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National Electric Mobility Policy and Market Readiness Framework for Ghana

UNIVERSITY OF GHANA

Authors

University of Ghana
Ebenezer Forkuo Amankwaa
Ernest Agyemang

And

UNEP-DTU Partnership
Subash Dhar
Talat Munshi
Jyoti Painuly

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Foreword

It is an honour to present a foreword for Ghana's comprehensive National Electric Mobility Policy Framework. The policy framework intends to guide the deployment and scale-up of electric vehicles. It also serves as one of the response measures to reduce the transportation sector's carbon footprint. The policy framework proposes a coordinated approach to deploying electric vehicles, charging infrastructure, research and development, and service delivery.

The policy framework has been finalized through an in-depth and comprehensive review of the relevant policy measures, fiscal and non-fiscal, infrastructure challenges and extensive consultations with relevant stakeholders. The stakeholder consultations included vehicle manufactures and assemblers, transport operators and associations, users, institutions of Government, and academia, among others.

Generally, it is understood that different transport modes are critical catalysts for socio-economic development. Unfortunately, the carbon footprint of this crucial sector is huge, and without an urgent and coordinated approach, irreversible damage to the environment could occur. Advancements in technology and other sustainable mobility systems have given hope to the new millennia. Electric mobility presents excellent opportunities for countries to leapfrog and promote clean development pathways. Policy interventions are critical to the diffusion and scale-up of e-mobility. Some of the important policy instruments to promote EVs include taxation and infrastructure measures in addition to financial incentives and subsidies for purchasing and supporting imports, local assembly and retrofitting, and private sector partnerships.

Implementing this Policy Framework will require a review of existing legislation and the introduction of new ones to ensure policy coherence and relevance combined with developing and implementing a communication strategy to create awareness and build public confidence in electric mobility. It also requires the development of standards for electric vehicles and related charging infrastructure and components. These are pertinent issues that have been highlighted in the policy framework. The Ministry of Transport will continue to work closely with the respective institutions and stakeholders to ensure policy coherence and implementation of the policy framework.

I wish to use this opportunity to acknowledge the efforts of the Consultants to the Project, Dr. Ernest Agyemang and Dr. Ebenezer Forkuo Amankwaa, both of the University of Ghana. Special thanks to Dr. Subash Dhar, Dr. Talat Munshi, and Dr. Jyoti Painuly from UNEP DTU Partnership for their technical support and Prof Darshini Mahadevia for her contribution as the gender expert.

My hearty gratitude extends to the Climate Technology Centre Network (CTCN) for providing the funding for this Technical Assistance. I also acknowledge the Project Steering Committee Members for their guidance and expertise during the Policy development processes. All the stakeholders' rich input and contributions are also duly recognized and appreciated.

KWAKU OFORI ASIAMAH

HON. MINISTER FOR TRANSPORT

Executive summary

Context

Ghana is one of the fast-growing economies in Sub Saharan Africa and the GHG emissions will reach to 74 $MtCO_2e$ in 2050 in the business as usual scenario compared to around 43 $MtCO_2e$ in 2016. The voluntary commitments will bring down the emissions by around 15% by 2030 but will be unable to stop the upward trend in growth of GHG emissions. The transport sector contributes to 47.7% of energy-related emissions. The government wants to reduce the emissions from transport sector by improving public transportation and improving the efficiency of vehicles. In addition, the government has banned the import of more than ten-year-old vehicles and promoted alternative vehicle technologies, including electric vehicles (EVs).

In Ghana, low standards for fuels and old vehicles result in high vehicular emissions that contribute to poor air quality, posing a grave threat to human lives. As a result, the annual average air quality in larger cities in Ghana is beyond the WHO prescribed levels. There is, however, limited monitoring and reporting of air quality. Ghana Urban Air Quality Project (GHAir), established in May 2019, raises hope that air quality concerns will be highlighted and can become a good tool in measuring the impacts of eMobility in Ghana.

Ghana plans to address this climate, and local environmental challenges through multiple strategies, e.g., by limiting the import of older vehicles, increasing the number of trips by public transportation by 10% in the four major cities, and electrification of vehicles. However, the uptake of e-mobility has been slow in Ghana. This CTCN technical assistance is helping the Ghanaian government develop a policy framework for inclusive eMobility, a roadmap for inclusive eMobility and a market feasibility assessment for eBuses. The report presents the eMobility Policy Framework, developed under the guidance of the Ministry of Transport and in consultation with key stakeholders in Ghana.

Priorities for eMobility

Ghana's e-mobility agenda would have to be delivered through a range of supportive government policies, private sector partnerships, and investments from international development partners. Policy interventions are critical to the penetration and adoption of eMobility and can potentially drive other related development in the urban transport landscape. However, being a developing country, the resources are limited, and it is important to direct the investment in a direction which delivers the highest benefits.

Using a mixed-methods approach, which combined quantitative analysis using the UNEP eMobility calculator and stakeholder inputs (using questionnaires), the top priorities for eMobility in Ghana were Buses for Public transport and Cars for Personal transport, as shown in the table below

