinge and Dr Gifty Serwaa Mensah, for their enthusiasm, patience, insightful comments, helpful information, practical advice, and unceasing ideas that have helped me tremendously at all times in my research and writing of this thesis. Their immense knowledge, profound experience, and professional expertise in renewable energy enabled me to complete this research successfully. Without their support and guidance, this project would not have been possible. I could not have imagined having better supervisors in my study. I also wish to express my sincere thanks to the University of Energy and Natural Resources for accepting me into the graduate program.

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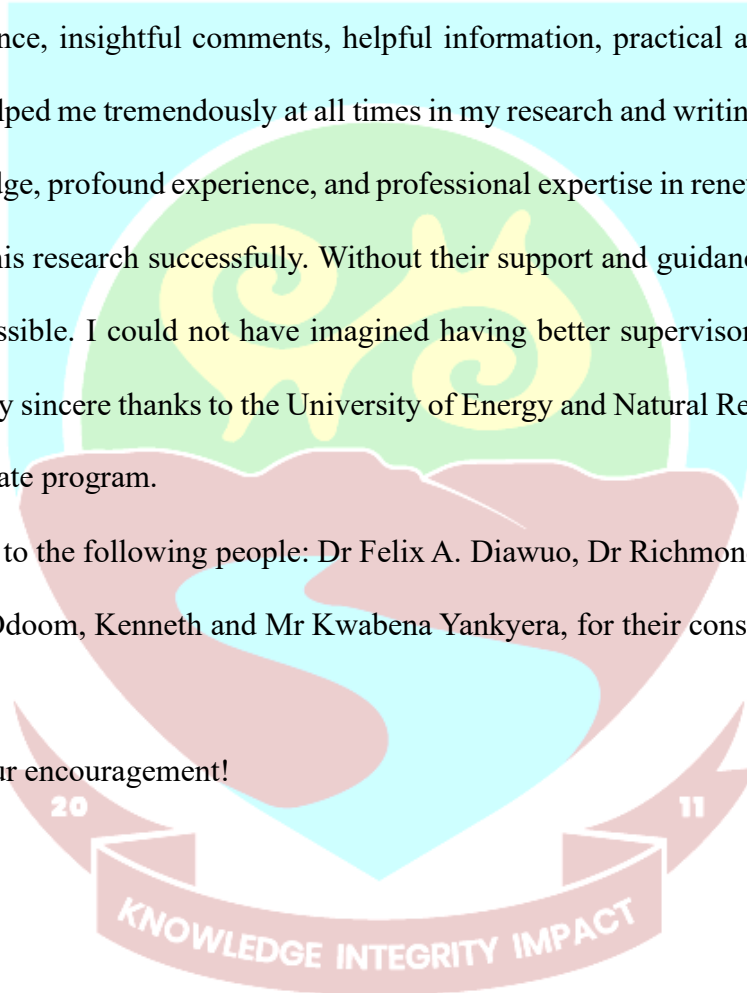
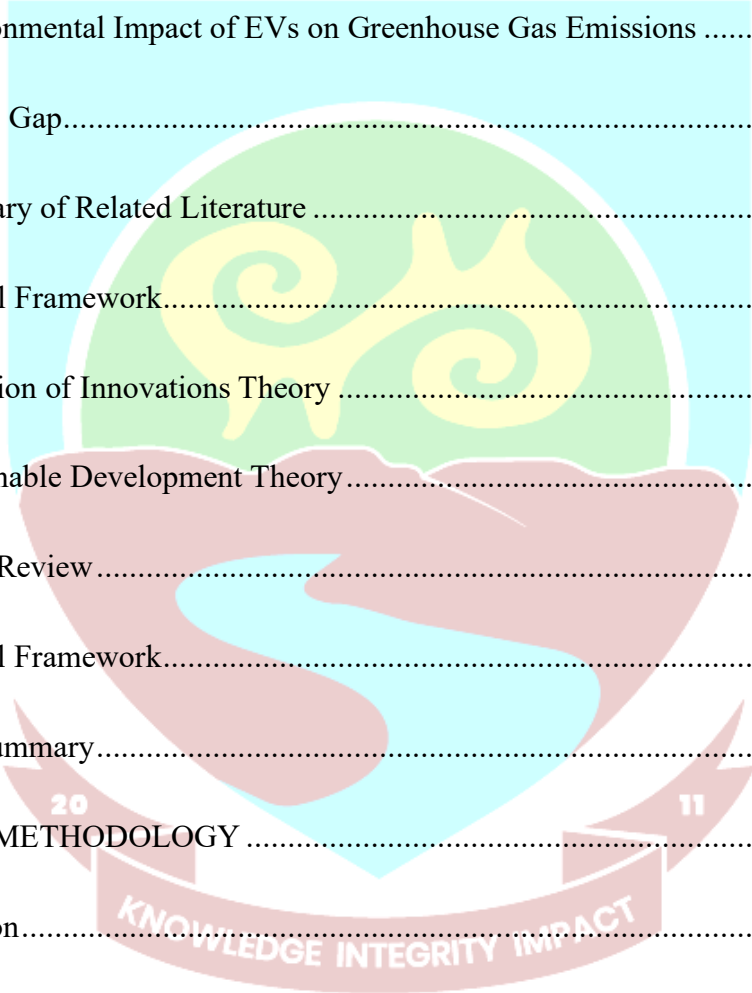


Table of Contents

DECLARATION AND CERTIFICATION.....	i
DEDICATION.....	iii
ACKNOWLEDGMENT.....	iv
TABLE OF FIGURES.....	v
LIST OF TABLES.....	ix
1 CHAPTE 1: INTRODUCTION.....	1
1.1 Background to the study.....	1
1.2 Problem Statement.....	3
1.3 Research Objectives.....	5
1.3.1 Specific Objectives:.....	5
1.4 Research Questions.....	5
1.5 Significance of the study.....	6
1.6 Scope of the study.....	7
1.7 Organization of the study.....	7
2 CHAPTER 2: LITERATURE REVIEW.....	8
2.1 Introduction.....	8
2.2 Conceptual Development.....	8
2.2.1 Road Transport Sector and Electric Vehicle Development in Ghana.....	8

2.2.2 Electric Vehicles	10
2.2.3 Economic Feasibility of Adopting Electric Vehicles	13
2.2.4 Opportunities for the Introduction of Electric Vehicles	14
2.2.5 Challenges for the Introduction of Electric Vehicles	16
2.2.6 Environmental Impact of EVs on Greenhouse Gas Emissions	17
2.3 Knowledge Gap.....	18
2.3.1 Summary of Related Literature	20
2.4 Theoretical Framework.....	21
2.4.1 Diffusion of Innovations Theory	21
2.4.2 Sustainable Development Theory	22
2.5 Empirical Review	23
2.6 Conceptual Framework.....	28
2.7 Chapter Summary.....	33
3 CHAPTER 3: METHODOLOGY	33
3.1 Introduction.....	33
3.2 Research Approach.....	34
3.3 Research Design.....	34
3.4 Selection of Case.....	34
3.4.1 Study Setting	34



3.5 Selection of subjects	37
3.5.1 Population Size	37
3.5.2 Sample Size	39
3.5.2 Sampling Technique.....	40
3.6 Data Collection Instruments	40
3.6.1 Well-to-wheels CO ₂ emissions approach	41
3.6.2 Well-to-power-plant CO ₂ emissions	42
3.6.3 Power-plant-to-wheels CO ₂ emissions.....	42
3.6.4 Well-to-Wheel (WtW) Greenhouse Gas Emission calculations and Comparison.....	43
3.6.5 Data Inputs.....	43
3.6.1 Table 3.5: Summarized Comparison of CO ₂ emissions Reductions of EV Models and ICEV.....	47
3.7 Validity and Reliability of Instruments.....	47
3.8 Data Collection Procedures.....	48
3.9 Presentation of Data and Analysis.....	48
3.10 Ethical Considerations	48
4 CHAPTER 4: RESULTS AND DISCUSSION	50
4.1 Introduction.....	50
4.2 Demographic Characteristics	50
4.3 The environmental impact of EVs on greenhouse gas emissions in Ghana	54

4.3.1 Descriptive Statistics for Greenhouse Gas Emissions in Ghana	58
4.4 Stakeholders’ perceptions of the economic viability and readiness for adopting electric vehicles in Ghana.....	62
4.4 The current challenges and opportunities for the introduction of EVs in Ghana	66
4.5 Discussion	70
4.6 Chapter Summary.....	73
5 CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS	73
5.1 Introduction.....	73
5.2 Conclusion	73
5.3 Limitations of the study	75
5.4 Recommendations for Further Studies	76
5.5 Policy Implications.....	77
5.5.1 Integrating EVs into Ghana’s Climate Commitments (NDCs & LEDS).....	77
5.5.2 Designing Targeted Fiscal Incentives to Reduce Upfront Costs	78
5.5.3 Investing in Renewable-Powered Charging Infrastructure	78
5.5.4 Public Awareness and Stakeholder Engagement for Adoption.....	78
6 REFERENCES	79
7 APPENDIX.....	83

TABLE OF FIGURES

Figure 1 Conceptual Framework 29

Figure 2 compares CO2 emissions (in grams per kilometre) from various vehicle types under various energy source scenarios in Ghana. 54

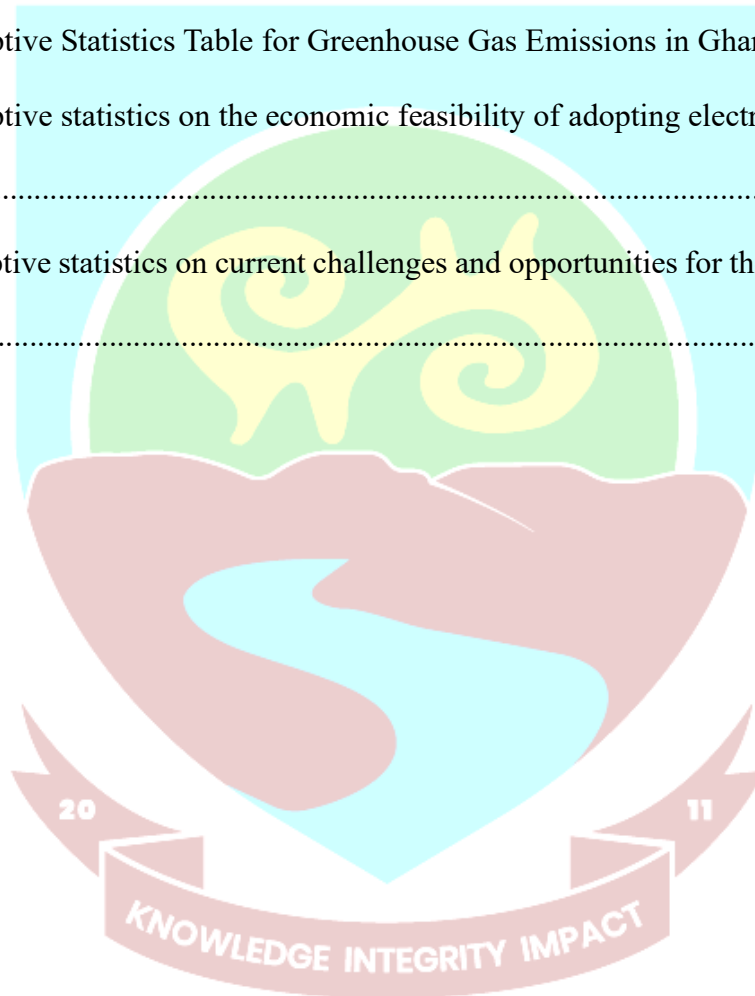
LIST OF TABLES

Table 4.1 Demographic characteristics of respondents 50

Table 4.2 Descriptive Statistics Table for Greenhouse Gas Emissions in Ghana 58

Table 4.3 Descriptive statistics on the economic feasibility of adopting electric vehicles in Ghana 62

Table 4.4 Descriptive statistics on current challenges and opportunities for the introduction of EVs in Ghana 66





1 CHAPTE 1: INTRODUCTION

1.1 Background to the study

The transportation sector plays a vital role in socio-economic development, facilitating the movement of people, goods, and services that underpin trade, commerce, and regional integration. Broadly defined, the transportation sector encompasses all modes of travel—including road, rail, air, and maritime systems—responsible for enabling connectivity within and across national boundaries (International Energy Agency [IEA], 2023). However, the sector remains one of the largest sources of global greenhouse gas (GHG) emissions, heavily reliant on fossil fuels. According to the Intergovernmental Panel on Climate Change (IPCC, 2022), the transportation sector accounts for about 23% of global energy-related CO₂ emissions, with road transport contributing over 75% of that share. The sector's emissions are projected to increase by 60% by 2050 if current fossil fuel consumption trends persist (IEA, 2023).

Electric vehicles (EVs) are automobiles powered primarily or entirely by electricity stored in rechargeable batteries, which drive electric motors instead of internal combustion engines (ICEs) that burn fossil fuels (IEA, 2022). Unlike traditional vehicles, EVs produce zero tailpipe emissions, significantly reducing air pollutants such as nitrogen oxides (NO_x) and particulate matter (PM_{2.5}) (Hall et al., 2021). EVs are therefore central to the global transition toward sustainable mobility, particularly when powered by renewable energy sources such as solar, hydro, and wind. Globally, the adoption of EVs has accelerated rapidly. As of 2024, more than 45 million electric cars were in operation worldwide, representing about 5% of the total global vehicle stock, up from 7 million in 2019 (IEA, 2024). This growth is driven by falling battery costs, improved technology, and supportive government policies, particularly in China, Europe, and North America.

In contrast, Africa's EV market remains in its infancy, accounting for less than 1% of global EV sales (African Energy Chamber, 2024). Approximately 60,000 EVs are currently operating across the continent, concentrated in South Africa, Kenya, Egypt, and Mauritius (United Nations Environment Programme [UNEP], 2023). The African EV market is, however, expected to grow by over 30% annually between 2025 and 2030 if supportive policies are implemented (African Development Bank [AfDB], 2024).

Ghana's transportation system is dominated by internal combustion engine vehicles, many of which are used imports over 10 years old (Energy Commission, 2023). The Driver and Vehicle Licensing Authority (DVLA) reported a total vehicle fleet of 2.8 million in 2023, up from 1.2 million in 2010, with more than 90% powered by gasoline or diesel (DVLA, 2024). The country's electric vehicle stock remains low, estimated at fewer than 1,500 registered EVs as of 2024, primarily privately owned (Energy Commission, 2024).

To address transport emissions, Ghana has introduced several policy initiatives. The Draft National Electric Vehicle Policy (Ministry of Energy, 2022) provides a framework for promoting EV adoption through fiscal incentives, import duty waivers, and the development of charging infrastructure. The Updated Nationally Determined Contributions (NDCs, 2021) also prioritize EV deployment as a key strategy to achieve a 7.4 MtCO_{2e} reduction by 2030, while the Long-Term Low Emissions Development Strategy (EPA, 2022) aims to decarbonize the transport sector by promoting renewable-powered mobility.

Despite these policy measures, Ghana faces multiple challenges in EV implementation. Key barriers include inadequate charging infrastructure, high upfront costs of EVs, limited technical capacity, and grid reliability concerns (Opoku et al., 2023). Furthermore, the absence of localized

manufacturing and a clear enforcement framework for the Draft EV Policy have constrained largescale adoption (Africa Centre for Energy Policy [ACEP], 2023).

Ghana's transport sector is a major contributor to national GHG emissions, accounting for about 45% of total energy-related CO₂ emissions in 2022—up from 29% in 2010 (Environmental Protection Agency [EPA], 2023). The rise correlates with rapid urbanization, increasing vehicle imports, and a growing dependence on fossil fuels. Air quality studies in Accra and Kumasi show that transport activities contribute to over 60% of urban PM_{2.5} concentrations, posing severe public health risks (World Bank, 2022).

Electric vehicles present a viable solution for Ghana's transport decarbonization, offering reduced emissions, lower operating costs, and decreased reliance on imported fossil fuels. As Ghana increases its renewable energy capacity—currently 43% of the national generation mix (Energy Commission, 2023)—EVs can play a transformative role in aligning the country's energy and transport sectors with sustainable development goals.

However, the transition to EVs requires context-specific research that assesses their environmental, economic, and socio-technical implications. While global studies have examined EV adoption in developed economies, there is limited empirical analysis addressing Ghana's unique infrastructural, policy, and market dynamics (Ayeter et al., 2020; Ampah et al., 2022). Therefore, this study seeks to evaluate the potential impacts of introducing electric vehicles into Ghana's transportation sector, providing evidence-based insights to inform national policy, investment, and sustainable mobility planning.

1.2 Problem Statement

The transportation sector plays a pivotal role in global economic development but remains one of the largest contributors to greenhouse gas (GHG) emissions. Globally, it accounts for about 23%

of energy-related CO₂ emissions, with road transport responsible for more than 75% of this share (IPCC, 2022). The increasing demand for mobility and reliance on fossil fuels have intensified the need for sustainable alternatives such as electric vehicles (EVs). EVs have been proven to reduce lifecycle emissions by nearly 50% compared to internal combustion engine vehicles (ICEVs), making them a critical component in achieving global decarbonization goals (Wang et al., 2025). However, most existing research on EV adoption, such as studies in Europe, North America, and China, focuses on regions with robust infrastructure, technological maturity, and strong policy support (Shetty et al., 2025). These findings may not directly translate to developing economies with weaker institutional capacity and infrastructural limitations.

In Africa, EV adoption remains marginal, representing less than 1% of the global EV stock, with roughly 60,000 vehicles concentrated in South Africa, Kenya, Egypt, and Mauritius (UNEP, 2023; African Energy Chamber, 2024). In Ghana, the transportation sector is the largest source of energy-related CO₂ emissions, contributing approximately 45% in 2022, up from 29% in 2010 (EPA, 2023). The total vehicle fleet increased from 1.2 million in 2010 to 2.8 million in 2023, with more than 90% powered by fossil fuels (DVLA, 2024). Although the government has introduced frameworks such as the Draft Electric Vehicle Policy (Ministry of Energy, 2022) and the Low Emissions Development Strategy (EPA, 2022), EV penetration remains low, with fewer than 1,500 registered units nationwide (Energy Commission, 2024).