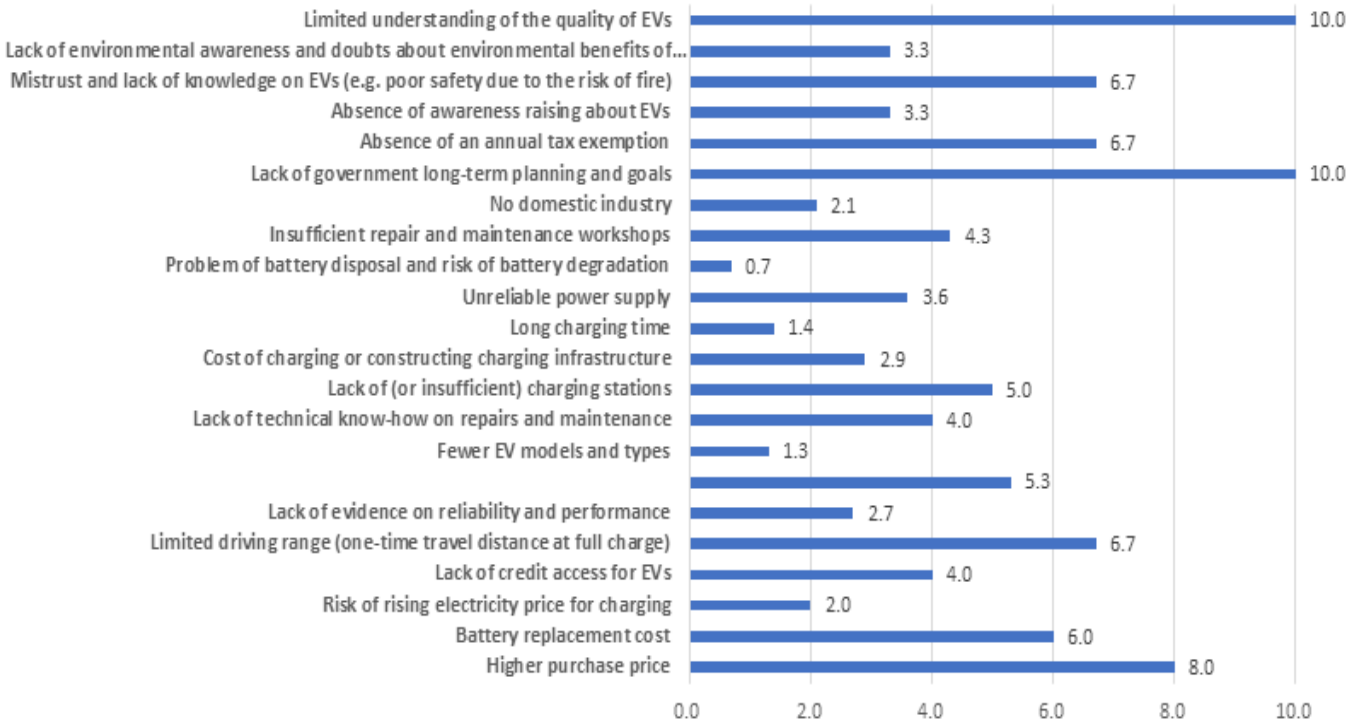
Usage Type	Modes	Overall Score
Public	**Bus**	70.11
	4W-Taxi	69.71
	Trotro	65.08
Personal	**Car**	55.64
	2W-Personal	49.55
	3W-Personal	47.24

These outputs of the prioritisation were presented to the Steering Committee, experts and stakeholders in a validation workshop on 7 July 2021.

Barriers to e-Mobility and Measures to Address Barriers

The barrier analysis was done using mixed methods involving a questionnaire survey, expert interviews with stakeholders and the general public. A total of 22 barriers were identified as inhibiting the uptake of EVs in Ghana. These barriers were subsequently classified under five key categories ranked in descending order: economic and financial, infrastructural, technical, policy and social barriers. The ranking of the identified barriers is shown in the figure below.

Overall ranking of barriers (weight in percentages)



The report proposes a long list of measures to address the barriers and accelerate EV uptake in Ghana. However, a more detailed discussion with stakeholders on these would happen in the roadmap preparation exercise, where we would also be looking at them within the context of ambition for eMobility, the budgets required and institutional structures of Ghana.

1. Introduction

Ghana is one of Africa's fastest-growing economies, with the transport sector playing a key strategic role in its growth and development. Despite the steady economic growth over the last two decades, Ghanaian cities, in particular, seem not to have benefited from the full dividends that accrue to the urbanization process. This may be due to challenges associated with the current monocentric urban spatial structure where important activity points are located in the city centre. In contrast, most of the city residents live at distant locations in sprawled neighbourhoods. The functional interlinkages established between the city centre and the sprawled neighbourhoods are organized principally by motorized transport.

Ghana's transport sector is characterised by an over-reliance on inefficient and low-capacity passenger vehicles run within informal public transport services. In addition, inadequate traffic management and non-motorized transport facilities have fuelled severe traffic congestion and limited accessibility. The reliance on informal transport is higher in small towns and rural areas (Porter 2007; Porter 2008). Furthermore, women are the main consumers of informal transport as men are primarily the owners of motorised and non-motorised vehicles (Porter 2008). All of these have implications for women's accessibility and affordability of public transport. The transport sector has also increasingly contributed to Ghana's GHG emissions. Ghana's fourth GHG Inventory shows a significant growth in the energy sector emissions, contributing 35.6% of overall GHG emissions in 2016, with the transport sector accounting for 47.7% of energy sector emissions. Overall the current transport situation limits accessibility, creates congestions and promotes high GHG emissions and therefore impedes sustainable economic development. Therefore, enhancing the sustainability of transport infrastructure and related services can thus accelerate the economic development of Ghana, curb its emissions growth and enable it to mitigate climate change.

1.1. Climate Change and Paris Agreement Targets

The Paris Agreement aims to strengthen the global response to the threat of climate change in the context of sustainable development, taking into account different national circumstances. The Paris Agreement aims for a long-term goal of limiting the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. Achieving the long-term temperature goals of the Paris Agreement depends strongly on implementing mitigation actions by 2030. The Paris Agreement aims to reach net-zero GHG emissions in the second half of this century, which means that any remaining CO_2 and non-CO_2 emissions are balanced with net CO_2 removal or negative emissions. To be consistent with global emission pathways with no or limited overshoot of the 1.5 °C goal, global net anthropogenic CO_2 emissions need to decline by about 45 per cent from the 2010 level by 2030, reaching net zero around 2050. For limiting global warming to below 2°C, CO_2 emissions need to decrease by about 25 per cent from the 2010 level by 2030 and reach net zero around 2070 (IPCC, 2018).

It should be noted that these net-zero target years are for the global pathways and therefore need to be achieved collectively. However, setting net-zero targets for individual countries involves equity and fairness considerations, which means that national net-zero targets do not necessarily have to coincide with the net-zero years and global pathways (IPCC, 2018). Further, these pathways should also be synergistic with the Sustainable Development Goals (SDGs) of which Goal 5, 'Achieve gender equality and empower all women and girls' is an important one.

Some Parties have already provided information on long-term mitigation visions, strategies and targets for up to and beyond 2050. However, these Parties' contributions would only allow a reduction of 26 (23–29) per cent compared with the 2010 level[1].

[1] Source FCCC/PA/CMA/2021/8 https://unfccc.int/documents/306848

There is an urgent need for increasing significantly the level of ambition of NDCs between now and 2030 to attain cost-optimal emission levels suggested in many of the scenarios for keeping warming well below 2 °C or limiting it to 1.5 °C (IPCC, 2018). Electric Vehicles (EVs) have emerged as one of the main options for decarbonising land transport GHG emissions and achieving a Net-Zero Energy Sector by 2050 (IEA, 2021).

1.2. Ghana's Nationally Determined Contributions (NDCs)

Ghana has signed on to several important international conventions and treaties aimed at promoting a greener future. These include the Paris Agreement (-15% in its GHG by 2030), Sustainable Development Goals (2016), and the African Union's Agenda 2063 (2014), seeking to transform economies and ensure environmental sustainability and climate-resilient infrastructure. These commitments, supported by several recent national policy developments, appear to have strengthened Ghana's policy preparedness in climate change mitigation and adaptation.

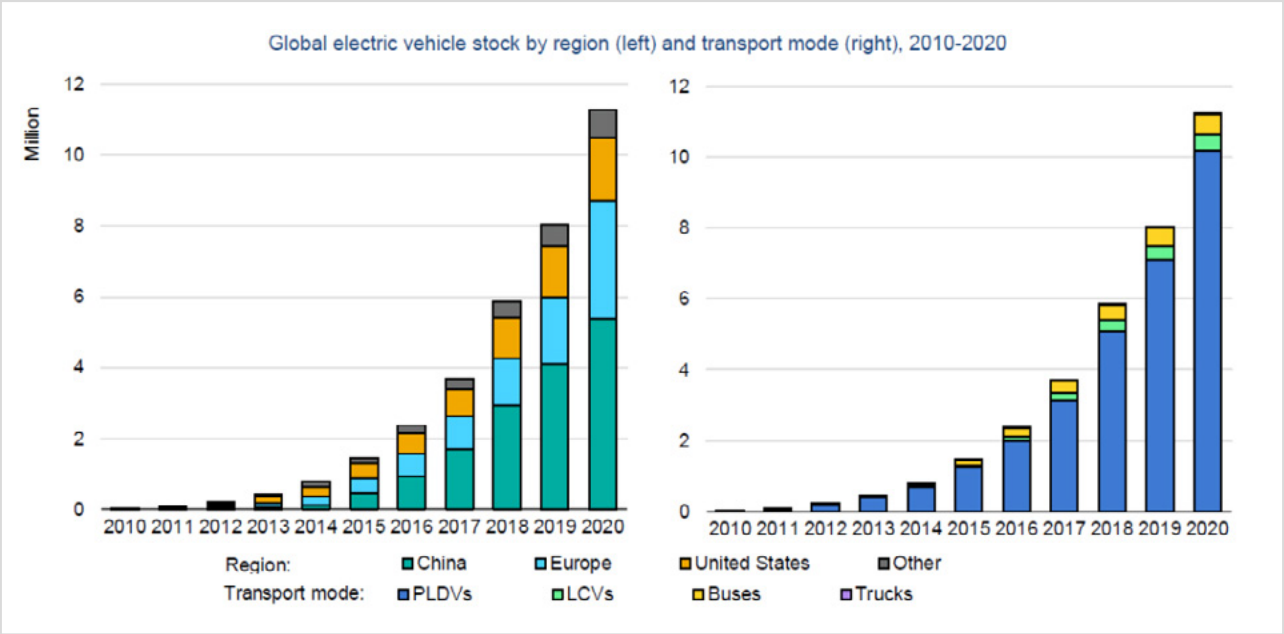
Ghana's strategy to tackle climate change has been articulated in its medium-term development policy framework on the Agenda for Jobs: Creating Prosperity and Equal Opportunity for All (2018-2021) and the National Climate Change Policy. According to the Avoid Shift and Improve framework, some actions proposed in these policy and development frameworks can be broadly classified (Bakker et al., 2014) for the transportation sector. The first action is to increase the share of road-based mass transportation systems, including extending Bus Rapid Transit (BRT) corridors, as one of the medium-term strategies to improve the efficiency and effectiveness of road transport infrastructure and services. An increasing share of formal public transportation has been found to improve accessibility for women. Second, reducing the amount of fossil fuel consumed, especially diesel, is key to meeting emission reductions targets in the Nationally Determined Contributions. Here, the government relies on one banning the import of light-duty vehicles more than 10 years and promoting efficient alternative vehicle technologies, including Electric Vehicles (EVs). However, increased EVs can only be good for CO_2 emissions if electricity is cleaner, and therefore the government is also committed to increasing the proportion of renewable energy into the national energy supply mix.