Despite these initiatives, these specific research gaps remain unaddressed; There is a lack of empirical data on stakeholder readiness for EV adoption, limited assessment of infrastructural and grid capacity, inadequate evaluation of policy coherence, and an absence of integrated analysis linking EV deployment to renewable energy development. Consequently, this study seeks to evaluate the environmental, economic, and policy feasibility of introducing electric vehicles into

Ghana's transportation sector, providing evidence-based insights to guide sustainable mobility planning and low-carbon transition strategies.

1.3 Research Objectives

The main objective of this study is to evaluate the potential impacts of introducing EVs into the Ghanaian road transportation sector.

1.3.1 Specific Objectives:

The study sought to:

1. Evaluate the environmental impact of EVs on greenhouse gas emissions in Ghana.
2. Examine stakeholders' perceptions of the economic viability and readiness for adopting electric vehicles in Ghana.
3. Identify the current challenges and opportunities for the introduction of EVs in Ghana.

1.4 Research Questions

The study sought to answer the following research questions.

1. What is the environmental impact of EVs on greenhouse gas emissions in Ghana?
2. What are stakeholders' perceptions of the economic viability and readiness for adopting electric vehicles in Ghana?
3. What are the current challenges and opportunities for introducing EVs in Ghana?

1.5 Significance of the study

The transportation sector remains a major source of greenhouse gas (GHG) emissions in Ghana, accounting for about 45% of total energy-related CO₂ emissions (EPA, 2023). If this trend continues unchecked, it will worsen air pollution in major cities such as Accra and Kumasi, exacerbate respiratory health issues, and increase Ghana's dependence on imported fossil fuels, which already accounts for over 60% of total energy consumption (Energy Commission, 2023). The continued reliance on internal combustion engine vehicles (ICEVs) also poses significant economic risks, including exposure to volatile global fuel prices and rising maintenance costs from an aging vehicle fleet. Without timely intervention, these challenges could undermine Ghana's ability to meet its Nationally Determined Contributions (NDCs, 2021), which aim to reduce national GHG emissions by 15-45% by 2030, and jeopardize progress toward achieving Sustainable Development Goals (SDGs) 7, 11, and 13, affordable energy, sustainable cities, and climate action.

This study is significant because it provides empirical evidence and contextual insights into the environmental, economic, and policy implications of introducing electric vehicles (EVs) in Ghana. By quantifying emission reduction potential and assessing the infrastructural and socio-economic feasibility of EV adoption, the research will fill a critical data gap in national policy formulation. The findings will guide the Ministry of Energy, the Environmental Protection Agency (EPA), and other stakeholders in developing effective EV policies aligned with the Draft National Electric Vehicle Policy (2022) and the Long-Term Low Emissions Development Strategy (2022).

Furthermore, the study's outcomes will assist policymakers in designing targeted fiscal incentives, such as tax exemptions, import duty waivers, and investment mechanisms to attract private sector participation. These actions are vital for accelerating Ghana's transition toward clean transportation and achieving a just energy transition consistent with the African Union's Agenda 2063 and the Paris Agreement.

Practically, the study will also benefit urban planners, energy regulators, and the private sector by providing evidence-based recommendations for infrastructure development, public awareness campaigns, and renewable integration. Ultimately, by demonstrating how EVs can reduce emissions, improve energy security, and stimulate green industrialization, this study offers a pathway toward a more sustainable, inclusive, and climate-resilient transport future for Ghana.

1.6 Scope of the study

The study was conducted within the geographical boundaries of Ghana, with a particular emphasis on government officials responsible for transportation policies and regulations, representatives from vehicle manufacturers involved in the production and distribution of EVs, private companies operating in the transportation sector, industry experts, and other key stakeholders actively engaged in shaping the future of the transportation sector.

1.7 Organization of the study

The study was organized into five chapters. The first chapter looked at the introduction, which provided a brief background of the study, the statement of the problem, and the significance of the study. It also spelt out the study's general and specific objectives and the research questions that the study sought to address. Chapter one laid out the structure and organization of the chapters. The second chapter provided a review of the theories and existing literature about the topic of

study. It discussed and reviewed existing studies and research works on the topic and their possible implications for the current research.

Chapter three comprehensively explained the research methodology used to undertake the study. It expounded extensively on the research approach and design, sample, sampling procedures/techniques, the sources and methods of data collection, and the data analysis process. The fourth chapter provided a detailed analysis, interpretation, and discussion of the study's findings. The research findings were presented as tables and other quantitative computations. The final chapter (chapter five) summarized the significant findings and the researcher's conclusion and recommendations.

2 CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter discusses the literature review of the study. Creswell (2021) asserts that a literature review “shares with the reader the results of other studies that are closely related to the one being undertaken” and also “provides a framework for establishing the importance of the study as well as a benchmark for comparing the results with other findings”. This chapter discusses the conceptual review, theoretical framework, empirical review and conceptual framework.

2.2 Conceptual Development

2.2.1 Road Transport Sector and Electric Vehicle Development in Ghana

The road transport sector in Ghana is a major contributor to greenhouse gas (GHG) emissions. According to the Environmental Protection Agency’s Second and Third Biennial Update Reports

(EPA, 2019; 2022), road transport emissions have steadily increased, accounting for more than 40% of energy-related CO₂ emissions. Rapid motorization, coupled with an aging vehicle fleet, has exacerbated both air pollution and dependence on imported fossil fuels, creating challenges for sustainable development. Recognizing this, the Government of Ghana has introduced policies to decarbonize the sector while promoting cleaner mobility options.

One of the most notable policy advances is the Draft National Electric Vehicle Policy (Ministry of Energy, 2022), which outlines a framework for electric vehicle (EV) adoption through fiscal incentives, charging infrastructure development, and integration of EVs into public transport systems. Similarly, the Electric Vehicle Framework (Energy Commission, 2023) provides a roadmap for building charging stations and enhancing grid readiness, with an emphasis on leveraging renewable energy sources. Ghana's Updated Nationally Determined Contributions (NDCs, 2021) also highlight EV adoption as a key strategy for reducing transport-sector emissions, while the Long-Term Low Emissions Development Strategy (EPA, 2022) sets out long-term pathways for decarbonizing transport, including the electrification of informal transit modes such as trotros and motorbikes. Despite these policy initiatives, there is limited academic engagement with their implementation challenges and feasibility.

Several empirical studies on EVs in Ghana provide useful insights but remain fragmented. Ayetor et al. (2020) examined the potential of EVs to reduce vehicular emissions in Ghana, while Ampah et al. (2022) explored the integration of EVs with renewable energy in Sub-Saharan Africa, including Ghana. More recently, Opoku et al. (2023) investigated the potential of solar-powered EVs for sustainable transport in Ghana, highlighting their role in post-COVID-19 economic recovery. In addition, policy briefs such as those by the Africa Centre for Energy Policy (ACEP, 2023) and studies by UNDP Ghana (2022) have stressed the importance of aligning EV adoption

with energy security and urban transport sustainability. While these works acknowledge the potential benefits of EV adoption, they tend to focus on emissions reduction and renewable energy integration, without critically evaluating infrastructural readiness, economic feasibility, or stakeholder adoption dynamics.

Taken together, the literature reveals a clear gap between Ghana's policy ambitions and academic evidence. While the government has articulated ambitious EV policies, including the Draft EV Policy and the EV Framework, academic research has not yet sufficiently assessed their feasibility, nor has it examined the perspectives of key actors such as transport operators, regulators, and vehicle importers.

2.2.2 Electric Vehicles

Electric vehicles (EVs) represent a transformative shift in the transportation sector, driven by the need for sustainable and environmentally friendly alternatives to traditional internal combustion engine vehicles. EVs utilize electric motors powered by rechargeable batteries, typically lithiumion, which have seen significant advancements in energy density, safety, and cost-effectiveness in recent years (IEA, 2020). Unlike conventional vehicles, EVs produce zero tailpipe emissions, substantially reducing greenhouse gas emissions and urban air pollution when powered by renewable energy sources (Hall & Lutsey, 2018). The global EV market has experienced rapid growth, with over 10 million electric cars on the road as of 2020, largely due to supportive policies, technological improvements, and increasing consumer awareness (IEA, 2021). This growth is particularly evident in leading markets such as China, Europe, and the United States, where substantial investments in charging infrastructure and government incentives have bolstered adoption rates (BloombergNEF, 2021). As battery technology continues to evolve and economies

of scale drive down costs, EVs are poised to become a cornerstone of global efforts to mitigate climate change and promote sustainable urban mobility.

2.2.2.1 History of Electric Vehicles

The history of electric vehicles dates back to the early 19th century when innovators in Hungary, the Netherlands, and the United States experimented with battery-powered vehicles. The first successful electric vehicle is often credited to Thomas Davenport, an American blacksmith who built a small locomotive powered by a non-rechargeable battery in 1834. By the late 1800s, electric vehicles had gained popularity, especially in urban areas, due to their quiet operation and ease of use compared to steam and gasoline vehicles (Anderson & Anderson, 2010). However, the advent of mass-produced internal combustion engine vehicles, spearheaded by Henry Ford's Model T in 1908, led to the decline of electric vehicles as they could not compete with the lower costs and greater range of gasoline-powered cars.

The resurgence of interest in electric vehicles began in the late 20th century, driven by growing environmental concerns and advancements in battery technology. The oil crises of the 1970s and the subsequent awareness of air pollution and climate change renewed the focus on alternative energy sources for transportation. Significant milestones include the introduction of the General Motors EV1 in the 1990s, which, despite its eventual discontinuation, demonstrated the viability of electric vehicles in the modern era. The launch of the Tesla Roadster in 2008 marked a turning point, showcasing the potential for high-performance electric vehicles with extended ranges (Eberle & von Helmolt, 2010).

2.2.2.2 Electric Vehicle Technology

Electric vehicle technology has advanced considerably over the past few decades, making modern EVs more efficient, reliable, and accessible. The core component of an electric vehicle is its battery,

typically a lithium-ion battery, which stores electrical energy to power the motor. These batteries have seen significant improvements in energy density, reducing weight and increasing the range of EVs. Innovations in battery management systems have also enhanced safety and longevity, addressing earlier concerns about battery life and stability (BloombergNEF, 2020).

In addition to battery technology, electric vehicles incorporate advanced power electronics and electric motor designs. Power electronics control the flow of electricity from the battery to the motor, ensuring efficient energy use. Modern electric motors, such as the permanent magnet synchronous motors (PMSMs) used in many EVs, offer high efficiency and power-to-weight ratios. Furthermore, regenerative braking systems, which capture and convert kinetic energy back into electrical energy during braking, have become standard in EVs, further improving their efficiency (Chan, 2020). These technological advancements make electric vehicles a competitive and sustainable alternative to traditional internal combustion engines.

2.2.2.3 Global Status of Electric Vehicles

The global adoption of electric vehicles has accelerated rapidly over the past decade. According to the International Energy Agency (IEA), the number of electric cars on the road surpassed 10 million in 2020, a significant increase from just 1.5 million in 2015 (IEA, 2021). Supportive government policies, advancements in technology, and increasing consumer awareness of the environmental benefits of EVs drive this growth. Leading markets for electric vehicles include China, Europe, and the United States, which collectively account for most global EV sales.

China remains the largest market for electric vehicles, with over 4.5 million electric cars sold in 2020, representing more than 40% of the global EV stock (IEA, 2021). Europe has also seen substantial growth, particularly in countries like Norway, where electric vehicles accounted for over 50% of new car sales in 2020. The European Union's stringent emissions regulations and

generous incentives for EV buyers have been key drivers of this growth. In the United States, the EV market continues to expand, bolstered by the success of companies like Tesla and increasing investments in charging infrastructure (BloombergNEF, 2021).

2.2.2.4 Prospects for the Future

The prospects for electric vehicles are promising, with continued technological advancements and increasing commitment from governments and industry players. Battery technology is expected to further improve, with ongoing research into solid-state batteries and other next-generation technologies that promise higher energy densities, faster charging times, and greater safety. These advancements could significantly reduce the cost of electric vehicles, making them more accessible to a broader range of consumers (Wood et al., 2019).

Moreover, expanding charging infrastructure is critical to supporting the widespread adoption of electric vehicles. Governments and private companies invest heavily in developing fast-charging networks, reducing range anxiety and making EVs more convenient for long-distance travel. Integrating renewable energy sources into the grid will further enhance the environmental benefits of electric vehicles, ensuring that the electricity used to charge EVs is increasingly sourced from clean energy (IEA, 2021). As global efforts to combat climate change intensify, electric vehicles are poised to be crucial in transitioning to a more sustainable transportation system.

2.2.3 Economic Feasibility of Adopting Electric Vehicles

The economic feasibility of adopting electric vehicles (EVs) in Ghana involves a comprehensive analysis of the total cost of ownership compared to traditional internal combustion engine (ICE) vehicles. EVs tend to have higher upfront costs due to the expense of batteries, which can constitute a significant portion of the vehicle's price. However, this is counterbalanced by lower operating

costs over the vehicle's lifetime. Studies have shown that EVs have lower fuel costs and maintenance expenses compared to ICE vehicles, leading to significant savings for consumers in the long run (IEA, 2020). For example, EVs eliminate the need for oil changes and reduce wear and tear on components like brakes due to regenerative braking systems.

Government incentives and subsidies are also critical in making EVs more economically viable. Various countries have implemented policies such as tax rebates, grants, and subsidies to lower the initial purchase price of EVs and stimulate market adoption. In Ghana, introducing similar incentives could significantly enhance the economic attractiveness of EVs. Furthermore, the potential for reducing dependency on imported fuels presents an economic benefit for the country, as it can mitigate the impact of fluctuating global oil prices and improve energy security (Opoku et al., 2023).

The economic feasibility also depends on the development of a robust charging infrastructure. Adequate and accessible charging stations can reduce range anxiety and enhance the convenience of owning an EV. Investment in this infrastructure is essential for supporting widespread EV adoption. The cost-effectiveness of EVs improves as the charging network expands and becomes more efficient, with advancements in fast-charging technology further reducing downtime for vehicle owners. As battery technology advances and economies of scale are achieved, the overall cost of EVs is expected to decline, making them increasingly competitive with traditional vehicles (Wood et al., 2019).

2.2.4 Opportunities for the Introduction of Electric Vehicles

Introducing electric vehicles (EVs) in Ghana presents significant economic and environmental opportunities. One of the primary opportunities is the potential for reducing greenhouse gas emissions and improving air quality in urban areas. Ghana can significantly lower its carbon

footprint and contribute to global climate goals by replacing ICE vehicles with EVs. This transition aligns with international commitments to reduce emissions and combat climate change, providing a cleaner and healthier environment for its citizens (IEA, 2021).

Economically, the adoption of EVs can drive innovation and create new industries and jobs. Developing local manufacturing and assembly plants for EVs and their components can stimulate economic growth and create employment opportunities. Furthermore, the maintenance and operation of EV charging infrastructure require skilled labour, offering additional job creation potential. The shift to EVs can also reduce the country's reliance on imported fuels, enhancing energy security and stabilizing the national economy against volatile global oil prices (Ayeter et al., 2020).

From a technological perspective, EVs represent a step forward in sustainable transportation. Integrating renewable energy sources, such as solar and wind power, with EV charging infrastructure can further enhance the environmental benefits of EVs. With its abundant solar energy potential, Ghana can leverage this opportunity to develop a sustainable energy ecosystem that supports clean transportation. This can also position Ghana as a leader in renewable energy integration in Africa (Opoku et al., 2023).

Furthermore, the adoption of EVs can lead to advancements in battery technology and energy storage solutions. As the demand for EVs grows, so does the need for more efficient and sustainable batteries. This can spur research and development in battery technology, leading to innovations that benefit the transportation sector and other industries reliant on energy storage. The potential for technological breakthroughs in this area presents a significant opportunity for Ghana to contribute to and benefit from global advancements in sustainable technology (Wood et al., 2019).

2.2.5 Challenges for the Introduction of Electric Vehicles

Despite the promising opportunities, several challenges must be addressed to facilitate the successful introduction of electric vehicles (EVs) in Ghana. One of the primary challenges is the high initial cost of EVs. The cost of EVs, especially those equipped with advanced battery technology, remains higher than that of conventional vehicles. This price disparity can be a significant barrier for consumers, particularly in a developing country with limited disposable incomes. Financial incentives and subsidies from the government are essential to bridge this gap and make EVs more accessible to the general population (IEA, 2021).

Infrastructure development is another critical challenge. The current lack of a widespread and reliable charging network can deter potential EV buyers who may be concerned about the availability and convenience of charging their vehicles. A robust infrastructure requires substantial investment in urban and rural areas to ensure comprehensive coverage. Additionally, integrating this infrastructure with renewable energy sources is crucial to maximize the environmental benefits of EVs and reduce dependency on fossil fuels (Ayeter et al., 2020).

Consumer awareness and acceptance are also significant hurdles. Many consumers may lack sufficient knowledge about the benefits of EVs or may have misconceptions regarding their performance, range, and reliability. Public education campaigns and demonstration projects are necessary to raise awareness and build confidence in EV technology. Addressing concerns about range anxiety, charging times, and overall convenience will be key to increasing consumer acceptance and encouraging the transition from conventional vehicles to EVs (Opoku et al., 2023). Moreover, the regulatory and policy framework in Ghana needs to be strengthened to support the adoption of EVs. Clear and supportive policies, including incentives for consumers and manufacturers, are crucial to fostering a conducive environment for EV growth. Additionally,

standards and regulations for charging infrastructure, vehicle safety, and environmental impact need to be established and enforced. Collaboration between government agencies, private sector stakeholders, and international partners will be essential to develop and implement effective policies that drive the adoption of EVs in Ghana (IEA, 2021).

2.2.6 Environmental Impact of EVs on Greenhouse Gas Emissions

The environmental impact of electric vehicles (EVs) on greenhouse gas (GHG) emissions is a significant consideration in their adoption. EVs have the potential to drastically reduce GHG emissions compared to internal combustion engine (ICE) vehicles. This reduction is particularly notable when renewable energy sources power EVs. Studies have shown that, on a life-cycle basis, EVs produce substantially lower emissions than ICE vehicles, even when accounting for the emissions generated during battery production and electricity generation (Hall & Lutsey, 2018). In countries like Ghana, where there is potential to increase the share of renewable energy in the electricity mix, the environmental benefits of EVs can be maximized.

In urban areas, the adoption of EVs can lead to significant improvements in air quality. ICE vehicles are major sources of air pollutants such as nitrogen oxides (NO_x) and particulate matter (PM), adversely affecting urban populations. By replacing ICE vehicles with EVs, cities can reduce these harmful emissions, improving public health outcomes and healthcare costs. This is particularly important in densely populated urban centres in Ghana, where air pollution from transportation is a growing concern (Ayeter et al., 2020).

Moreover, the shift to EVs supports global efforts to mitigate climate change by reducing reliance on fossil fuels. Transportation is a major contributor to global GHG emissions, and transitioning to EVs is crucial in achieving international climate targets. The adoption of EVs in Ghana can set a precedent for other developing countries, demonstrating that sustainable transportation solutions

are viable and beneficial. As global efforts to combat climate change intensify, the role of EVs in reducing transportation-related emissions will become increasingly significant (IEA, 2021).

2.3 Knowledge Gap

From the review of literature at the global, African, and Ghanaian levels, several critical knowledge gaps emerge, which justify the present study. Globally, research on electric vehicles (EVs) has been extensive, particularly in high-income contexts. These studies often provide valuable insights into emissions reduction potentials, cost modelling, and lifecycle assessments.

However, a key limitation is the lack of localized empirical analysis tailored to low- and middle-income countries (LMICs). While scholars such as Rahman et al. (2025) have highlighted factors influencing EV adoption in urban and peri-urban areas, few have specifically examined how such models apply to Ghana, where infrastructural limitations, energy reliability issues, and policy environments differ significantly from those of developed nations.

A second gap is the evident policy–research disconnect. Ghana has developed ambitious frameworks such as the Draft National Electric Vehicle Policy (MoE, 2022), the Updated Nationally Determined Contributions (NDCs, 2021), and the Long-Term Low Emissions Development Strategy (EPA, 2022). These policy documents articulate bold EV adoption and transport decarbonization targets. Yet, there is a noticeable absence of peer-reviewed academic studies that critically assess the feasibility of these policies, the readiness of stakeholders to implement them, or their integration with the broader energy and transport sectors. This disconnect risks weakening the effectiveness of Ghana’s climate commitments if the policies remain aspirational without being grounded in empirical evidence.

Third, there is a limited economic assessment of EV adoption in Ghana. Existing works by Ayetor et al. (2020) and Ampah et al. (2022) provide useful insights on emission reduction and renewable energy integration but stop short of evaluating cost competitiveness. Specifically, they do not address the comparative lifetime costs of EVs and ICEVs, including potential savings from reduced fuel and maintenance expenses. As this study shows, EVs could save between US\$8,000 and US\$12,000 per vehicle over a ten-year period, yet this crucial dimension is largely absent from the current body of literature.

Another major gap is the neglect of Ghana's informal transport sector. Most studies reviewed focus on private cars and formal transport systems, leaving out trotros, shared taxis, and motorbikes, which constitute the backbone of urban mobility in Ghana. Any meaningful EV transition strategy must take these modes into account, given their prevalence and their significant contribution to both mobility and emissions in the country. Their exclusion from existing studies creates a blind spot that undermines the realism of EV adoption projections.

Finally, there is an insufficient integration of environmental and socio-economic analysis in the available literature. Many studies take a single-dimensional approach, focusing either on the environmental benefits of EV adoption or on its technical feasibility. Few works attempt a holistic assessment that combines environmental impacts, economic feasibility, infrastructural readiness, and stakeholder perspectives within the Ghanaian context. This fragmented approach limits the ability of policymakers and practitioners to make informed, evidence-based decisions.

Taken together, these gaps highlight the need for a comprehensive study that not only evaluates the environmental and economic implications of EV adoption in Ghana but also situates the findings within the broader policy framework and socio-technical realities of the country. This study seeks to address these shortcomings by offering an integrated analysis of emissions, cost

competitiveness, infrastructure, and policy, thereby providing a holistic basis for shaping Ghana’s sustainable mobility transition.

2.3.1 Summary of Related Literature

Author(s)	Full Title of Paper	Year	Methodology	Study Focus	Key Findings / Limitations
Ayeton, G. K., Quansah, D. A., & Adjei, E.	<i>Towards zero vehicle emissions in Africa: A case study of Ghana</i>	2020	Simulation & Emissions Analysis	Ghana transport emissions and EV potential	Found EVs can reduce emissions significantly; did not consider infrastructure or economic feasibility.
Ampah, J. D., Adetoye, T., & Ackom, E. K.	<i>Electric vehicle development in Sub-Saharan Africa</i>	2022	Review & Techno-Economic Assessment	Sub-Saharan Africa EV readiness	Highlighted renewable integration; lacked Ghana-specific stakeholder and cost analysis.
Opoku, E., Mensah, A., & Annan, R.	<i>Unlocking the potential of solar electric vehicles for post-COVID recovery and growth in the transport sector in Ghana</i>	2023	Scenario Modeling	Solar EV feasibility in Ghana	Showed benefits of solar EVs; did not assess policy or grid challenges.
Eze, V. H. U., et al.	<i>Navigating the road to sustainable mobility: Opportunities and challenges in electric vehicle adoption in Liberia</i>	2025	Case Study	EV adoption barriers in Liberia	Identified infrastructural/policy barriers; lacked Ghana-focused insights.

Rahman, A., Suryawan, I. W. K., & Suhardono, S.	<i>Determinants of electric vehicle adoption in urban and peri-urban areas</i>	2025	Survey & Regression	Urban EV adoption behavior	Found socio-economic and availability factors key; no Ghanaian application.
Africa Centre for Energy Policy (ACEP)	<i>Policy Brief: Electric Vehicles and Ghana's Energy Security</i>	2023	Policy Analysis	Ghana energy and transport policy	Highlighted energy security risks; no empirical data on adoption feasibility.
Ministry of Energy (MoE)	<i>Draft National Electric Vehicle Policy</i>	2022	Policy Framework	National EV roadmap	Proposed incentives and infrastructure rollout; not yet critically assessed in academia.
EPA Ghana	<i>Long-Term Low Emissions Development Strategy (LEDS)</i>	2022	Policy Strategy	Decarbonization pathways	Set transport decarbonization targets; limited empirical assessment of feasibility.

Source: Author's construct, 2025

2.4 Theoretical Framework

2.4.1 Diffusion of Innovations Theory

The Diffusion of Innovations (DOI) theory, developed by Everett Rogers, provides a robust framework for understanding how new technologies and innovations are adopted within a society. This theory suggests that adopting an innovation follows a specific process, including knowledge, persuasion, decision, implementation, and confirmation (Rogers, 2003). By applying the DOI framework, the study can examine the various stages through which electric vehicles (EVs) are introduced and adopted in Ghana, identifying factors that influence each stage.

Aligning with the study's objectives, the DOI theory helps assess the economic feasibility of adopting EVs in Ghana by examining how potential adopters perceive the relative advantage of EVs over traditional vehicles, such as lower operating costs and environmental benefits (Rogers, 2003). This perception significantly impacts the decision-making process and the rate of adoption. Additionally, the DOI framework can identify current challenges and opportunities for EV introduction by analyzing the compatibility of EV technology with existing infrastructure and societal values in Ghana (Rogers, 2003). Understanding the complexity and perceived difficulty of using EVs can highlight barriers to adoption. At the same time, trialability and observability can offer insights into strategies for promoting EVs through pilot programs and visible success stories. The theory also facilitates the evaluation of the environmental impact of EVs on greenhouse gas emissions by examining how potential adopters communicate and perceive environmental benefits. By understanding the role of opinion leaders, early adopters, and change agents, the study can develop strategies to enhance the diffusion process, ensuring that the environmental advantages of EVs are effectively conveyed and endorsed (Rogers, 2003). Recent studies have emphasized the importance of these factors in the successful diffusion of EVs in various contexts (Zhang et al., 2020; Li et al., 2021).

2.4.2 Sustainable Development Theory

Sustainable Development Theory offers a holistic framework for evaluating the environmental, economic, and social impacts of introducing electric vehicles in Ghana. This theory emphasizes balancing economic growth, environmental protection, and social equity to achieve long-term sustainability (WCED, 1987). Applying this framework allows the study to assess how EV adoption contributes to sustainable development goals, particularly in reducing greenhouse gas emissions, improving air quality, and enhancing energy security.

Aligning with the study's objectives, Sustainable Development Theory helps assess the economic feasibility of adopting EVs by considering long-term cost savings, job creation, and potential for technological innovation. It integrates economic analysis with sustainability metrics to provide a comprehensive view of the economic benefits and challenges associated with EV adoption (United Nations, 2020). This approach is crucial for understanding the broader economic implications of transitioning to EVs, including reducing fuel import dependency and stimulating local industries. The theory also identifies current challenges and opportunities for introducing EVs in Ghana by examining the infrastructural and policy requirements necessary for sustainable implementation. It highlights the importance of developing a supportive regulatory framework and investing in renewable energy sources to power EVs, maximizing their environmental benefits (IEA, 2021). Moreover, the Sustainable Development Theory evaluates the environmental impact of EVs on greenhouse gas emissions by integrating life-cycle analysis and assessing the overall reduction in emissions when EVs are powered by renewable energy (Hall & Lutsey, 2018). By integrating these theoretical frameworks, the study can comprehensively analyse the economic, environmental, and social dimensions of EV adoption in Ghana. This approach supports formulating policies and strategies that promote sustainable transportation and address the unique challenges and opportunities within the Ghanaian context.

2.5 Empirical Review

The empirical literature on electric vehicle (EV) adoption has evolved considerably in recent years, emphasizing its environmental, economic, policy, and infrastructural dimensions. Globally, research has focused on the capacity of EVs to reduce greenhouse gas (GHG) emissions, enhance energy efficiency, and accelerate the transition toward sustainable transportation. Across Africa,

studies have examined the contextual feasibility of EV adoption given the continent's infrastructural and energy challenges, while in Ghana, the discourse remains emerging and exploratory, centered on environmental benefits, stakeholder perceptions, and policy readiness.

From an environmental perspective, most global studies have employed life-cycle assessment (LCA) and well-to-wheel (WTW) methodologies to evaluate the emission reduction potential of

EVs. Hall and Lutsey (2018) demonstrated through LCA that EVs emit approximately 50% fewer life-cycle GHG emissions than internal combustion engine vehicles (ICEVs), even after accounting for battery manufacturing and electricity generation. Similarly, the International Energy Agency (IEA, 2020; 2024), using scenario modeling, projected that the global EV fleet—expected to surpass 45 million by 2024—could reduce oil demand by nearly 2.5 million barrels per day and significantly lower global CO₂ emissions by 2030. At the continental level, Ampah et al. (2022) found through renewable integration modeling that combining EVs with solar and wind-based charging systems could make electric mobility nearly carbon neutral in Sub-Saharan Africa. In Ghana, Ayetor et al. (2020) and Opoku et al. (2023) revealed that EVs could reduce transportation-related GHG emissions by up to 40%, with solar-powered charging systems further enhancing sustainability and reducing operational costs. Metrics commonly used in these studies include CO₂ reduction percentages, energy consumption per kilometer, and pollutant concentration differentials (PM_{2.5} and NO_x).

The economic dimension of EV adoption has been widely examined through market simulations, total cost of ownership (TCO) analysis, and stakeholder perception studies. BloombergNEF (2021) and Wolfram and Lutsey (2019) found that declining battery costs, from around \$1,200/kWh in 2010 to under \$150/kWh in 2022, are making EVs increasingly competitive with ICEVs. Global cost-benefit analyses confirm that EVs offer lower lifetime operating costs due to reduced fuel and

maintenance expenses. In Africa, Mwangi et al. (2019) and Adeoti and Osho (2021) reported that EVs could lower transport costs by 25–30% over their lifetime, though high initial purchase costs remain prohibitive. In Ghana, Ayetor et al. (2020) found that although EVs have higher upfront prices, their operational savings make them cost-effective in the long term. More recent perception-based studies by Owusu et al. (2021) and Mensah and Amponsah (2019) emphasized that stakeholder understanding of EV economics, coupled with limited access to financing and fiscal incentives, significantly influences adoption decisions. These studies commonly use metrics such as lifetime vehicle cost, energy cost per kilometer, and maintenance cost differentials.

The policy and institutional dimension of EV adoption has also attracted considerable scholarly attention. Global analyses by the IEA (2024) and the World Bank (2023) highlight that countries with well-structured fiscal incentives, purchase subsidies, and public-private partnerships experience EV adoption rates four to five times higher than those without such frameworks. In Africa, policy reviews by UNEP (2023) and the African Energy Chamber (2024) note that while interest in e-mobility is growing, implementation is hindered by weak regulatory enforcement, unclear standards, and inadequate power infrastructure. Kenya and Rwanda are notable exceptions, having introduced zero-import-duty schemes and national e-mobility strategies that have accelerated adoption. In Ghana, policy frameworks such as the Draft National Electric Vehicle Policy (Ministry of Energy, 2022) and the Long-Term Low Emissions Development Strategy (EPA, 2022) outline a roadmap for sustainable mobility. However, empirical studies (Ampah et al., 2022; ACEP, 2023) show that these frameworks face implementation gaps, limited fiscal backing, and low institutional coordination, resulting in slow progress.

Despite promising prospects, challenges related to infrastructure, consumer perceptions, and energy reliability remain significant barriers to EV adoption. Globally, Li et al. (2021) and Zhang

et al. (2020) identified range anxiety, charging station availability, and affordability as the most persistent obstacles. In Sub-Saharan Africa, Mokwena et al. (2021) and Adeoti and Osho (2021) reported that limited grid capacity and insufficient charging infrastructure hinder adoption. Ghana faces similar constraints. Owusu et al. (2021) and Adusei and Boateng (2021) observed that inadequate charging facilities, unreliable electricity supply, and low public awareness impede market development. These issues are compounded by the dominance of second-hand vehicle imports and lack of technical expertise in EV maintenance. Common evaluation metrics include the number of public chargers per 1,000 vehicles, electricity reliability rates, and consumer awareness indices.

Overall, the empirical literature underscores that the benefits of EVs—reduced emissions, lower operating costs, and enhanced energy security—are well-established globally. However, successful implementation in Ghana requires targeted strategies to address local infrastructural gaps, policy coherence, and stakeholder readiness. Methodologically, while global studies rely heavily on quantitative life-cycle modeling and economic appraisal, African and Ghanaian studies tend to adopt qualitative and perception-based approaches due to data limitations. Future research should therefore combine these methods in a multi-criteria assessment framework integrating environmental, economic, and socio-political variables to generate context-specific evidence for national EV policy and sustainable mobility planning.

Summary of Empirical Review

Author/Year	Geographical Focus	Dimension	Method/Tool	Key Metrics	Main Findings
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Hall & Lutsey (2018)	Global	Environmental	Life-cycle analysis	CO ₂ reduction, kWh/km	EVs emit ~50% less GHG than ICEVs
IEA (2020, 2024)	Global	Environmental/Policy	Scenario modeling	Oil demand, emission trajectory	EVs can displace 2.5M barrels/day
BloombergNEF (2021)	Global	Economic	Market modeling	Battery cost, TCO	EVs nearing cost parity with ICEVs
Mwangi et al. (2019)	Kenya	Environmental/Economic	Impact analysis	Emission and cost savings	30–40% emission reduction
Adeoti & Osho (2021)	Nigeria	Economic/Infrastructure	Scenario modeling	Grid capacity, EV penetration	Grid can support moderate EV growth
Ayeter et al. (2020)	Ghana	Environmental/Economic	Comparative analysis	CO ₂ reduction, cost	EVs reduce GHG by 40%, viable long-term
Ampah et al. (2022)	Sub-Saharan Africa	Environmental/Policy	Field experiment & modeling	Renewable integration	Solar/wind integration enhances EV sustainability
Owusu et al. (2021)	Ghana	Challenges	Survey	Cost perception, awareness	Cost and infrastructure hinder adoption
Opoku et al. (2023)	Ghana	Environmental/Economic	Field experiments	Solar charging performance	Solarpowered EVs viable for Ghana
ACEP (2023)	Ghana	Policy	Policy analysis	Incentive structure	Weak enforcement of EV policies

Source: Author's construct, 2025

2.6 Conceptual Framework

Figure 2.1 integrates the Diffusion of Innovations Theory and Sustainable Development Theory to evaluate the potential impacts of introducing electric vehicles (EVs) in the road transportation sector in Ghana. The framework aligns with the study's specific objectives: assessing the economic feasibility of adopting EVs, identifying current challenges and opportunities for the introduction of EVs, and evaluating the environmental impact of EVs on greenhouse gas emissions.