The introduction of EVs has been touted to be a game-changer in Ghana's efforts to reduce the transport sector's dependency on fossil fuels and mitigate GHG emissions. Policies play a pivotal role in enhancing stakeholder and consumer awareness, acceptability, preference and sustainability of electric mobility initiatives. Electric mobility policies have primarily focused on addressing barriers such as purchasing cost, infrastructure development cost (charging stations and associated land costs), technical know-how (maintenance and repairs), and public awareness (user acceptability). Additionally, fiscal and non-fiscal policy measures play a significant role in catalyzing market uptake and upscale. However, given that public funds are limited, it is crucial to prioritise investments, subsidies, and fiscal interventions for electric mobility. Further to address barriers, should take a coordinated, collaborative, and inclusive approach. All relevant stakeholders, including the private sector, industry players, associations, social groups, etc., should be brought on board. The benefits of promoting EVs are numerous and include reduced vehicle ownership cost for some use cases, GHG mitigation improved local air quality and energy security.

1.3. Global trends in electric mobility

Battery Electric Vehicles (BEV) has gained commercial viability within land transport vehicles for two-wheelers, three-wheelers, four-wheelers and buses. Around 15 countries had a BEV market share (share of new vehicles sold) of more than 1% in 2019 for light-duty vehicles (mainly cars) (IEA, 2021) though most are developed countries. The global electric car market has been experiencing rapid growth for more than a decade now and reached 10 million vehicles in 2020. About 3 million new electric cars were registered in 2020. China had the largest fleet of electric cars at 4.5 million. Several governments supported electric cars through fiscal, and other incentives and electric cars are slowly becoming competitive in some countries (IEA, 2021). Figure 1 shows the growth of the different types of electric vehicles and growth in different regions.

FIGURE 1. Growth of electric vehicles over last 10 years



Notes: PLDVs = passenger light-duty vehicles, LCVs = light-commercial vehicles. Electric vehicles include battery electric and plug-in hybrid electric vehicles. Europe includes EU27, Norway, Iceland, Switzerland and United Kingdom. Other includes Australia, Brazil, Canada, Chile, India, Japan, Korea, Malaysia, Mexico, New Zealand, South Africa and Thailand
Source: IEA, 2021

Electric 2 wheelers have been a great success in China, and now several Asian countries with a large two-wheeler population are a potential market. China has also been at the forefront of electric buses and, many cities worldwide are opting for electric buses. The prospects for EVs have dramatically improved due to strong policy support in many countries that have involved financial incentives, duty exemptions, and mandates for phasing out fossil-fuelled vehicles (Santos & Rembalski, 2021). In this scenario, EVs are bound to become a dominant technology for personal and public transport in cities in the coming decades. EVs are also emerging as a preferred technology for shared mobility.

Major contributors to the growth of the electric market in 2020 were Europe, China and the US. In Europe, the electric car market doubled despite a contraction in the car market due to the pandemic. In several European countries, policies on CO_2 emissions standards and subsidy schemes led to this increase in electric car sales. On the other hand, due to the pandemic, China experienced a slowdown in new electric car registrations in 2020.

Worldwide about 370 electric car models were available in 2020, a 40% increase from 2019. China had the maximum number of models. The average driving range of new BEVs has also been increasing, reaching 350 km in 2020. The sale of electric light commercial vehicle (LCV) also increased in Europe, but total LCV stock was below half- million in 2020. Bus registrations also increased, with China dominating the electric bus market with 78000 new vehicles in 2020. Local policies to curb pollution were the driving force in China for electric buses. In Europe, electric bus registrations (at 2100) reached 4% of all new bus registrations in 2020, and most of this seems to be due to municipal level policies. (IEA, 2021).

BEVs are a crucial solution for decarbonising road transport; however, this will depend on the electricity used for charging and CO_2 emissions in batteries' production. Battery electric LDV produced and operated on low carbon electricity would yield a CO_2 footprint of only 33 gCO_2-eq/vkm for a compact sized car (Ellingsen et al. 2014, 2016). Efficient ICE and Hybrid engines running on fossil fuels cannot go below 130 gCO_2-eq/vkm for LDVs (GFEI, 2020). However, if BEV is produced using coal-based electricity, the CO_2 emissions can even exceed 300 gCO_2-eq/vkm on a life cycle basis (Ellingsen et al., 2016). In cases of buses operated within the cities, BEVs have much lower CO_2 emissions than all the alternative drive train technologies (ICEs, Hybrid, Plug in Hybrid and Fuel Cell) (European Commission, 2020).