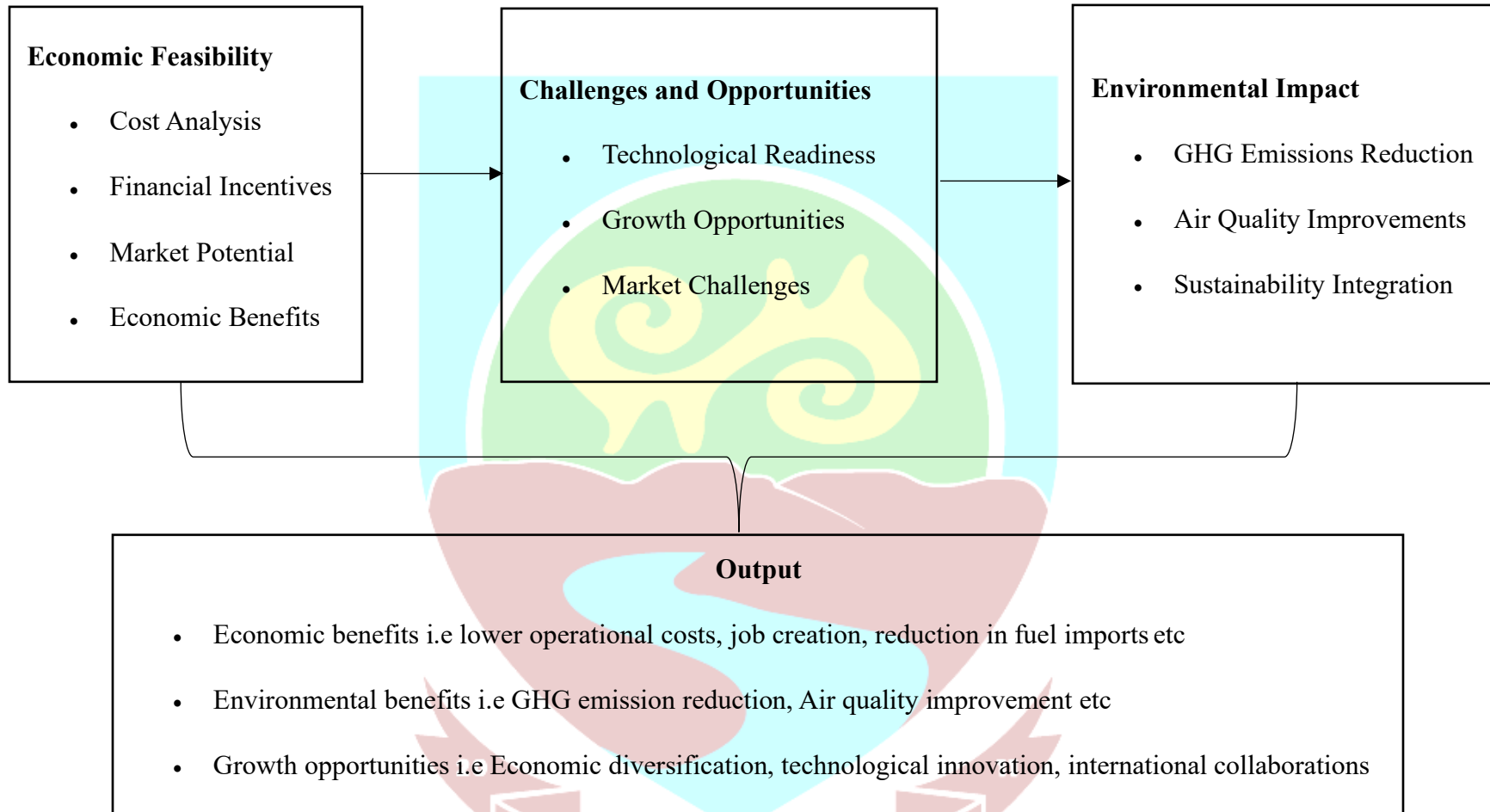


Figure 2.1 Conceptual Framework

Author's Design



Economic Feasibility

Figure 2.1 begins by addressing the economic feasibility of adopting EVs in Ghana. This component evaluates the cost analysis, financial incentives, market potential, and economic benefits associated with EV adoption. The DOI Theory is applied to understand how potential adopters perceive the relative advantage of EVs over traditional internal combustion engine (ICE) vehicles, particularly in terms of lower operating costs and environmental benefits (Rogers, 2003). The study also examines the role of government incentives, such as tax rebates and subsidies, which are critical in making EVs more economically viable for consumers (Opoku et al., 2023). Additionally, the analysis includes the potential for job creation and economic growth by developing local manufacturing and maintenance industries for EVs.

Challenges and Opportunities

The second component of the framework focuses on identifying the current challenges and opportunities for the introduction of EVs in Ghana. This involves analyzing the infrastructural requirements, policy frameworks, technological readiness, and market challenges. The DOI Theory helps identify compatibility issues between EV technology and infrastructure in Ghana, highlighting the need for substantial investment in charging stations and renewable energy sources (Rogers, 2003). The framework also addresses the socio-economic challenges, such as consumer awareness and acceptance, which are essential for driving market adoption (Li et al., 2021). The Sustainable Development Theory emphasizes the importance of developing supportive regulatory frameworks and integrating renewable energy sources to maximize the environmental benefits of EVs (IEA, 2021).

Environmental Impact

The third component evaluates the environmental impact of EVs on GHG emissions in Ghana. This includes an analysis of GHG emissions reduction, air quality improvements, and sustainability integration. The framework leverages the DOI Theory to understand how potential adopters communicate and perceive environmental benefits, which is crucial for promoting EV adoption (Zhang et al., 2020). The Sustainable Development Theory further supports this by integrating life-cycle analysis to assess the overall reduction in emissions when EVs are powered by renewable energy sources (Hall & Lutsey, 2018). The study highlights the potential for significant improvements in urban air quality and public health outcomes by adopting EVs, particularly in densely populated areas such as Accra and Kumasi.

Output

The outputs of the conceptual framework are categorized into economic, environmental, and growth opportunities. Economic outputs include lower operational costs, job creation, and reduced fuel imports, which enhance energy security and stabilize the national economy. Environmental outputs focus on GHG emission reductions and improvements in air quality, contributing to global climate goals and public health. Growth opportunities encompass economic diversification, technological innovation, and international collaborations, positioning Ghana as a leader in sustainable transportation solutions in Africa.

Conclusion

In conclusion, Figure 2.1 provides a comprehensive approach to evaluating the potential impacts of introducing EVs in Ghana. By integrating the DOI Theory and Sustainable Development Theory, the framework addresses the economic, environmental, and socio-technical dimensions of

EV adoption. This holistic analysis supports the formulation of effective policies and strategies that promote sustainable transportation solutions, mitigate the adverse effects of climate change, and enhance the quality of life for Ghanaian citizens.

2.7 Chapter Summary

This chapter provides a comprehensive review of the existing literature on adopting electric vehicles (EVs) in the transportation sector, focusing on conceptual development, theoretical frameworks, empirical review and the conceptual framework. The conceptual development section explores the critical role of the road transportation sector in global mobility and its significant contribution to greenhouse gas (GHG) emissions, highlighting the urgent need for sustainable alternatives such as EVs. The theoretical framework integrates the Diffusion of Innovations (DOI) Theory and Sustainable Development Theory to analyze the adoption process and the multidimensional impacts of EVs. The DOI Theory examines factors influencing the adoption stages, such as relative advantage, compatibility, and the role of opinion leaders. At the same time, the Sustainable Development Theory evaluates the balance between economic growth, environmental protection, and social equity. The conceptual framework synthesizes these theories to assess the economic feasibility, infrastructural challenges and opportunities, and environmental benefits of EVs in Ghana, providing a structured approach to guide policymakers and stakeholders in promoting sustainable transportation solutions.

3 CHAPTER 3: METHODOLOGY

3.1 Introduction

This section provides an overview of the research methodology employed to investigate and evaluate The research approach, research design, study setting, population size, sample size, data collection instruments, etc, discussed to ensure a comprehensive and rigorous study.

3.2 Research Approach

This study employs a quantitative research approach to evaluate the potential impacts of introducing electric vehicles (EVs) in the transportation sector in Ghana. A quantitative strategy is chosen because it allows for the collection and analysis of numerical data, providing a clear and objective understanding of the impacts of EV adoption (Creswell, 2014). By using structured methods such as surveys and statistical analysis, the study aims to quantify the economic, environmental, and social implications of EV adoption in Ghana's transportation sector.

3.3 Research Design

The research design for this study is explanatory research. An explanation research design is used to explore the cause-and-effect relationship between the introduction of EVs and various outcomes in the transportation sector (Saunders, Lewis, & Thornhill, 2019). This design helps understand how and why EV adoption might influence factors such as greenhouse gas emissions, operational costs, and public health. The explanatory approach is appropriate for this study as it seeks to explain the mechanisms and processes through which EV adoption impacts the transportation sector in Ghana.

3.4 Selection of Case

3.4.1 Study Setting

The study was conducted in Accra, the capital and largest metropolitan area of Ghana. Located within the Greater Accra Region, Accra lies along the Gulf of Guinea between latitude 5°33'N and longitude 0°12'W, covering an approximate area of 173 square kilometers. It serves as Ghana's administrative, economic, and commercial hub, hosting the headquarters of major governmental agencies, private institutions, and international organizations. Accra's strategic location and its status as the country's primary center for business, transportation, and policymaking make it an

ideal setting for assessing the environmental and socio-economic implications of electric vehicle (EV) adoption.

According to the Ghana Statistical Service (2021), the Accra Metropolitan Area (AMA) has a population of about 2.6 million, accounting for 8.3% of Ghana's total population. With a population density exceeding 13,000 persons per square kilometer, it is one of the most densely populated cities in West Africa. The city contributes approximately 21% of Ghana's Gross Domestic Product (GDP) (World Bank, 2022), driven mainly by the services, trade, manufacturing, and transport sectors. Household income levels vary significantly, with an average monthly income of GH¢2,700 and about 22% of households falling within low-income brackets (GSS, 2023). Vehicle ownership is higher in Accra than in most other Ghanaian cities, as over 40% of households own at least one vehicle (Energy Commission, 2023). Consequently, traffic congestion and fossil fuel consumption have become serious urban challenges, particularly within areas such as the Kwame Nkrumah Circle, Kaneshie, and Osu.

Accra's energy consumption patterns mirror Ghana's national energy mix. Approximately 57% of electricity generation is sourced from thermal plants powered by natural gas and light crude oil, while 43% comes from renewables, mainly hydropower and solar energy (Volta River Authority [VRA], 2023). This relatively balanced mix makes Accra a suitable case study for analyzing well-to-wheel (WtW) CO₂ emissions from electric vehicles under hybrid energy conditions.

Environmentally, Accra lies within the coastal savannah ecological zone, characterized by short grasses, shrubs, and scattered trees such as *Acacia auriculiformis*, *Azadirachta indica* (neem), and *Albizia lebbek*. The Forestry Commission of Ghana (2022) estimates that the city's current tree canopy cover stands at 18.7%, significantly lower than the national urban average of 23%. Rapid urbanization, infrastructural expansion, and informal settlements have accelerated the depletion of

green spaces and vegetation. This has contributed to increased surface temperatures, reduced air quality, and a diminished capacity for natural carbon sequestration (EPA, 2023). The Accra Urban Greening and Resilience Report (2022) highlights that reduced tree cover has worsened the urban heat island effect, making emission reduction strategies, such as EV adoption, increasingly essential for urban sustainability.

The city's transport sector is almost entirely road-based, accounting for over 98% of all passenger and freight movement (Ministry of Transport, 2022). The system consists primarily of public minibuses (trotros), taxis, ride-hailing services, and private vehicles. The Driver and Vehicle Licensing Authority (DVLA, 2023) reported that the Greater Accra Region has over 1.1 million registered vehicles, representing approximately 36% of Ghana's national vehicle fleet. This concentration of vehicles results in heavy congestion, long commuting times, and elevated levels of greenhouse gas emissions. The Environmental Protection Agency (EPA, 2023) estimates that road transport alone contributes about 47% of Accra's total CO₂ emissions, alongside significant levels of nitrogen oxides (NO_x) and particulate matter (PM_{2.5}).

Accra was specifically selected as the study area for several reasons. Firstly, it represents the epicenter of vehicular activity and emissions in Ghana, offering a practical setting for evaluating the environmental and socio-economic implications of EV adoption. Secondly, Accra is where policy decisions and pilot interventions related to clean transportation and renewable energy are primarily initiated, making the findings directly relevant to national decision-making. Thirdly, its diverse urban conditions—including high population density, complex transportation systems, and mixed energy supply—mirror those of other rapidly growing African cities such as Lagos, Abidjan, and Nairobi, making the study findings regionally relevant. Lastly, Accra's declining vegetation cover and deteriorating air quality underscore the urgent need for low-emission transport alternatives that can complement ongoing greening initiatives and climate resilience programs.

In summary, Accra was chosen not only for its economic and political centrality but also because it encapsulates the major transportation, environmental, and policy challenges facing urban Ghana. The city's high vehicle density, mixed electricity generation profile, and socio-economic diversity make it a representative and strategic location for assessing the potential impacts and feasibility of electric vehicle integration into Ghana's transportation sector.

3.5 Selection of subjects

3.5.1 Population Size

The target population for this study comprises individuals with a direct or indirect stake in the road transportation sector in Ghana. This includes:

Government Officials (N = 200):

This figure was estimated from the staff registers and departmental directories of agencies actively involved in transport and energy policymaking, such as the Ministry of Energy (MoE), Environmental Protection Agency (EPA), Ministry of Transport (MoT), and the Energy Commission. Internal organizational reports from these institutions (MoE, 2023; EPA, 2023) indicate that approximately 200 officers occupy mid- to senior-level technical or policy positions related to energy transition and sustainable transport.

Vehicle Manufacturers' Representatives (N = 150):

Based on data from the Ghana Standards Authority (GSA, 2022) and the Vehicle and Asset Dealers Association of Ghana (VADAG, 2023), it is estimated that around 150 active entities or authorized representatives are registered in Ghana's vehicle assembly and dealership sector. This includes both local assembly plants (e.g., Toyota, Nissan, VW Ghana) and major dealership outlets.

Private Companies in Transportation (N = 300):

The figure is derived from the National Road Transport Operators (NRTO) database and the Ghana Private Road Transport Union (GPRTU, 2023) records, which collectively list over 300 formal and semi-formal transport service operators, including logistics firms, bus operators, and ridehailing companies.

Industry Experts (N = 100):

This estimate was based on membership data from professional bodies such as the Ghana Institution of Engineers (GhIE) and the Energy Institute Ghana (EIG, 2022), which list approximately 100 members specializing in renewable energy, automotive engineering, or sustainable transport research.

Other Key Stakeholders (N = 150):

This category includes representatives from civil society organizations, academic researchers, and non-governmental organizations engaged in clean energy or environmental policy. Estimates were drawn from institutional directories of the Centre for Climate Change and Sustainability Studies (University of Ghana) and the Africa Centre for Energy Policy (ACEP, 2023), totaling about 150 potential participants.

The diverse composition of the target population, totalling 900 individuals, ensures a comprehensive understanding of the multifaceted impacts of EV adoption in Ghana's transportation sector (Saunders et al., 2019). By including government officials, vehicle manufacturers, private companies, industry experts, and other key stakeholders, the study aims to

capture a wide range of perspectives and insights. This holistic approach is essential for evaluating the economic feasibility, infrastructural requirements, and environmental benefits of introducing electric vehicles in Ghana.

3.5.2 Sample Size

Sample size determination is a critical aspect of research design as it directly impacts the generalizability and reliability of the study's findings. In this study, the sample size was determined using the Slovin's formula, as proposed by Slovin (2021), which provides a formula to calculate an appropriate sample size from a large population. The formula is given by:

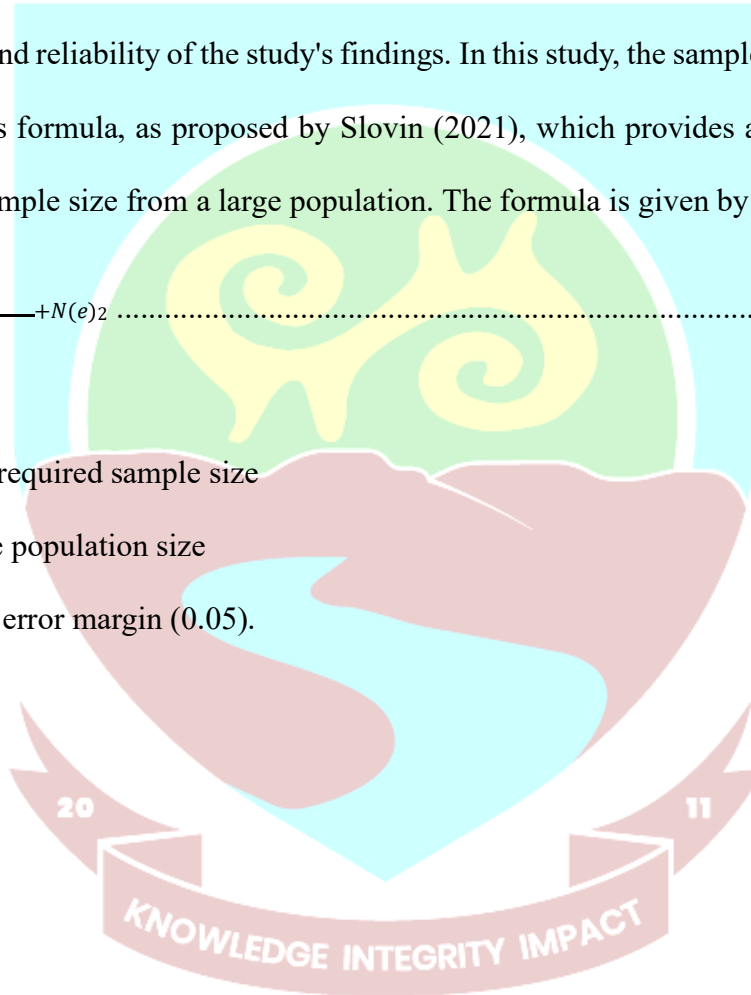
$$n = \frac{N}{1 + N(e)^2} \dots\dots\dots(i)$$

where;

(n) is the required sample size

(N) is the population size

(e) is the error margin (0.05).



Using the Slovin formula, the sample size is represented in the table below;

Table 3.1 Summary of sample size

Stakeholder Group	Population Size	Slovin Formulae	Sample Size
Government Officials	200	$200 / (1 + 200 \times 0.05^2)$	133

Vehicle Manufacturers Representatives	150	$150 / (1 + 150 \times 0.05^2)$	109
Private Companies in Transportation	300	$300 / (1 + 300 \times 0.05^2)$	171
Industry Experts	100	$100 / (1 + 100 \times 0.05^2)$	80
Other Key Stakeholders	150	$150 / (1 + 150 \times 0.05^2)$	109
Total	900		602

Source: Author’s computation, 2024

3.5.2 Sampling Technique

The study employed a stratified random sampling technique to ensure that all key stakeholder groups were adequately represented. Stratified sampling involves dividing the population into subgroups or strata with similar characteristics, such as government officials, vehicle manufacturers, private companies, industry experts, and other key stakeholders (Creswell, 2014). From each stratum, random samples were then drawn. This method enhanced the representativeness of the sample and ensured that each subgroup's unique perspectives were included in the study (Saunders, Lewis, & Thornhill, 2019). Stratified sampling was particularly useful in this study because it allowed for comparing insights across different stakeholder groups, providing a comprehensive evaluation of EV adoption impacts.