2. Urban Passenger Transport sector in Ghana: An Overview

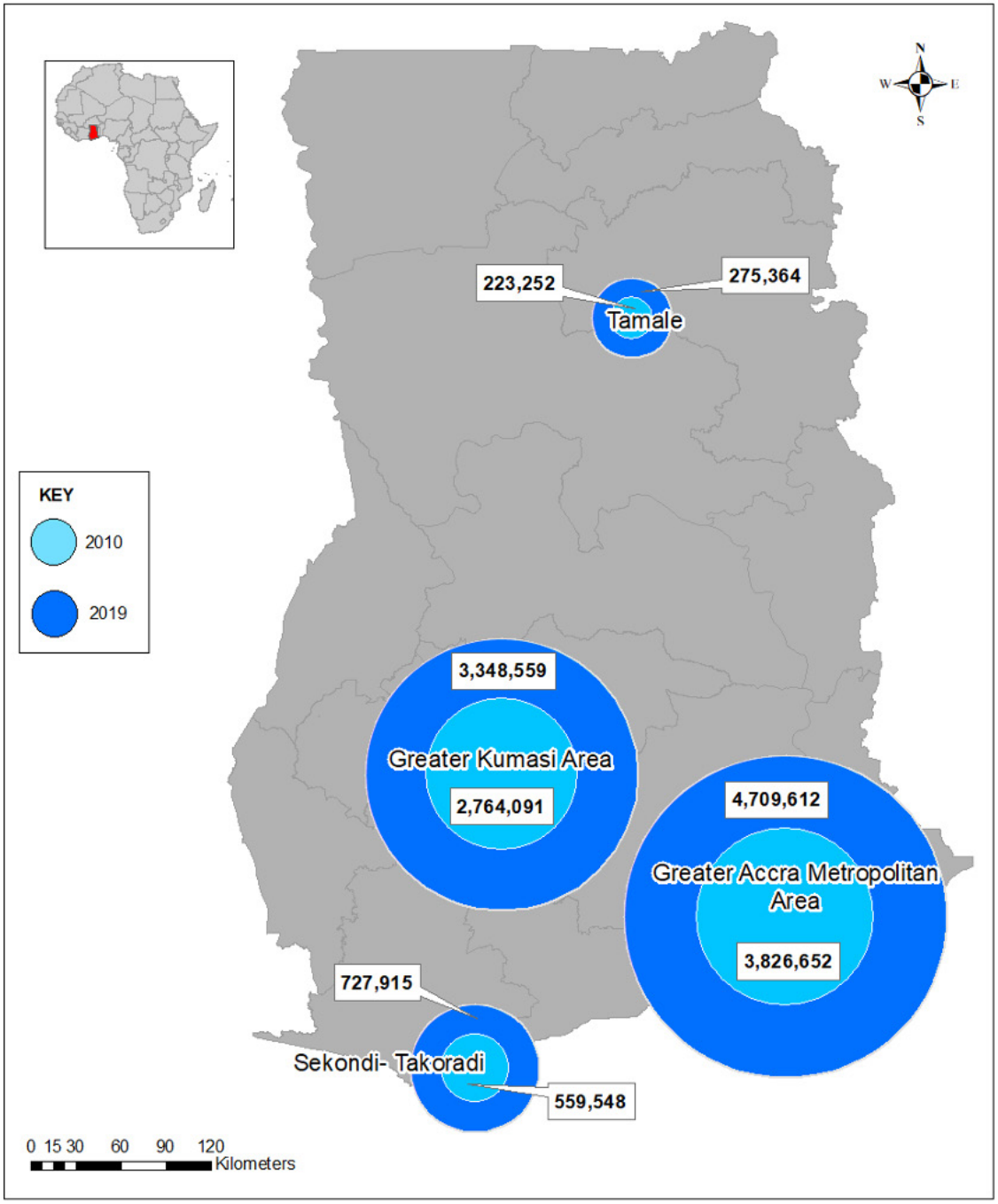
According to the United Nations (2019), about 4.4 billion people are urban dwellers, representing 56% of the world's total population. Compared to other regions of the world, urbanization is occurring at a much faster pace in Sub-Saharan Africa (SSA). Between 1980 and 2020, urban dwellers in SSA increased from 84 million to 450 million. More than one-half of the population in some 19 major SSA countries, Ghana inclusive, lived in cities by the end of 2020. Ghana's urban population grew rapidly in the mid-1980s and has continued to grow at a rapid rate. Between 1984 and 2013, for instance, Ghana's urban population more than tripled, soaring from a mere 4 million to almost 14 million people (World Bank, 2015). At the current growth rate of 3.3%, by 2030, an estimated 24 million people will be staying in major Ghanaian cities, and the figure is likely to expand to 38 million by 2050 (UN, 2019).

In order of importance, Accra, Kumasi, Sekondi-Takoradi, and Tamale represent the 4 most urbanized areas in Ghana since the 1980s. Accra, the national capital since 1957, and its contiguously built area, commonly referred to as the Greater Accra Metropolitan Area (GAMA), is the most urbanized. In what began in the late 16th century as a "small fish village" (Stanley, 1874; cited in Acquah, 1972), GAMA presently is the hub for business, technology, and education, raking in a quarter of the country's GDP and attracting over 80% of all foreign direct investment in Ghana (ARUP, 2016). GAMA covers about 1,500 km^2 of urban space. It is composed of the Accra Metropolis (AMA, >2 million inhabitants (Ghana Statistical Service, 2019)) at its core and 12 other metropolises and municipalities, including the shipping and industrial metropolis of Tema, to the east, and to the west, the Awutu Senya East municipality whose administrative capital –Kasoa –is functionally linked to the AMA regarding work and shop-related trips (Agyemang, 2017; Yeboah, 2000).

Accra seems to have reached saturation point as it has shown consistent declines in the annual growth of its urban population from 6.1 per cent in 1960 to 3.5 per cent in 2010 (Ghana Statistical Service, 2013). This may partly be due to the continued fragmentation and carving out of some municipalities and district assemblies from the Accra metropolis. Thus, Accra no longer enjoys its primacy status, as Kumasi, the nation's second-largest city, is fast urbanizing.

Kumasi is located in the transitional forest zone of Ghana and covers about 250 km2 of geographic space. Kumasi's strategic location makes it a major destination for migrants from all over the country and beyond (Cobbinah & Amoako, 2012). Kumasi City (>2 million inhabitants (Ghana Statistical Service, 2019) and its 7 contiguously built municipalities and districts, collectively known as Greater Kumasi Area (GKA), presently accommodate over 3 million inhabitants, according to estimates by the Ghana Statistical Service (2019). The potential for further urbanization of GKA is high as the growth rate is well above the regional and national annual growth rates of 2.6 and 2.4, respectively (Ghana Statistical Service, 2011). A summary of the most recent statistics on urbanization trends in Ghana's top four most urbanized areas is presented in Figure 2 and Table 1.