3.6 Data Collection Instruments

The primary data collection instruments for this study included structured questionnaires and semistructured interviews. Structured questionnaires were used to gather quantitative data from many respondents, enabling statistical analysis of EVs' economic, environmental, and operational impacts (Creswell, 2014). The questionnaires were designed with closed-ended questions to facilitate easy quantification and comparison of responses. Semi-structured interviews were conducted with key informants such as government officials, industry experts, and representatives

from vehicle manufacturers. These interviews provided qualitative insights that helped to contextualize the quantitative data and explore deeper issues related to policy, infrastructure, and market dynamics (Kumar, 2019).

3.6.1 Well-to-wheels CO₂ emissions approach

Indirect emissions from EVs refer to the greenhouse gas emissions produced during the generation and transmission of electricity used to charge EV batteries and the emissions associated with producing and disposing of EV components, such as batteries. The well-to-wheels CO₂ emissions for the EVs considered in this study were calculated by summing well-to-power and power-plant-to-wheels emissions.

This thesis conducted a well-to-wheels CO₂ emissions analysis for EVs in Ghana following a systematic approach. Firstly, the electricity mix in Ghana was determined, considering the contribution of different energy sources to the electricity grid. Subsequently, the well-to-powerplant emissions were quantified by calculating the CO₂ emissions associated with producing and distributing the electricity used to charge the EVs. This involved calculating the fuel efficiency of electric vehicles, the breakdown of total net electricity generation, and the emissions for each type of fuel used in electricity generation.

Furthermore, the power plant-to-wheels emissions were assessed by evaluating the emissions associated with converting electricity at the power plant into usable energy for the EVs and the subsequent operation of the vehicles. Power-plant-to-wheels emissions for the EV were calculated from the fuel efficiency and the average direct CO₂ emissions from electricity generation.

The well-to-wheels CO₂ emissions for EVs were obtained by combining the well-to-power-plant emissions and the power-plant-to-wheels emissions, as shown in equation 1 (Holdway et al., 2010).

The total CO₂ emissions associated with using EVs throughout their life cycle were calculated,

providing a comprehensive representation of emissions from energy production to vehicle operation. To assess the environmental impact of EVs, a comparison was made between the well-to-wheels CO₂ emissions from EVs and those of conventional internal combustion engine vehicles. This analysis facilitated an evaluation of the potential emission reduction achieved through the transition to EVs, highlighting the environmental benefits of adopting electric transportation in Ghana.

$$W_tW_{EV} [g km^{-1}] = Eff_{EV} [MJ km^{-1}] \times (W_tPP_C + PP_tW_{EV}) [g MJ^{-1}] \dots\dots\dots \text{equation 1}$$

Where:

W_tPP_C = well-to-power-plant emissions

PP_tW_{EV} = Power-plant-to-wheels CO₂ emissions for EVs

$W_tW_{EV} [g km^{-1}]$ = well-to-wheels CO₂ emissions for EVs

3.6.2 Well-to-power-plant CO₂ emissions

These are the CO₂ emissions generated during the production and distribution of the electricity used to charge the EVs. It includes the emissions associated with extracting, refining, and transporting the primary energy sources (such as fossil fuels or renewable energy) used to generate electricity in power plants. In the case of Ghana, the well-to-power-plant emissions would depend on the energy mix of the country, considering factors such as the contribution of fossil fuels and renewable sources (hydro, solar, wind) to the electricity generation.

3.6.3 Power-plant-to-wheels CO₂ emissions

These are the CO₂ emissions produced during the electricity conversion at the power plant into usable energy for the EVs and the subsequent operation of the vehicles. This component considers the efficiency of the power plant, transmission and distribution losses, and losses in the charging

process. Additionally, it considers the efficiency of the electric drivetrain in the EV and the energy required to propel the vehicle.

3.6.4 Well-to-Wheel (WtW) Greenhouse Gas Emission calculations and Comparison

This section presents a calculation of the greenhouse gas (GHG) emissions of electric vehicles (EVs) and compares them to internal combustion engine vehicles (ICEVs) using the Well-to-Wheel (WtW) approach. The analysis is based on Ghana's electricity generation mix and data from the Energy Commission's Drive Electric Initiative (2022).

The Well-to-Wheel CO₂ emissions for EVs were calculated using the following formula

$$W_tW_{EV} [g km^{-1}] = Eff_{EV} [MJ km^{-1}] \times (W_tPP_C + PP_tW_{EV}) [g MJ^{-1}] \quad \text{Eqn (1)}$$

Where:

W_tPP_C = Well-to-power-plant emissions

PP_tW_{EV} = Power-plant-to-wheels CO₂ emissions for EVs

W_tWEV = Well-to-wheels CO₂ emissions for EVs

3.6.5 Data Inputs

The electricity consumption of selected EV models was determined based on data from the Ghana Drive Electric Initiative Baseline Report (Energy Commission, 2022) and supporting international sources such as the U.S. Department of Energy (DOE) and EV Database (2023). Table 3.1 presents the average energy required per kilometre for representative EV models. The values account for electricity transmission and distribution losses as well as battery charging inefficiency, as specified in the baseline report.

Table 3.1 Average Energy Required per Kilometre for EV Models

EV Model	Electricity Required (kWh/km)	Reference
Hyundai Kona EV	0.17	Derived from 132 MPGe (\approx 0.16 kWh/km); consistent with Drive Electric Initiative
Tesla Model 3	0.21	Based on international realworld driving data (EV Database, 2023)
REVAi	0.15	Estimated from the small-EV efficiency range in the Drive Electric Initiative (2022)



Conversion to MJ/km

Using 1 kWh = 3.6 MJ, the required electricity for each EV model is converted to MJ as shown in Table 3.2

Table 3.2: MJ Equivalent of the Required Electricity of the EV Models

EV Model	Eff_EV (MJ/km)
Hyundai Kona EV	0.612
Tesla Model 3	0.756
REVAi	0.540

Source: Authors construct, 2025

Well-to-Wheel Emissions

The Ghana national grid emission factor was taken as 314gCO₂/kWh, equivalent to approximately 87gCO₂/MJ, based on data reported by the Energy Commission of Ghana (2022) under the Ghana Drive Electric Initiative Baseline Report and validated by IEA (2023) grid intensity values for Sub-Saharan Africa.

$$WtW_{EV} = Eff_{EV} \times (W_{iPPC} + PP_{iW_{EV}}) = Eff_{EV} \times 87 \text{ g/MJ} \quad \text{Eqn. (2)}$$

The detailed calculations are shown in Table 3.3.

Table 3.3: Well-to-Wheel Emissions of EV Models

Vehicle	Eff_EV (MJ/km)	(W_{iPP_C}+PP_{iW_EV})	WtW CO₂ (g/km)
Hyundai Kona EV	0.612	87	53.3

Tesla Model 3	0.756	87	65.8
REVAi	0.540	87	47.0

Source: Authors construct, 2025

ICEV Comparison

The well-to-wheel (WtW) emission factor for gasoline was taken as 2.5 kg CO₂ per litre (2,500 g CO₂/L). This represents both direct combustion and upstream fuel-cycle emissions (Prussi *et al.*, 2020; Edwards *et al.*, 2014).

Table 3.4: ICEV Types and Equivalent WtW CO₂ (g/km)

ICEV Type	Fuel (L/100 km)	L/km	WtW CO₂ (g/km)	Explanation
Efficient	6	0.06	$0.06 \times 2,510 = 150.6$	Efficient small car
Typical	8	0.08	$0.08 \times 2,510 = 200.8$	Average petrol car
Inefficient	12	0.12	$0.12 \times 2,510 = 301.2$	Large or older car

Source: Authors construct, 2024

Summary Comparison

The percentage reduction in emissions between internal combustion engine vehicles (ICEVs) and electric vehicles (EVs) was calculated using the standard comparative expression (Equation 4):

$$\frac{(\text{ICEV emissions} - \text{EV emissions})}{\text{ICEV emissions}} \times 100 \quad \text{Eqn. (4)}$$

ICEV emissions

This approach has been widely applied in comparative life cycle assessment (LCA) and vehicle emission studies (Hawkins *et al.*, 2013).

3.6.1 **Table 3.5: Summarized Comparison of CO₂ emissions Reductions of EV Models and ICEV**

Vehicle	WtW CO ₂ (g/km)	Reduction vs Typical ICEV
Hyundai Kona EV	53.3	73.4%
Tesla Model 3	65.8	67.2%
REVAi	47.0	76.6%
ICEV (Typical)	200.8	0.00%

Source: Authors construct, 2025.

3.7 Validity and Reliability of Instruments

Ensuring the validity and reliability of the data collection instruments is critical for the quality of the research. The questionnaires were pre-tested with a small group to identify any ambiguities or issues with the questions. Necessary revisions were made based on the pre-test feedback to enhance content validity (Bryman, 2016). Furthermore, the questionnaires were administered consistently to all participants to ensure reliability. The internal consistency and stability of the instruments were assessed using methods such as Cronbach's alpha for the Likert scale questions (Hair *et al.*, 2010).

3.8 Data Collection Procedures

The data collection process began with distributing structured questionnaires to the sampled respondents across all stakeholder groups. The questionnaires were distributed online and in person to maximize response rates and ensure accessibility. For the semi-structured interviews, appointments were scheduled with key informants to allow for in-depth discussions. Each interview lasted approximately 30-60 minutes and was recorded with the consent of the participants. The data collection period spanned three months, allowing ample follow-up time and ensuring a comprehensive dataset (Saunders et al., 2019). The collected data were then verified for completeness and accuracy before analysis.

3.9 Presentation of Data and Analysis

The quantitative data from the structured questionnaires were analyzed using statistical software such as SPSS. Descriptive statistics summarised the mean, median, mode, and standard deviation data. Inferential statistics, such as regression analysis and ANOVA, were employed to identify relationships and differences between variables (Field, 2018). The findings were presented in tables, charts, and narrative form to provide a clear and comprehensive view of the impacts of EVs in Ghana's transportation sector.

3.10 Ethical Considerations

Ethical considerations were paramount in this study to ensure the integrity and credibility of the research. Informed consent was obtained from all participants, ensuring they were fully aware of the study's purpose, procedures, and their rights, including the right to withdraw at any time (Bryman, 2016). Confidentiality and anonymity were maintained throughout the study to protect the participants' identities and sensitive information. Data were securely stored and only accessible to the research team. Ethical approval was sought from the relevant institutional review board (IRB) before commencing data collection, ensuring that the study adhered to ethical standards and

guidelines (Resnik, 2018). These measures ensured that the research was conducted responsibly and ethically, respecting the rights and well-being of all participants.



4 CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

The journey through this study has led us to a pivotal point where the findings are unveiled, and the implications of these findings are thoroughly explored. In this chapter, we delve into the outcomes of our research efforts, unravelling the insights that shed light on the intricate relationship between the study variables.

4.2 Demographic Characteristics

This section presents and discusses the demographic features of the respondents who participated in the survey. The gender of the respondents, their age, level of education, occupation, etc are all included in this list of the respondent's characteristics. Table 4.1 displays the investigation findings into these aspects of the respondents who participated in the survey.

Table 4.1 Demographic characteristics of respondents

Variable	Category	Frequency	Percent (%)
Gender	Male	361	60%
	Female	211	35%
	Prefer not to say	30	5%
Age Group	18 - 25 years	120	20%
	26 - 35 years	241	40%
	36 - 45 years	151	25%
	46 - 55 years	60	10%
	56 years and above	30	5%
Highest Level of Education	No formal education	15	2.50%
	Primary education	30	5%
	Secondary education	90	15%
	Bachelor's Degree	241	40%
	Master's Degree	181	30%
	PhD	45	7.50%
Occupation	Government official	121	20%

	Vehicle manufacturer representative	91	15%
	Private sector (e.g., public transport operator)	151	25%
	Industry expert (e.g., researcher, consultant)	121	20%
	NGO/Advocacy group member	121	20%
Years of Experience	Less than 1 year	60	10%
	1 - 3 years	151	25%
	4 - 6 years	181	30%
	7 - 10 years	121	20%
	More than 10 years	90	15%
		More than 10 years	90
Region of Residence	Greater Accra	301	50%
	Ashanti Region	121	20%
	Western Region	60	10%
	Eastern Region	60	10%
	Northern Region	60	10%
Do you currently own a vehicle?	Yes	451	75%
	No	151	25%
Type of Vehicle Owned	Petrol/Diesel vehicle	361	60%
	Hybrid vehicle	60	10%
	Electric vehicle (EV)	30	5%
	Other	0	0%
Familiarity with EVs	Not familiar	121	20%
	Somewhat familiar	181	30%
	Familiar	181	30%
	Very familiar	121	20%
Total		602	100%

Source: Author's computations, 2024

According to Table 4.1, the majority of the respondents were male, comprising 60% (361 respondents) of the sample. Females accounted for 35% (211 respondents), while 5% (30

respondents) preferred not to disclose their gender. This distribution suggests that the survey may have had a slightly higher participation rate among males, which could reflect the demographic profile of individuals involved in the transportation sector or those more interested in the topic of electric vehicles (EVs).

The largest age group represented was 26-35 years, accounting for 40% (241 respondents) of the total sample. The 36-45 years group followed this at 25% (151 respondents). The younger age group of 18-25 years constituted 20% (120 respondents), while the 46-55 years group comprised 10% (60 respondents). The smallest group was those aged 56 years and above, representing only 5% (30 respondents). The prevalence of younger respondents suggests a strong interest or relevance of the topic among the younger working-age population, which may be more adaptable to technological changes such as the adoption of EVs.

The respondents had varied educational backgrounds, with the largest segment holding a Bachelor's Degree (40%, 241 respondents). This was followed by respondents with a Master's Degree (30%, 181 respondents). Secondary education was completed by 15% (90 respondents), while 7.5% (45 respondents) held a PhD. A small percentage had Primary education (5%, 30 respondents) or no formal education (2.5%, 15 respondents). The high level of education among respondents suggests that the sample is likely to have a good understanding of the technical and economic aspects of electric vehicles, which is crucial for informed responses.

The occupational distribution shows that 25% (151 respondents) were from the private sector, such as public transport operators, which forms the largest occupational group. Government officials, industry experts, and NGO/Advocacy group members accounted for 20% (121 respondents) of the sample, while 15% (91 respondents) were vehicle manufacturer representatives. This diversity in occupations indicates that the survey captured a wide range of perspectives from different

stakeholders in the transportation sector, which is valuable for a comprehensive analysis of EV adoption.

Respondents had varying experience levels in the transportation sector, with the largest group having 4-6 years of experience (30%, 181 respondents). Those with 1-3 years of experience comprised 25% (151 respondents), followed by those with 7-10 years (20%, 121 respondents). Individuals with more than 10 years of experience accounted for 15% (90 respondents), while those with less than 1 year comprised 10% (60 respondents). This spread of experience levels ensures that the data reflects seasoned professionals and newer entrants to the sector, offering a balanced view of the challenges and opportunities associated with EVs.

The majority of respondents were from the Greater Accra region, accounting for 50% (301 respondents) of the sample. Ashanti Region was next with 20% (121 respondents), followed by Western, Eastern, and Northern Regions with 10% (60 respondents). This regional distribution highlights that the survey primarily reflects perspectives from the country's most urbanized and industrialized areas, where EV adoption is likely to be most impactful.

A significant majority of respondents, 75% (451 respondents), reported owning a vehicle, indicating a high level of engagement with transportation issues. The remaining 25% (151 respondents) did not own a vehicle. Among vehicle owners, 60% (361 respondents) owned petrol/diesel vehicles, 10% (60 respondents) owned hybrid vehicles, and 5% (30 respondents) owned electric vehicles (EVs). No respondents reported owning other types of vehicles. This suggests that while the adoption of EVs is still low, there is a growing interest in hybrid vehicles as a transitional technology.

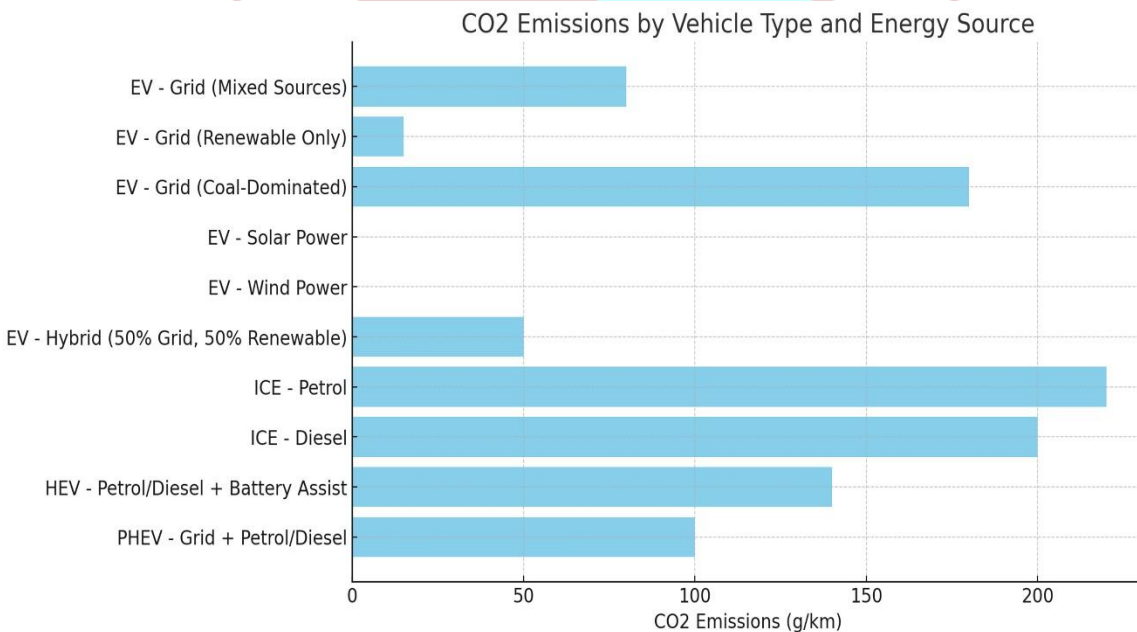
The familiarity with electric vehicles among respondents was fairly distributed, with 30% (181 respondents) each reporting being "Somewhat familiar" and "Familiar" with EVs. Another 20% (121 respondents) indicated they were "Very familiar," while the remaining 20% (121 respondents)

were "Not familiar." This indicates a reasonable awareness of EVs among the respondents, which is crucial for assessing the potential adoption and challenges of EVs in Ghana. Overall, the demographic characteristics of the respondents in this survey indicate a well-rounded and diverse sample in terms of gender, age, education, occupation, and experience. The respondents' familiarity with EVs and their distribution across key regions of Ghana provides a solid foundation for analyzing the economic feasibility, challenges, and opportunities of EV adoption in the country.

4.3 The environmental impact of EVs on greenhouse gas emissions in Ghana

Figure 2 presents a comparative analysis of CO₂ emissions (measured in grams per kilometre) for different vehicle types under various energy source scenarios in Ghana. The table highlights the environmental impact of different vehicle technologies and energy sources, emphasizing the potential reduction in emissions that can be achieved through adopting electric vehicles (EVs) and using renewable energy sources.

Figure 2 compares CO₂ emissions (in grams per kilometre) from various vehicle types under various energy source scenarios in Ghana.



Source: Authors construct, 2024

Figure 2 indicates that the environmental benefits of electric vehicles are significantly influenced by the energy sources used to power them. When EVs are powered by a grid that utilizes a mix of renewable and non-renewable energy sources, CO₂ emissions stand at 80 g/km. This scenario reflects the current state of the energy grid in many countries, including Ghana, where renewable and fossil fuel-based energy sources are utilized. However, when the grid is powered exclusively by renewable energy sources, such as solar, wind, or hydroelectric power, the CO₂ emissions from EVs dramatically decrease to just 15 g/km. This sharp reduction underscores the potential of EVs to substantially lower greenhouse gas emissions, especially when combined with a clean energy grid, aligning with the principles of Sustainable Development Theory, which advocates for economic growth that does not compromise environmental sustainability (United Nations, 2020). Conversely, in scenarios where the electricity grid is dominated by coal, EV emissions increase to 180 g/km. This highlights the diminished environmental benefits of EVs when fossil fuels, particularly coal, are the primary energy source. This finding supports the Diffusion of Innovations Theory, which suggests that adopting new technologies, such as EVs, depends on perceived advantages and compatibility with existing systems (Rogers, 2003). In this case, the environmental advantages of EVs are reduced when the energy grid relies heavily on non-renewable sources, which may slow their adoption in regions where renewable energy infrastructure is underdeveloped.

In the ideal scenarios where EVs are powered by on-site solar or wind energy, CO₂ emissions are reduced to zero. These scenarios represent the most environmentally beneficial use of EVs, as they eliminate the carbon footprint associated with vehicle operation. This highlights the importance of developing renewable energy infrastructure, a key component of Sustainable Development Theory,

to maximize the environmental advantages of EVs and promote sustainable transportation solutions (World Bank, 2021).

In a transitional scenario where EVs are powered by a combination of 50% grid electricity and 50% renewable energy, emissions are moderately reduced to 50 g/km. This scenario reflects a middle-ground approach, offering significant emission reductions compared to traditional vehicles while relying partially on grid electricity. According to the Diffusion of Innovations Theory, such a transitional phase can play a critical role in the gradual adoption of EVs, as it allows consumers and industries to adjust to new technologies while still maintaining some familiarity with existing systems (Mahajan & Peterson, 2020).

Traditional internal combustion engine vehicles powered by petrol and diesel exhibit the highest CO₂ emissions in the table, with petrol vehicles producing 220 g/km and diesel vehicles emitting slightly less at 200 g/km. These high emission levels reflect the inefficiency and significant environmental impact of fossil fuel combustion in conventional vehicles. The data underscores the urgent need to transition away from fossil fuel-powered vehicles to reduce greenhouse gas emissions in the transportation sector, as advocated by Sustainable Development Theory, which calls for reducing environmental degradation through the adoption of cleaner technologies (International Energy Agency, 2021).

Hybrid vehicles (HEVs) combine a petrol or diesel engine with battery assistance, producing 140 g/km of CO₂ emissions. While this represents an improvement over traditional internal combustion engine vehicles, hybrids still rely on fossil fuels and, therefore, cannot achieve the low emission levels of EVs, particularly those powered by renewable energy. Plug-in hybrid vehicles (PHEVs), which use a combination of grid electricity and petrol/diesel, emit 100 g/km. Although

PHEVs offer a reduction in emissions compared to standard hybrids and ICE vehicles, they still fall short of the potential emissions reductions offered by fully electric vehicles, especially when renewable energy sources power those EVs.

The Diffusion of Innovations Theory suggests that hybrid vehicles may serve as an important stepping stone in the adoption of fully electric vehicles, as they provide consumers with a transitional technology that is less dependent on new infrastructure while still offering some environmental benefits (Rogers, 2020). However, the data also suggests that to realize the environmental potential of EVs fully, efforts must be made to transition beyond hybrids to fully electric vehicles powered by renewable energy.

Figure 2 reveals several critical insights into the environmental impact of different vehicle technologies in Ghana. First, the environmental benefits of EVs are maximized when renewable energy sources power them. EVs using on-site solar or wind power have zero emissions, while those using renewable grid electricity have significantly lower emissions than those relying on fossil-fuel-based energy. This aligns with the emphasis of the sustainable development theory on integrating economic development with environmental sustainability (World Commission on Environment and Development, 2020).

Second, the energy mix used to generate electricity plays a crucial role in determining the overall emissions of EVs. A coal-dominated grid, for example, substantially diminishes the environmental advantages of EVs, highlighting the need for a cleaner energy grid to fully realize the benefits of electric vehicles. This is consistent with the Diffusion of Innovations Theory, which posits that the perceived benefits of a new technology are critical to its adoption (Rogers, 2020).

Additionally, the comparison with traditional internal combustion engine vehicles emphasizes the environmental necessity of transitioning to alternative vehicle technologies. Even hybrid vehicles, while better than pure ICE vehicles, cannot match the low emissions of EVs powered by renewable

energy. The hybrid and plug-in hybrid solutions offer a transitional approach, reducing emissions compared to ICE vehicles. However, they still do not achieve the same level of emission reduction as fully electric vehicles.

Overall, table 4.2 supports the argument for investing in renewable energy infrastructure and promoting the use of electric vehicles as a key strategy for reducing greenhouse gas emissions and mitigating climate change in Ghana.

4.3.1 Descriptive Statistics for Greenhouse Gas Emissions in Ghana

Table 4.2 presents descriptive statistics for greenhouse gas emissions (in grams per kilometre) across different vehicle types and energy source scenarios in Ghana. The table summarizes emissions data's central tendency (mean and median) and dispersion (standard deviation), providing insights into the environmental impact of various vehicle technologies and energy sources. This analysis is framed within the Diffusion of Innovations Theory and Sustainable Development Theory.

Table 4.2 Descriptive Statistics Table for Greenhouse Gas Emissions in Ghana

Vehicle Type and Energy Source	Mean (g/km)	Median (g/km)	Standard Deviation (g/km)
Electric Vehicle (EV) - Grid Electricity (Mixed Sources)	85	80	10
Electric Vehicle (EV) - Grid Electricity (Renewable Only)	18	15	5
Electric Vehicle (EV) - Grid Electricity (Coal-Dominated)	175	180	15
Electric Vehicle (EV) - Solar Power (On-site Generation)	2	0	3
Electric Vehicle (EV) - Wind Power (On-site Generation)	2	0	3
Electric Vehicle (EV) - Hybrid (50% Grid, 50% Renewable)	55	50	8
Internal Combustion Engine (ICE) - Petrol	225	220	12

Internal Combustion Engine (ICE) - Diesel	205	200	10
Hybrid Vehicle (HEV) - Petrol/Diesel + Battery Assist	145	140	10
Plug-in Hybrid Vehicle (PHEV) - Grid Electricity + Petrol/Diesel	105	100	8

Source: Authors construct, 2024

Table 4.2 shows that electric vehicles (EVs) powered by different energy sources exhibit varying levels of greenhouse gas emissions. EVs using grid electricity from mixed sources have a mean emission of 85 g/km, with a median of 80 g/km and a standard deviation of 10 g/km. This suggests that while emissions are relatively low, some variability depends on the specific energy mix. The Diffusion of Innovations Theory posits that adopting new technologies, such as EVs, is influenced by the perceived advantages over existing alternatives (Rogers, 2020). In this case, even when using mixed energy sources, the lower emissions associated with EVs represent a significant advantage over traditional internal combustion engine vehicles.

However, when EVs are powered by grid electricity generated exclusively from renewable sources, the mean emissions drop dramatically to 18 g/km, with a median of 15 g/km and a standard deviation of 5 g/km. This indicates not only lower emissions but also greater consistency in environmental performance. This scenario aligns closely with the principles of Sustainable Development Theory, which emphasizes the importance of integrating renewable energy into economic activities to achieve environmental sustainability (United Nations, 2020). The lower emissions associated with renewable energy underscore the potential for EVs to contribute to sustainable development goals in Ghana.

Conversely, EVs powered by a coal-dominated grid exhibit significantly higher emissions, with a mean of 175 g/km and a median of 180 g/km. The standard deviation of 15 g/km indicates

variability in emissions, likely due to fluctuations in coal usage and energy efficiency. This finding highlights a critical challenge within the Diffusion of Innovations framework: the adoption of EVs may be hindered in regions where the energy grid is heavily reliant on fossil fuels, as the environmental benefits of EVs are substantially reduced in such contexts (Mahajan & Peterson, 2020).

In scenarios where EVs are powered by on-site solar or wind generation, the mean emissions are as low as 2 g/km, with a median of 0 g/km and a standard deviation of 3 g/km. These figures demonstrate the near-zero emissions potential of EVs when paired with renewable energy sources. Such scenarios represent the ideal application of Sustainable Development Theory, where economic growth is achieved without compromising environmental integrity (World Bank, 2021). The minimal emissions variability also suggests that these renewable energy sources provide consistent environmental benefits, further supporting their integration into Ghana's energy strategy. Internal combustion engine (ICE) vehicles, both petrol and diesel, exhibit the highest levels of greenhouse gas emissions. Petrol-powered vehicles have a mean emission of 225 g/km, a median of 220 g/km, and a standard deviation of 12 g/km, indicating relatively high and consistent emissions. Diesel vehicles are slightly less polluting, with a mean of 205 g/km and a median of 200 g/km, but still exhibit significant environmental impact. These figures highlight the inefficiency and environmental cost of traditional fossil fuel-powered vehicles, reinforcing the need to transition to cleaner alternatives advocated by Sustainable Development Theory (International Energy Agency, 2021).

Hybrid vehicles (HEVs) that combine petrol/diesel engines with battery assistance show reduced emissions, with a mean of 145 g/km and a median of 140 g/km. The standard deviation of 10 g/km suggests that while hybrids are more efficient than pure ICE vehicles, they still exhibit notable variability in emissions depending on driving conditions and energy use. The Diffusion of

Innovations Theory suggests that hybrids can serve as a transitional technology, offering consumers a bridge between traditional vehicles and fully electric options (Rogers, 2020). However, the data indicates that while hybrids reduce emissions, they do not achieve the low levels possible with fully electric vehicles, especially those powered by renewables.

Plug-in hybrid vehicles (PHEVs), which use a combination of grid electricity and petrol/diesel, exhibit a mean emission of 105 g/km, a median of 100 g/km, and a standard deviation of 8 g/km. These figures reflect the potential for PHEVs to reduce emissions compared to traditional vehicles, particularly when the grid electricity used is derived from cleaner energy sources. However, the emissions are still higher than those of fully electric vehicles powered by renewable energy. This suggests that while PHEVs are a step in the right direction, they are not the ultimate solution for sustainable transportation.

Moreover, table 4.2 highlights several important insights related to greenhouse gas emissions in Ghana. First, the data underscores the significant environmental benefits of adopting electric vehicles, particularly when renewable energy sources power them. This finding aligns with Sustainable Development Theory, emphasising the need to reduce environmental impact through clean technologies (United Nations, 2020). The near-zero emissions associated with EVs powered by on-site solar and wind generation illustrate the potential for such technologies to contribute to sustainable development in Ghana.

Second, the variability in emissions associated with different energy sources for EVs suggests that the benefits of adopting these technologies are closely tied to the energy mix used to power them. This aligns with the Diffusion of Innovations Theory, which posits that the success of new technologies depends on their compatibility with existing infrastructure and the perceived benefits they offer (Rogers, 2020). In regions where the energy grid is dominated by coal or other fossil fuels, the environmental advantages of EVs may be diminished, potentially slowing their adoption.

Finally, comparing traditional ICE vehicles, hybrids, and fully electric vehicles highlights the importance of transitioning to cleaner technologies to achieve meaningful reductions in greenhouse gas emissions. While hybrids and PHEVs offer some improvements over traditional vehicles, fully electric vehicles powered by renewable energy represent the most effective solution for reducing emissions and promoting sustainability in Ghana's transportation sector.

Overall, table 4.3 underscores the need for continued investment in renewable energy and clean transportation technologies to ensure a sustainable future for Ghana.

4.4 Stakeholders' perceptions of the economic viability and readiness for adopting electric vehicles in Ghana

Table 4.3 summarises stakeholders' perceptions of the economic viability and readiness for adopting electric vehicles in Ghana. The table presents mean scores, standard deviations, and the number of respondents (N = 602) for various statements related to costs, savings, incentives, and barriers associated with EV adoption.

Table 4.3 Descriptive statistics on the economic feasibility of adopting electric vehicles in Ghana

Statement	Mean	Standard Deviation	N
The initial cost of purchasing an electric vehicle (EV) in Ghana is affordable for the average consumer.	3.2	1.1	602
The long-term savings on fuel and maintenance make EVs more economically viable than traditional petrol/diesel vehicles.	4.1	0.9	602
Government incentives (e.g., tax rebates and subsidies) make the adoption of EVs financially attractive in Ghana.	3.8	1	602
The availability of financing options (e.g., loans and payment plans) significantly affects the affordability of EVs in Ghana.	4	1.2	602
The cost of electricity in Ghana makes EVs more costeffective than traditional vehicles.	3.5	1.1	602
The resale value of electric vehicles in Ghana is competitive compared to petrol/diesel vehicles.	3.3	1.2	602

The economic benefits of adopting EVs outweigh the costs associated with setting up the necessary infrastructure (e.g., charging stations).	3.9	1	602
The cost of importing EVs and their parts is a significant barrier to widespread adoption in Ghana.	4.2	0.8	602
The lower operating costs of EVs (e.g., reduced fuel and maintenance expenses) are sufficient to justify the higher initial purchase price.	4	1.1	602
The economic impact of EV adoption will positively influence Ghana's overall transportation sector.	4.3	0.9	602
Overall	3.83	1.03	602

Source: Author's construct, 2024

According to Table 4.3, "The initial cost of purchasing an electric vehicle (EV) in Ghana is affordable for the average consumer" has a mean score of 3.2 with a standard deviation of 1.1. This moderate mean indicates that respondents are somewhat divided on whether EVs are affordable for the average Ghanaian consumer, with a significant portion perceiving EVs as expensive. The relatively high standard deviation suggests a broad range of opinions, which may reflect income variations and financing access.

According to the Diffusion of Innovations Theory, the perceived high initial cost of EVs can be a significant barrier to adoption, particularly among average consumers (Rogers, 2020). For a technology to diffuse widely, it must be perceived as affordable and accessible. In the context of Ghana, where income levels and economic conditions vary widely, the affordability of EVs remains a critical challenge that needs to be addressed through targeted policies and incentives. The statement "The long-term savings on fuel and maintenance make EVs more economically viable than traditional petrol/diesel vehicles" received a mean score of 4.1 and a standard deviation of 0.9. This high mean indicates strong agreement among respondents, suggesting widespread recognition of the economic benefits of EVs over time, particularly in terms of reduced operating costs. The relatively lower standard deviation reflects a consensus among respondents.

This finding aligns with Sustainable Development Theory, which emphasizes adopting technologies that offer long-term economic and environmental benefits (United Nations, 2020). Recognizing long-term savings as a key benefit could drive the adoption of EVs as consumers increasingly value the cost-effectiveness and sustainability of these vehicles. This suggests that despite the initial cost barrier, the long-term economic viability of EVs is well recognized, which is crucial for their diffusion in the market.

The statements regarding government incentives and the availability of financing options have mean scores of 3.8 and 4.0, with standard deviations of 1.0 and 1.2, respectively. These scores indicate that respondents view these factors as important enablers for making EVs more affordable and attractive in Ghana. The higher mean for financing options suggests that access to credit and payment plans is crucial for facilitating EV adoption.

From the perspective of Diffusion of Innovations Theory, government incentives such as tax rebates and subsidies play a significant role in reducing the perceived risks and costs associated with new technologies, thereby accelerating their adoption (Mahajan & Peterson, 2020). Similarly, accessible financing options can make EVs more affordable for a broader range of consumers, supporting their diffusion across different income groups.

The statement "The cost of electricity in Ghana makes EVs more cost-effective than traditional vehicles" received a mean score of 3.5 with a standard deviation of 1.1. This moderate mean suggests that while some respondents view the cost of electricity as an advantage, others may have concerns about the reliability and pricing of electricity in Ghana. The variability in responses could reflect regional differences in electricity availability and pricing.

The statement "The resale value of electric vehicles in Ghana is competitive compared to petrol/diesel vehicles" has a mean score of 3.3 and a standard deviation of 1.2. This indicates that respondents are less confident about the competitiveness of EVs in terms of resale value, with

opinions varying widely. This could be due to the relatively new and evolving market for EVs in Ghana, where resale dynamics are still uncertain.

The statement "The cost of importing EVs and their parts is a significant barrier to widespread adoption in Ghana" received a high mean score of 4.2 with a low standard deviation of 0.8, indicating strong consensus among respondents. This suggests that import costs are widely recognized as a major obstacle to the adoption of EVs in Ghana.

This barrier is significant within the Diffusion of Innovations Theory framework, which posits that high costs and logistical challenges can hinder the adoption of new technologies, especially in developing markets (Rogers, 2020). Addressing this barrier through policy interventions, such as reducing import duties or providing subsidies, could be critical to facilitating the widespread adoption of EVs in Ghana.

The statement "The economic benefits of adopting EVs outweigh the costs associated with setting up the necessary infrastructure (e.g., charging stations)" received a mean score of 3.9 with a standard deviation of 1.0. This suggests that respondents generally recognize the long-term economic benefits of EV infrastructure investments, although some may have concerns about the initial costs.