FIGURE 2. Urbanisation trend in the four major cities of Ghana (2010 – 2019)



Source: Ghana Statistical Service, 2019

TABLE 1. Profile of urbanization in major cities of Ghana

Location	Constituent regions	2010			2019		
		Male	Female	Total	Male	Female	Total
Ghana	Total	12024845	12633978	24658823	14888646	15391836	30280482
	Urban	6016059	6529170	12545229	++	++	17249055
	Rural	6008786	6104808	12113594	++	++	13031427
Greater Accra Metropolitan Area	Ga South Municipal	201222	210155	411377	252366	254825	507191
	Ga West Municipal	107742	112046	219788	135126	135862	270989
	Ga East Municipal	72987	74755	147742	91537	90644	182182
	Accra Metropolis	800935	864151	1665086	1004506	1047835	2052341
	Adenta Municipal	39366	38849	78215	49371	47106	96478
	Ledzokuku Krowor Municipal	109185	118747	227932	136936	143987	280924
	Ashaiman Municipal	93727	97245	190972	117549	117915	235464
	Tema Metropolis	139958	152815	292773	175530	185297	360828
	Ada East	34012	37659	71671	42656	45663	88320
	Ga Central Municipal	57321	59899	117220	71890	72631	144521
	La Dadekotopon Municipal	86738	96790	183528	108783	117363	226147
	La Nkwantanang-Madina Municipal	54271	57655	111926	68064	69910	137975
	Awutu Senya East Municipal	52197	56225	108422	62536	63711	126247
Greater Kumasi Area	Ejisu Juaben Municipal	68648	75114	143762	84427	89727	174155
	Bosumtwi	44793	49117	93910	55089	58672	113761
	Atwima Kwanwoma	43792	46842	90634	53858	55955	109813
	Kumasi Metropolis	826479	903770	1730249	1016454	1079600	2096053
	Atwima Nwabiagya	71948	77077	149025	88486	92072	180558
	Afigya Kwabre	66350	69790	136140	81601	83367	164969
	Kwabre East	55106	60450	115556	67772	72210	139983
	Asokore Mampong Municipal	145779	159036	304815	179287	189976	369264
Sekondi Takoradi	Sekondi Takoradi Metropolis	273436	286112	**559548**	353037	374878	**727915**
Tamale	Tamale Metropolis	111109	112143	**223252**	135952	139411	**275364**

Source: Ghana Statistical Service, 2019

Rapid urbanization has brought enormous benefits to Ghana in the form of industrialisation, commercialisation, and economic growth (UN-Habitat, 2012). The World Bank reports that urbanization in Ghana has resulted in "rapid GDP growth, helping create jobs, increase human capital, decrease poverty, and expand opportunities and improve living conditions for millions of Ghanaians" (World Bank, 2015, p.1). Earlier, Grant and Yankson (2003) specifically identify the benefits of Accra's urbanization, including the advent of multinational companies and home-based small-scaled enterprises. Urbanization in Kumasi is also believed to have significantly facilitated international trade between Ghana, with the city acting as an important bulk-breaking centre for its land-locked neighbours (Cobbinah & Erdiaw-kwasie, 2016; Cobbinah & Amoako, 2012; Adarkwa, 2011).

However, achieving the full benefits of urbanization has been a mirage due to a number of challenges that confront Ghanaian cities. These include land-use disorder and uncontrolled urban sprawl, increasing environmental deterioration, inadequate urban infrastructure, and services, to name a few (GoG, 2012). Cities in Ghana are characterized by a concentric urban form with a high concentration of important socio-economic service points at the core and largely unplanned, sprawled peri-urban areas where most

residents reside. In both GAMA and GKA, evidence of urban sprawl has been reported (Cobbinah & Amoako, 2012; Owusu, 2013; Doan & Oduro, 2012; Yeboah, 2003; Grant & Yankson, 2003; Grant & Nijman, 2002). About 25% of GAMA's residents, for instance, worked at locations that are located beyond 5 kilometres from their residences, indicating just how far the city's frontiers are fast expanding (Ghana Statistical Service, 2007).

The implications of the land use and transportation system interactions against the backdrop of urban sprawl have been the focal point of earlier debates. Besides pollution and environmental degradation, as argued in earlier studies (Oteng-Ababio et al., 2013; Angel et al., 2011; Moller-Jensen et al., 2005; Amuzu & Leitmann, 1994), urban sprawl promotes automobile dependency, longer commuting time and distances (Yeboah, 2003; Abane, 1993). This has negative implications for energy use and GHG emissions. The low-income populations tend to live in peri-urban areas making their commuting, particularly women, difficult (Porter, 2013) as they sometimes have to headload goods and transport them by foot.

2.1. Transport infra and travel characteristics in urbanising Ghanaian cities

Most of the trips in Ghana (90% passenger and 95% of cargo traffic) are conducted by roads (GoG, 2017). Despite this reality, public investments in infrastructure generally, particularly the road sector, have been meagre compared to its demand. Road infrastructure financing in Ghana is obtained primarily from the Consolidated Fund, the Road Fund, and other internally generated funds. Also, financial support from donors plays a critical role for the sector, even though such support appears to have dwindled significantly in recent years. As a result, road infrastructure is beset with poor maintenance and unimproved surfaces. For instance, most roads in cities are unpaved (30.6%) while a paltry 19.4% is paved. The rest of the statistics on the nature of urban roads in Ghana is captured in Table 2. GAMA has a total of 7,592 km of roads, out of which approximately 147 kilometres is classified as "trunk"; 6,892 kilometres as "urban" and 553 kilometres as "feeder" roads, respectively (MoT, 2016). However, the surface quality of these roads and their design results in treacherous peak-hour traffic congestion, prolonged commute times, as well as high transport costs, and reduced connectivity. In both Kumasi and Accra, there are vast areas without high

TABLE 2. Urban road network by surface type by Length (km) as at 2015

Surface Type	Total length(Km)	Percentage
Rigid	3.29	0.01
Asphaltic Concrete	956.37	3.09
Surface Treated	5044.48	16.31
Gravel	5225.98	16.90
Earth	4231.65	13.68
Total paved	6004.14	19.42
Total unpaved	9457.63	30.58
Total	30923.54	100.00

Source: Compiled from GoG 2017

traffic capacity corridors. Traffic generally flows into a limited number of arterials and some key intersections with limited capacity to handle the number of vehicles.

The number of road intersections by square kilometres, which is a measure of the density of the road network, is very low in Accra at less than 40 (Figure 3), compared to well-functioning cities which have a least 100 street intersections per square kilometre.

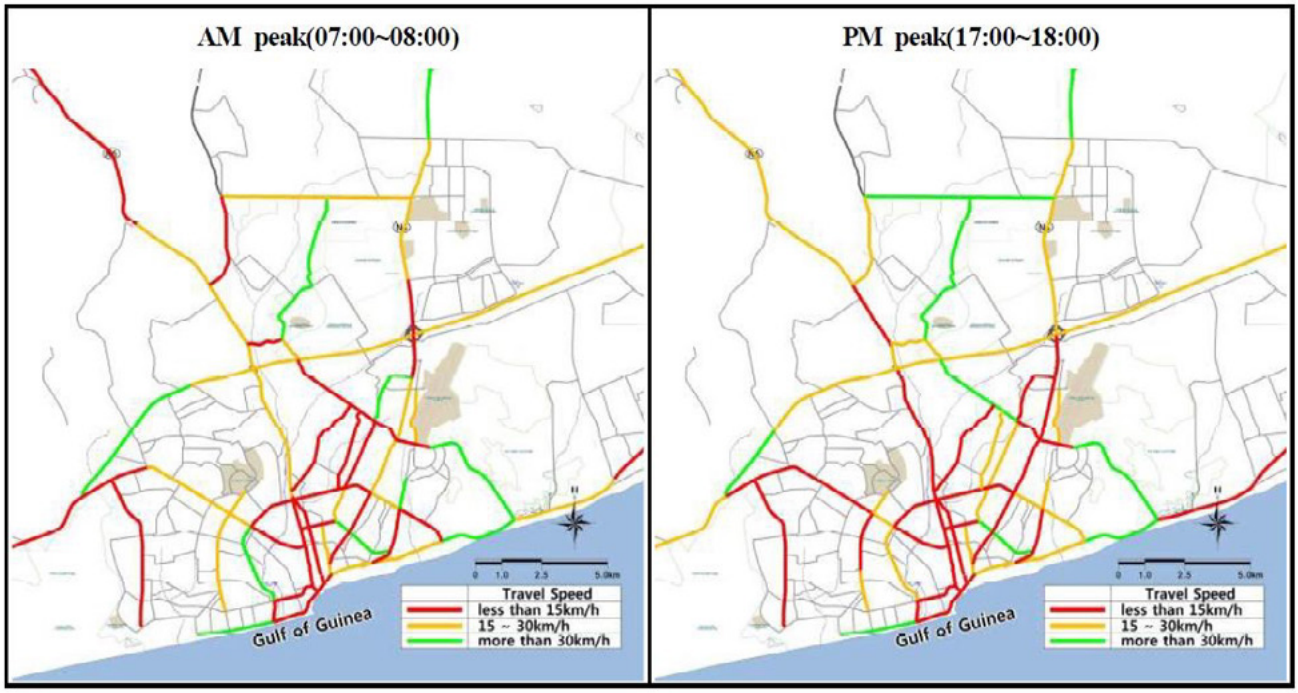
The challenges associated with urban infrastructure notwithstanding, there is a growing level of motorization and increased vehicle stock in recent decades. In terms of vehicle stock.

Within the main metropolitan areas (including greater Accra and Kumasi), there are two main forms of public transport operations: Tro-tro (mini buses) and shared taxi services. These transport services are managed by unions and co-operatives and offer services along defined routes, usually between terminals or 'lorry parks'. In the Greater Accra area there are believed to be about 6,000 engaged in the operation of recognized routes.

These services have many positive points, including being considered safe for women, universal provision, stability, self-financing, and relative affordability to the people[2]. Nonetheless, as reported by the World Bank study[3] these operations also suffer from a number of quality problems including:

[2] https://www.ssatp.org/sites/ssatp/files/publications/Toolkits/ITS%20Toolkit%20content/case-studies/accra-ghana.html
[3] https://www.ssatp.org/sites/ssatp/files/publications/Toolkits/ITS%20Toolkit%20content/case-studies/accra-ghana.html

FIGURE 3. Number of street intersections/sq.km



Source: SSATP UTM (2018)

(i) operation of a 'fill and go' system which can result in long delays for users in the off-peak, and difficulty to board along the route;

(ii) large numbers of vehicles parked at terminals in the off-peak leading to congestion, inefficiency, and long hours for drivers;