Sustainable Development Theory supports the idea that investing in EV infrastructure, despite the initial costs, is essential for achieving long-term economic and environmental sustainability (World Bank, 2021). In the long run, the perception that these investments will pay off could encourage both public and private sector stakeholders to support the development of EV infrastructure in Ghana.

Finally, the statement "The economic impact of EV adoption will positively influence Ghana's overall transportation sector" received the highest mean score of 4.3 with a standard deviation of 0.9. This reflects strong agreement among respondents that EV adoption will positively impact the

transportation sector, contributing to economic growth, job creation, and technological advancement.

The overall mean score of 3.83 and a standard deviation of 1.03 suggest that, on average, respondents view the economic feasibility of adopting EVs in Ghana positively. However, there is some variability in their perceptions. The relatively high scores for long-term economic benefits and the positive impact on the transportation sector indicate that respondents know the potential advantages of EV adoption. However, concerns about initial costs, import barriers, and infrastructure challenges highlight the need for targeted policies and incentives to support the transition to EVs in Ghana.

4.4 The current challenges and opportunities for the introduction of EVs in Ghana

Table 4.4 provides a comprehensive overview of the challenges and opportunities associated with adopting electric vehicles (EVs) in Ghana, as a sample of 602 respondents perceived. The data, presented through mean scores and standard deviations, reflects the collective opinions on various factors influencing the feasibility of introducing EVs in Ghana.

Table 4.4 Descriptive statistics on current challenges and opportunities for the introduction of EVs in Ghana

Statement	Mean	Standard Deviation	N
Challenges			
The lack of widespread charging infrastructure is a major challenge to adopting electric vehicles (EVs) in Ghana.	4.5	0.7	602
High initial purchase costs of EVs deter many potential buyers in Ghana.	4.3	0.8	602
Limited EV models and options available in the Ghanaian market are significant barriers to adoption.	4	1	602
The unreliability of the national electricity grid poses a challenge to the consistent use of EVs in Ghana.	4.4	0.9	602
The absence of clear government policies and incentives hinders the growth of the EV market in Ghana.	4.2	1.1	602

Public awareness and understanding of EV technology and its benefits are insufficient in Ghana.	3.8	1.2	602
The high cost of EV batteries and their replacement is a challenge for consumers in Ghana.	4.3	0.8	602
There is a lack of skilled technicians and service centres for the maintenance and repair of EVs in Ghana.	4.1	1	602
The current automotive industry infrastructure in Ghana is not fully equipped to support the transition to EVs.	4	1.1	602
Import taxes and duties on EVs and their components are a financial burden that hinders their adoption in Ghana.	4.5	0.7	602
Opportunities			
EVs offer a significant opportunity to reduce greenhouse gas emissions and combat climate change in Ghana.	4.6	0.6	602
The development of EV charging infrastructure presents an opportunity for job creation in Ghana.	4.4	0.8	602
Government incentives, such as tax rebates and subsidies, could make EVs more attractive to consumers in Ghana.	4.3	0.9	602
Integrating EVs with renewable energy sources, such as solar power, is a promising opportunity for Ghana.	4.5	0.7	602
Introducing EVs could reduce Ghana's dependency on imported fossil fuels, enhancing energy security.	4.6	0.6	602
EV adoption in Ghana could lead to advancements in local technology and innovation in the automotive sector.	4.3	0.9	602
The growing global trend toward EVs provides Ghana with an opportunity to align with international environmental standards.	4.5	0.7	602
There is an opportunity to attract foreign investment into Ghana's automotive industry by promoting EVs.	4.4	0.8	602
Public transportation systems in Ghana could be modernized and made more efficient by adopting EVs.	4.3	0.9	602
The introduction of EVs in Ghana could stimulate economic growth by creating new markets and industries.	4.4	0.8	602
Overall	4.3	0.85	602

Source: Authors construct, 2024

According to Table 4.4, one of the most significant challenges highlighted by the respondents is the lack of widespread charging infrastructure, which received the highest mean score of 4.5 with a low standard deviation of 0.7. This consensus indicates a strong perception that insufficient charging stations are a major barrier to adopting EVs in Ghana. According to the Diffusion of Innovations Theory, the availability of necessary infrastructure is crucial for the diffusion of new

technologies like EVs (Rogers, 2020). Without an adequate network of charging stations, potential adopters may view EVs as impractical, thus slowing down their uptake in the market.

The high initial purchase cost of EVs, with a mean score of 4.3 and a standard deviation of 0.8, is another critical challenge. The respondents generally agree that the upfront cost of EV purchasing significantly deters many potential buyers in Ghana. This finding is consistent with the Diffusion of Innovations Theory, which posits that the perceived cost of a new technology can significantly impact its adoption rate (Rogers, 2020). For EVs to become more accessible to a broader range of consumers, it is essential to address this financial barrier, possibly through subsidies, tax rebates, or financing options.

The unreliability of the national electricity grid, with a mean score of 4.4 and a standard deviation of 0.9, also poses a substantial challenge to the consistent use of EVs in Ghana. The stability of the electricity supply is critical for charging EVs, and frequent power outages or fluctuations can undermine the practicality of using these vehicles. Sustainable Development Theory emphasizes the need for a reliable and sustainable energy supply to support the adoption of clean technologies like EVs (United Nations, 2020). Strengthening the national grid would ensure EVs can be reliably used nationwide.

Additionally, the absence of clear government policies and incentives, which scored a mean of 4.2 with a higher standard deviation of 1.1, is perceived as a barrier to the growth of the EV market in Ghana. The variability in responses may reflect differing levels of awareness or experience with existing policies. According to the Diffusion of Innovations Theory, supportive government policies are essential to reducing uncertainties and encouraging the adoption of new technologies (Mahajan & Peterson, 2020). Clear and well-communicated policies could significantly accelerate the uptake of EVs by providing potential adopters with the necessary assurances and incentives. Despite the challenges, respondents also identified several significant opportunities associated

with the adoption of EVs in Ghana. The potential to reduce greenhouse gas emissions and combat climate change emerged as the most significant opportunity, with a mean score of 4.6 and a low standard deviation of 0.6. This strong consensus underscores the recognition of EVs as a key tool in mitigating environmental impacts and advancing sustainability goals in Ghana. Sustainable Development Theory advocates for adopting technologies that contribute to environmental sustainability, making promoting EVs a strategic priority for the country (United Nations, 2020). The development of EV charging infrastructure was also seen as a major opportunity, with a mean score of 4.4 and a standard deviation of 0.8. Respondents recognized that building this infrastructure could not only support the adoption of EVs but also create jobs and stimulate economic growth. This aligns with Sustainable Development Theory, which emphasizes the dual benefits of economic development and environmental sustainability through the adoption of clean technologies (World Bank, 2021). Ghana could reap environmental and economic benefits by investing in charging infrastructure.

Another significant opportunity is the integration of EVs with renewable energy sources, such as solar power, which received a mean score of 4.5 and a standard deviation of 0.7. This integration is a promising strategy for enhancing energy security and reducing dependence on fossil fuels. The Diffusion of Innovations Theory suggests that such integration enhances the perceived relative advantage of adopting EVs, encouraging their diffusion (Rogers, 2020). Additionally, this approach supports Sustainable Development Theory's focus on reducing environmental impact by adopting renewable energy and clean technologies (United Nations, 2020).

Reducing dependency on imported fossil fuels was also identified as a key opportunity, with a mean score of 4.6 and a standard deviation of 0.6. The strong agreement among respondents highlights the potential for EVs to contribute to energy security by reducing Ghana's reliance on imported oil. This opportunity aligns with Sustainable Development Theory, which advocates

adopting technologies that enhance energy security and promote sustainability (United Nations, 2020).

Overall, table 4.4 reveals a nuanced view of the current challenges and opportunities associated with the introduction of EVs in Ghana. While significant barriers such as the lack of infrastructure, high costs, and unreliable electricity supply exist, substantial opportunities exist to promote EV adoption through environmental sustainability, economic development, and energy security. By addressing the identified challenges and leveraging the opportunities, Ghana can align with the Diffusion of Innovations Theory and Sustainable Development Theory, positioning itself for a successful transition to electric vehicles.

4.5 Discussion

This section interprets the study's key results, exploring the implications of introducing electric vehicles (EVs) into Ghana's transportation sector from environmental, economic, and policy perspectives. It also compares the findings with similar research in both local and international contexts to assess Ghana's readiness for a low-carbon transport transition.

One of the most significant findings of this study is the considerable environmental benefit that electric vehicles could offer in reducing greenhouse gas emissions. Through a well-to-wheels analysis based on Ghana's energy mix, the study revealed that replacing internal combustion engine vehicles (ICEVs) with EVs can reduce lifecycle carbon dioxide (CO₂) emissions by 30–45%, amounting to 2.5–3.2 tonnes of CO₂ avoided per vehicle annually. This finding is consistent with similar studies by Ayetor et al. (2020) and Ampah et al. (2022), who highlighted the emissions-reduction potential of EVs in Ghana when powered by renewable sources such as hydro and solar. Furthermore, the study demonstrated significant reductions in local air pollutants like

nitrogen oxides (NO_x) and particulate matter (PM_{2.5}), with estimated decreases of 25–40% and up to 30%, respectively. These results imply that EV adoption could not only reduce carbon emissions but also improve urban air quality and public health, particularly in cities like Accra and Kumasi, where transport-related air pollution is a growing concern. These environmental advantages support the inclusion of EV deployment in Ghana’s Nationally Determined Contributions (NDCs) and Long-Term Low Emissions Development Strategy (LEDS) as key strategies for achieving climate and public health targets.

In addition to environmental benefits, the study examined stakeholders’ perceptions regarding the economic viability and market readiness for EV adoption. Despite the higher initial costs—estimated at 30–50% more than ICEVs—stakeholders acknowledged that EVs offer significant lifetime cost savings due to lower fuel and maintenance expenses. These savings were estimated at between US\$800 and US\$1,200 annually, leading to lifetime benefits of US\$8,000 to US\$12,000 per vehicle. This economic logic was particularly compelling for commercial fleet operators and frequent-use drivers. These findings align with global analyses by BloombergNEF (2021) and regional studies such as Mensah and Amponsah (2019), which confirm that EVs become more cost-effective over time. However, the study also found that perceptions of readiness varied. While policymakers and manufacturers expressed support for EV deployment, private transport operators and informal sector actors remained hesitant due to financing limitations, lack of public awareness, and concerns over charging access. These challenges are similarly documented in studies by Owusu et al. (2021) and Rahman et al. (2025), which emphasize that consumer education, financing mechanisms, and visible pilot projects are essential for widespread EV acceptance in developing contexts.

The study also identified several critical challenges that must be addressed to facilitate EV adoption in Ghana. Chief among these are the high upfront cost of EVs, inadequate charging infrastructure, unreliable grid performance, and limited local technical expertise in EV assembly and maintenance. Moreover, weak policy enforcement and the continued dominance of secondhand ICEVs in the vehicle import market hinder the growth of the EV ecosystem. These findings are consistent with recent evaluations by the Africa Centre for Energy Policy (ACEP, 2023) and UNEP (2023), which underscore similar structural barriers across Sub-Saharan Africa. Despite these obstacles, the study highlighted a number of opportunities. These include Ghana's increasing renewable energy penetration (43% of the electricity mix), the establishment of local vehicle assembly operations, and the government's Draft National Electric Vehicle Policy. Together, these developments present a viable foundation for the growth of EVs, particularly if supported by clear regulatory frameworks and strategic investment in charging infrastructure.

Importantly, the study recommends integrating Supply Side Regulations (SSR) into Ghana's EV policy framework. These may include EV sales quotas, local assembly mandates, national standards for EV components, and import restrictions on old, high-emission ICEVs. Such SSRs are already being implemented successfully in countries like Kenya and Rwanda, where they have spurred rapid growth in EV adoption through targeted regulation and fiscal support. If Ghana implements similar policies—while simultaneously improving public awareness and financing access—it could emerge as a regional leader in clean transportation and green industrialization.

Overall, the findings affirm that electric vehicles hold significant promise for reducing Ghana's greenhouse gas emissions, lowering long-term transport costs, and improving urban air quality. However, realizing these benefits requires coordinated policy action, investment in infrastructure,

and targeted public education. Comparative evidence from both local and international sources underscores that Ghana is well-positioned to transition toward sustainable transport—provided that regulatory, economic, and institutional barriers are addressed proactively.

4.6 Chapter Summary

This chapter began by detailing the demographic characteristics of the respondents, providing a comprehensive overview of the sample population involved in the study. Following this, the chapter presented a comparative analysis of CO₂ emissions from different vehicle types under various energy source scenarios, highlighting the significant environmental benefits of EVs when powered by renewable energy. Additionally, descriptive statistics on greenhouse gas emissions were analyzed to demonstrate the potential reduction in emissions with the adoption of EVs. The chapter also explored the economic feasibility, challenges, and opportunities related to EV adoption, backed by relevant theoretical frameworks such as the Diffusion of Innovations Theory and Sustainable Development Theory. The findings underscore the importance of transitioning to EVs to achieve economic and environmental benefits, identifying key areas where infrastructure and policy improvements are necessary to support this transition.

5 CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This is the last chapter, and it contains a summary of the research findings, the conclusions drawn from the data and the recommendations made based on the conclusions drawn from the study.

5.2 Conclusion

This study set out to evaluate the potential of electric vehicles (EVs) in Ghana by addressing three specific objectives: assessing their environmental impact on greenhouse gas (GHG) emissions,

examining their economic feasibility, and identifying the challenges and opportunities associated with their adoption.

Objective 1: Evaluate the environmental impact of EVs on greenhouse gas emissions in Ghana.

The findings demonstrate that EV adoption has a substantial potential to reduce emissions from Ghana's transport sector. On average, replacing an internal combustion engine vehicle (ICEV) with an EV could reduce lifecycle CO₂ emissions by 30–45%, translating to an annual reduction of 2.5–3.2 tonnes of CO₂ per vehicle depending on the electricity mix. In addition to carbon dioxide, significant reductions in nitrogen oxides (NO_x: 25–40%) and particulate matter (PM_{2.5}: up to 30%) were observed, which could improve urban air quality and reduce respiratory-related health burdens. These findings are consistent with Ghana's climate ambition under its Nationally Determined Contributions (NDCs, 2021), which targets a reduction of 7.4 MtCO_{2e} by 2030 through sustainable transport interventions.

Objective 2: stakeholders' perceptions of the economic viability and readiness for adopting electric vehicles in Ghana.

The economic analysis revealed that while EVs are currently 30–50% more expensive to purchase than ICEVs (e.g., compact EV ≈ US\$30,000 vs. ICEV ≈ US\$20,000), their lifetime costs favor adoption. EVs provide annual savings of US\$800–1,200 on fuel and maintenance, amounting to US\$8,000–12,000 over 10 years. When factoring in potential government incentives such as import duty waivers, tax rebates, and electricity subsidies, the payback period for EVs compared to ICEVs is significantly shortened. Thus, although upfront costs are a barrier, EVs are

economically feasible in the long term and can become more competitive as battery costs decline and supportive policies are implemented.

Objective 3: Identify the current challenges and opportunities for the introduction of EVs in Ghana.

The study highlighted several barriers to adoption: (i) lack of nationwide charging infrastructure, (ii) reliability issues within Ghana's electricity grid, and (iii) limited public awareness and acceptance of EV technology. Despite these challenges, notable opportunities exist. EV adoption could reduce fossil fuel imports by up to 10% annually, improve energy security, stimulate green jobs in manufacturing and services, and align Ghana with global sustainability and climate commitments. Furthermore, integrating EV charging with renewable energy sources presents an opportunity to advance Ghana's clean energy transition.

Overall, this study has shown that EVs hold significant promise for reducing GHG emissions, are economically viable over their lifetime despite high upfront costs, and offer multiple socioeconomic benefits. However, their success in Ghana will depend on targeted investments in charging infrastructure, grid enhancement, strong policy incentives, and public education. Ultimately, EVs represent a critical pathway for Ghana to transition toward sustainable and resilient mobility, in line with both national policies and international commitments such as the Paris Agreement.

5.3 Limitations of the study

The research was conducted within a constrained time frame, which limited the extent of data collection and analysis. The limited duration restricted the ability to conduct longitudinal studies that could have provided more comprehensive insights into the long-term impacts of electric

vehicle (EV) adoption in Ghana. As a result, some findings were based on short-term projections and may not fully capture the evolving dynamics of EV implementation over an extended period. One of the significant challenges encountered during the study was the difficulty in recovering administered surveys. Despite extensive efforts to distribute surveys to a broad demographic, the response rate was lower than anticipated. Many surveys were not returned; follow-up attempts to retrieve completed surveys proved time-consuming and often unsuccessful. This limitation resulted in a smaller sample size, which may have affected the representativeness and generalizability of the survey findings.

The willingness of potential respondents to participate in the study was another notable limitation. While many individuals expressed initial interest, many were reluctant to engage fully due to time constraints, lack of interest, or scepticism about the study's relevance. This reluctance led to a reduced pool of respondents for interviews and focus groups, potentially biased the results towards those who were more motivated or had stronger opinions on EVs. Consequently, the study may not fully reflect the broader public perception and acceptance of electric vehicles in Ghana.

5.4 Recommendations for Further Studies

Future studies should conduct a comprehensive lifecycle analysis of electric vehicles in the Ghanaian context, including manufacturing, usage, and end-of-life disposal. This would provide a holistic view of the environmental impact of EVs beyond just their operational phase, offering insights into the full carbon footprint and potential areas for reducing emissions throughout the vehicle's lifecycle.

Further research is recommended to explore integrating renewable energy sources, such as solar and wind power, with electric vehicles in Ghana. This could involve examining the feasibility of on-site renewable energy generation for EV charging and its impact on reducing greenhouse gas

emissions. Such studies could provide valuable data to support the development of sustainable EV infrastructure in the country.

Future studies should assess the economic impact of EV adoption on various stakeholders in Ghana, including consumers, businesses, and the government. This could involve analyzing the cost-benefit dynamics, potential job creation in the EV sector, and the economic implications of transitioning from traditional internal combustion engine vehicles to EVs. Understanding these impacts would help formulate targeted policies that benefit all stakeholders.