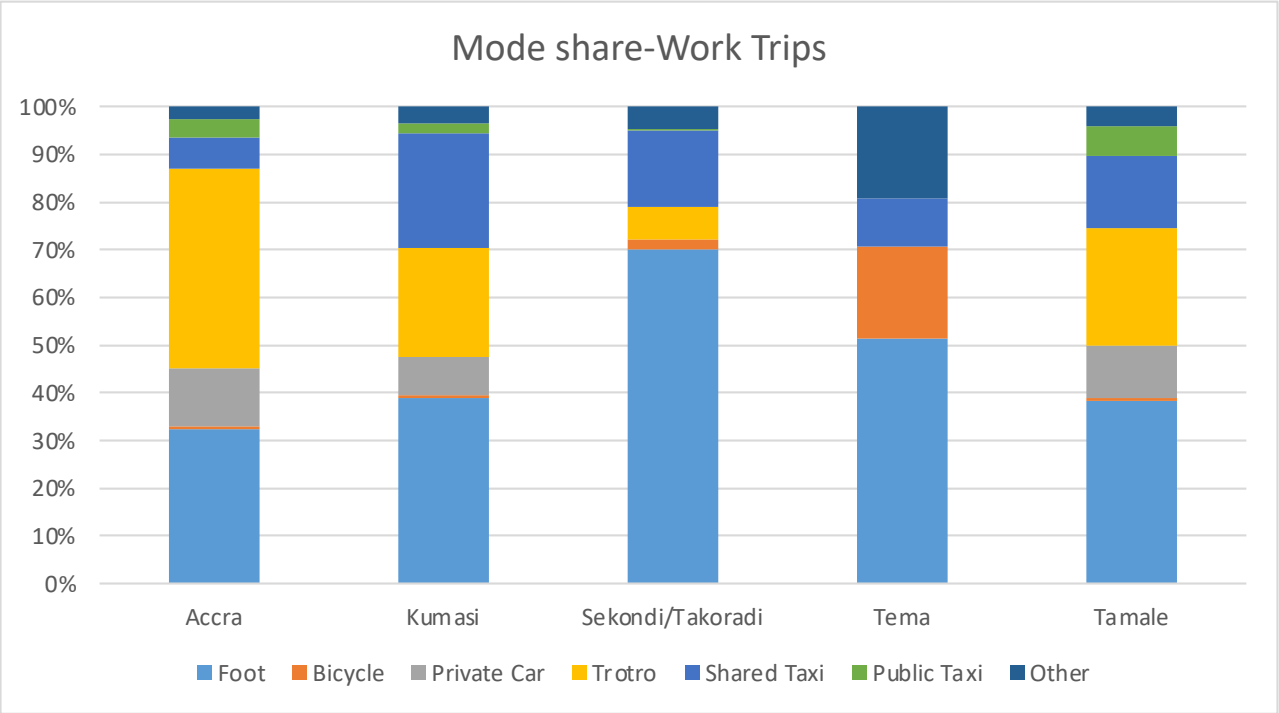
(iii) lack of incentives for vehicle owners to improve their vehicles or to train their drivers properly.

Large bus services, mostly provided by the new Metro Mass Transit (MMT), a quasi-private company that receives favourable financial support from the government. MMT currently has a total fleet of about 1,000 vehicles, of which about 250 operate in and around Accra.

As a result of poor infrastructure provision and low levels of motorised vehicle ownership, most urban residents in Ghana are forced to use walking as a mode; for example, around 65% of residents walk for different purpose trips in Accra. A greater share of this category is made up of women who operate retail trade and mostly headload their wares. A large section of the population also depends on public transport modes; thus more than 85% of the population in Accra either uses public transport or walk to their different destination[4] . Women use trotro for transporting their goods, or they work as porters to transport market goods. Figure 4 shows mode split for commute trips in five cities in Ghana; even for commute trips walking (foot) is the most common mode of transport. Furthermore, the next most popular modes are Trotro and shared taxis; bicycles are used in Tema, Sekondi/Takoradi. Low motor vehicle ownership also results in small shares of private automobiles for commute travel.

[4] http://airqualityandmobility.org/STR/NMTStrategy_Ghana_200402.pdf

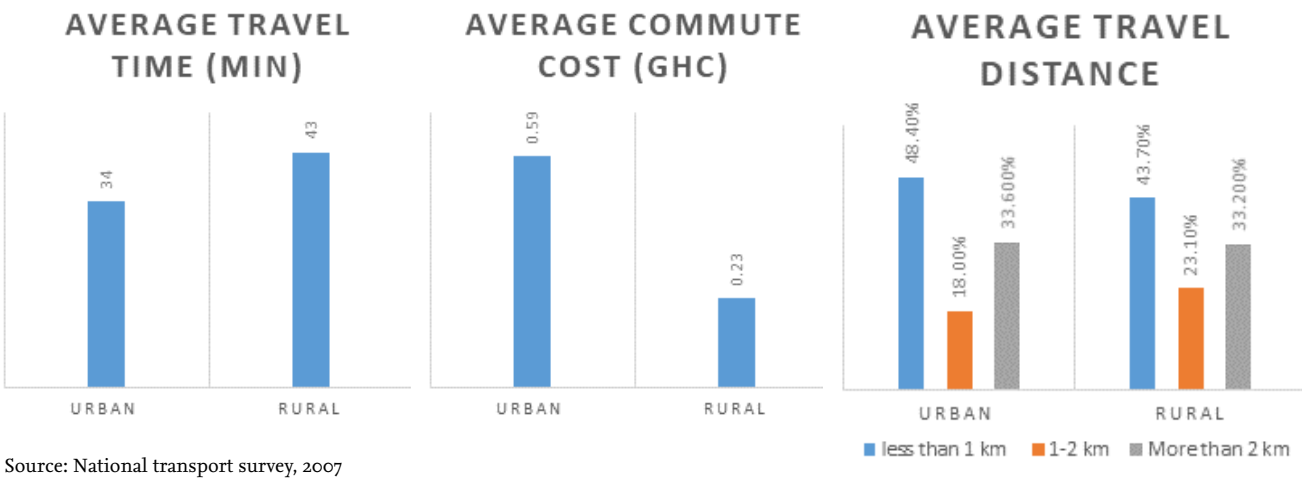
FIGURE 4. Mode share work trips



Source: National transport survey, 2007

In