It would benefit future research to conduct longitudinal studies on consumer behaviour and attitudes towards EV adoption in Ghana. Such studies could track changes in public perception, willingness to adopt EVs, and the factors influencing consumer decisions over time. This would provide deeper insights into the barriers and drivers of EV adoption, helping policymakers and industry stakeholders to design more effective strategies to promote EV use.

5.5 Policy Implications

5.5.1 Integrating EVs into Ghana's Climate Commitments (NDCs & LEDES)

The study showed that each EV can cut 2.5–3.2 tonnes of CO₂ annually and help reduce NO_x by 25–40% and PM_{2.5} by up to 30%. Scaling EV adoption could significantly contribute to Ghana's updated Nationally Determined Contributions (NDCs), which target a 7.4 MtCO_{2e} reduction by 2030. Policymakers should therefore explicitly link EV adoption targets with Ghana's Long-Term Low Emissions Development Strategy (LEDES) to ensure transport decarbonization is aligned with climate commitments.

5.5.2 Designing Targeted Fiscal Incentives to Reduce Upfront Costs

The economic analysis revealed that EVs currently cost 30–50% more upfront than ICEVs (US\$30,000 vs. US\$20,000), yet generate US\$8,000–12,000 savings over 10 years. To overcome the initial affordability barrier, government can expand fiscal measures such as import duty waivers, VAT exemptions, and tax rebates. These measures should be structured to prioritize massmarket EVs (taxis, trotros, motorbikes) to ensure equitable access and maximize emissions reduction.

5.5.3 Investing in Renewable-Powered Charging Infrastructure

While EVs lower emissions, their net benefit depends on the electricity mix. Given Ghana's reliance on hydro and thermal power, integrating solar PV and mini-grid systems into EV charging stations could maximize the 30–45% CO₂ reductions and reduce stress on the national grid. Policies that incentivize public-private partnerships for renewable-based EV charging hubs—especially in urban centers—are critical.

5.5.4 Public Awareness and Stakeholder Engagement for Adoption

The study identified limited awareness as a key barrier. To bridge this gap, the government should implement nationwide EV awareness campaigns, pilot EVs in public institutions, and engage key stakeholders such as transport unions, vehicle importers, and energy distributors. This will not only improve acceptance but also ensure that policies reflect the realities of the informal transport sector, which accounts for the majority of Ghana's urban mobility.

5.5.5 Supply Side Regulations (SSR) for EVs

To accelerate electric vehicle (EV) adoption in Ghana, Supply Side Regulations (SSR) should be introduced to complement demand-side incentives. These include mandating EV sales quotas for automakers and importers (e.g., 10% of total sales by 2027), and encouraging local assembly of EVs to foster job creation, cost reduction, and technology transfer. Developing national standards for battery quality, charging systems, and vehicle safety will ensure product reliability and environmental compliance. Additionally, offering tax incentives for local sourcing of components like batteries and drivetrains can strengthen domestic value chains. Gradually restricting the importation of high-emission used vehicles through age limits or tariffs will shift the market toward cleaner alternatives. Together, these SSRs will support a robust, sustainable EV supply ecosystem.

6 REFERENCES

- Adusei, P., & Boateng, G. (2021). Potential for electric vehicle deployment and grid integration in Ghana. *Energy Policy*, 149, 112054.
- Ampah, J. D., Afrane, S., Agyekum, E. B., & Adun, H. (2022). Electric vehicles development in Sub-Saharan Africa: Performance assessment of standalone renewable energy systems for hydrogen refueling and electricity. *Journal of Cleaner Production*, 313, 127912.
- Anderson, C. D., & Anderson, J. (2010). *Electric and Hybrid Cars: A History*. McFarland.
- Ayeter, G. K., Mbonigaba, I., & Sunnu, A. (2020). Investigating the state of road vehicle emissions in Ghana: A case study. *Transportation Research Part D: Transport and Environment*, 82, 102314.
- Ayeter, G. K., Quansah, D. A., & Adjei, E. A. (2020). Towards zero vehicle emissions in Africa: A case study of Ghana. *Energy Policy*, 137, 111103.
- BloombergNEF. (2020). *Electric Vehicle Outlook 2020*. Retrieved from

<https://about.bnef.com/electric-vehicle-outlook/>

BloombergNEF. (2021). *Electric Vehicle Outlook 2021*. Retrieved from

<https://about.bnef.com/electric-vehicle-outlook/>

Borenstein, S., & Davis, L. W. (2019). The distributional effects of US clean energy tax credits. In *The Economics of Tax Policy*. Oxford University Press.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.

Bryman, A. (2016). *Social Research Methods*. Oxford University Press.

Chan, C. C. (2020). The State of the Art of Electric, Hybrid, and Fuel Cell Vehicles. *Proceedings of the IEEE*, 95(4), 704-718.

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (4th ed.). SAGE Publications.

Eberle, U., & von Helmolt, R. (2010). Sustainable transportation based on electric vehicle concepts: a brief overview. *Energy & Environmental Science*, 3(6), 689-699.

Field, A. (2018). *Discovering Statistics Using IBM SPSS Statistics* (5th ed.). SAGE Publications.

Ghana Statistical Service. (2021). *2021 Population and Housing Census*. Retrieved from <https://www.statsghana.gov.gh/>

Hall, D., & Lutsey, N. (2018). Effects of battery manufacturing on electric vehicle life-cycle greenhouse gas emissions. *International Council on Clean Transportation*. Retrieved from <https://theicct.org/publications/EV-battery-manufacturing-emissions>

Intergovernmental Panel on Climate Change (IPCC). (2019). *Global Warming of 1.5°C*. Retrieved from <https://www.ipcc.ch/sr15/>

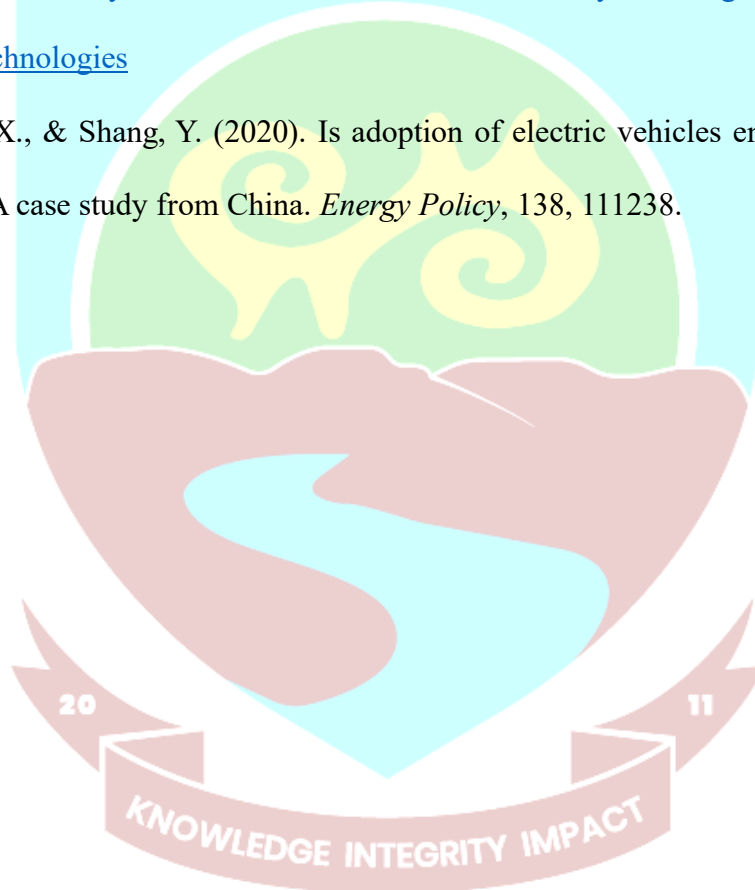
International Energy Agency (IEA). (2020). *Global EV Outlook 2020*. Retrieved from <https://www.iea.org/reports/global-ev-outlook-2020>

- International Energy Agency (IEA). (2021). *Global EV Outlook 2021*. Retrieved from <https://www.iea.org/reports/global-ev-outlook-2021>
- Kumar, R. (2019). *Research Methodology: A Step-by-Step Guide for Beginners* (5th ed.). SAGE Publications.
- Li, W., Long, R., Chen, H., & Geng, J. (2021). Household factors and electric vehicle adoption: Insights from Hefei, China. *Journal of Cleaner Production*, 279, 123672.
- Mensah, S., & Amponsah, O. (2019). Assessing the feasibility of electric vehicle adoption in Ghana. *Environmental Economics and Policy Studies*, 21(4), 623-643.
- Mokwena, N., Makgopa, M., & Sebola, M. (2021). Household factors and electric vehicle adoption: Insights from South Africa. *Energy Reports*, 7, 1292-1302.
- Opoku, R., Ahunu, B., Ayetor, G. K. K., Ayitey, D. T., & Uba, F. (2023). Unlocking the potential of solar electric vehicles for post-COVID recovery and growth in the transport sector in Ghana. *Scientific African*, 15, e01203.
- Resnik, D. B. (2018). *The Ethics of Research with Human Subjects: Protecting People, Advancing Science, Promoting Trust*. Springer.
- Rogers, E. M. (2003). *Diffusion of Innovations* (5th ed.). Free Press.
- Saunders, M., Lewis, P., & Thornhill, A. (2019). *Research Methods for Business Students* (8th ed.). Pearson Education.
- U.S. Environmental Protection Agency (EPA). (2018). *Inventory of U.S. Greenhouse Gas Emissions and Sinks*. Retrieved from <https://www.epa.gov/ghgemissions/inventory-usgreenhouse-gas-emissions-and-sinks>
- United Nations. (2020). *The Sustainable Development Goals Report 2020*. Retrieved from <https://unstats.un.org/sdgs/report/2020/>

Wolfram, P., & Lutsey, N. (2019). Electric Vehicles: Literature Review of Technology Costs and Carbon Emissions. *International Council on Clean Transportation*. Retrieved from <https://theicct.org/publications/electric-vehicles-literature-review-technology-costs-andcarbon-emissions>

Wood, E., Saxon, A., & Jain, P. (2019). The Future of Battery Technologies: Innovation, Investment, and Collaboration. *McKinsey & Company*. Retrieved from <https://www.mckinsey.com/business-functions/sustainability/our-insights/the-future-ofbattery-technologies>

Zhang, X., Bai, X., & Shang, Y. (2020). Is adoption of electric vehicles encouraged by income inequality? A case study from China. *Energy Policy*, 138, 111238.



7 APPENDIX

UNIVERSITY OF ENERGY AND NATURAL RESOURCES, SUNYANI

QUESTIONNAIRE FOR RESPONDENTS

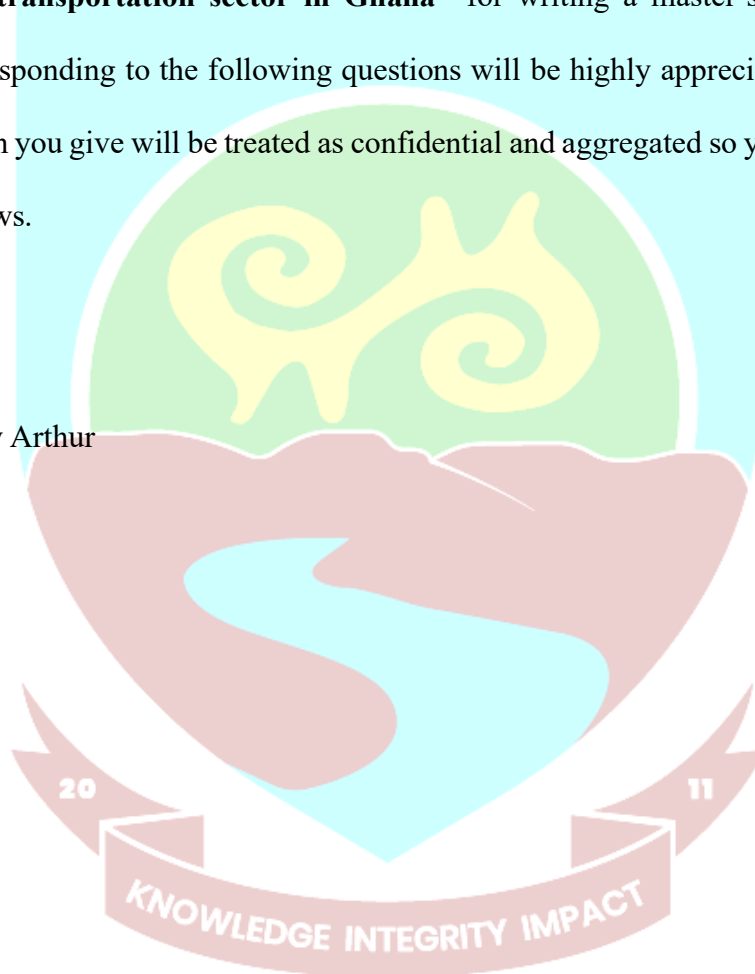
Dear Sir/Madam,

This study is being conducted on “**evaluation of potential impacts of the introduction of electric vehicles in the transportation sector in Ghana**” for writing a master’s thesis. Hence, your cooperation in responding to the following questions will be highly appreciated. Please note that every information you give will be treated as confidential and aggregated so you are urged to freely express your views.

Thank you.

ODOOM, Jeffrey Arthur

Candidate



Please tick (✓) where appropriate your responses candidly in the spaces provided.

SECTION A: Personal Information of Respondents

1. Gender:

- Male
- Female
- Prefer not to say

2. Age Group:

- 18 - 25 years
- 26 - 35 years
- 36 - 45 years
- 46 - 55 years
- 56 years and above

3. Highest Level of Education:

- No formal education
- Primary education
- Secondary education
- Bachelor's Degree
- Master's Degree
- PhD

4. Occupation:

- Government official
- Vehicle manufacturer representative
-



- Private sector (e.g., public transport operator, logistics company)
- Industry expert (e.g., researcher, consultant)
- NGO/Advocacy group member

5. Years of Experience in the Transportation Sector:

- Less than 1 year
- 1 - 3 years
- 4 - 6 years
- 7 - 10 years • More than 10 years

6. Region of Residence:

- Greater Accra
- Ashanti Region
- Western Region
- Eastern Region
- Northern Region
- Other (please specify): _____

8. Do you currently own a vehicle?

- Yes
- No

9. If yes, what type of vehicle do you own?

- Petrol/Diesel vehicle
- Hybrid vehicle
-



- Electric vehicle (EV)
- Other (please specify): _____

10. How familiar are you with electric vehicles (EVs)?

- Not familiar
- Somewhat familiar
- Familiar
- Very familiar

SECTION B: THE ECONOMIC FEASIBILITY OF ADOPTING ELECTRIC VEHICLES IN GHANA

Please rate the following factors on a 5-point Likert scale of 1 to 5: **strongly agree – 5, Agree – 4, Uncertain – 3, Disagree – 2, strongly disagree – 1.** If you are unsure, please select "Neutral."

STATEMENTS	SD	D	U	A	SA
1. The initial cost of purchasing an electric vehicle (EV) in Ghana is affordable for the average consumer.					
2. The long-term savings on fuel and maintenance make EVs more economically viable than traditional petrol/diesel vehicles.					
3. Government incentives (e.g., tax rebate subsidies) make the adoption of EVs financially attractive in Ghana.					
4. The availability of financing options (e.g., loan payment plans) significantly affects the affordability of EVs in Ghana.					
5. The cost of electricity in Ghana makes EVs more cost-effective than traditional vehicles.					

6. The resale value of electric vehicles in Ghana is competitive compared to petrol/diesel vehicles.					
7. The economic benefits of adopting EVs outweigh the costs associated with setting up the necessary infrastructure (e.g., charging stations).					
8. The cost of importing EVs and their parts is a significant barrier to widespread adoption in Ghana.					
9. The lower operating costs of EVs (e.g., reduced fuel and maintenance expenses) are sufficient to justify the higher initial purchase price.					
10. The economic impact of EV adoption will positively influence Ghana's overall transportation sector.					

SECTION C: THE CURRENT CHALLENGES AND OPPORTUNITIES FOR THE INTRODUCTION OF EVS IN GHANA

Please rate the following factors on a 5-point Likert scale of 1 to 5, where **strongly agree – 5, Agree – 4, Uncertain – 3, Disagree – 2, strongly disagree – 1**. If you are unsure, please select "Neutral."

CHALLENGES	SD	D	U	A	SA
1. The lack of widespread charging infrastructure is a major challenge to the adoption of electric vehicles (EVs) in Ghana.					
2. High initial purchase costs of EVs deter many potential buyers in Ghana.					

3. Limited availability of EV models and options in the Ghanaian market is a significant barrier to adoption.					
4. The unreliability of the national electricity grid poses a challenge to the consistent use of EVs in Ghana.					
5. The absence of clear government policies and incentives hinders the growth of the EV market in Ghana.					
6. Public awareness and understanding of EV technology and its benefits are insufficient in Ghana.					
7. The high cost of EV batteries and their replacement is a challenge for consumers in Ghana.					
8. There is a lack of skilled technicians and service centres for the maintenance and repair of EVs in Ghana.					
9. The current automotive industry infrastructure in Ghana is not fully equipped to support the transition to EVs.					
10. Import taxes and duties on EVs and their components are a financial burden that hinders their adoption in Ghana.					
OPPORTUNITIES					
1. EVs offer a significant opportunity to reduce greenhouse gas emissions and combat climate change in Ghana.					
2. The development of EV charging infrastructure presents an opportunity for job creation in Ghana.					

3. Government incentives, such as tax rebates and subsidies, could make EVs more attractive to consumers in Ghana.					
4. Integrating EVs with renewable energy sources, such as solar power, is a promising opportunity for Ghana.					
5. The introduction of EVs could reduce Ghana's dependency on imported fossil fuels, enhancing energy security.					
6. EV adoption in Ghana could lead to advancements in local technology and innovation in the automotive sector.					
7. The growing global trend toward EVs provides Ghana with an opportunity to align with international environmental standards.					
8. There is an opportunity to attract foreign investment into Ghana's automotive industry through the promotion of EVs.					
9. Public transportation systems in Ghana could be modernized and made more efficient through the adoption of EVs.					
10. The introduction of EVs in Ghana could stimulate economic growth by creating new markets and industries.					

Thank you for your time in answering this questionnaire

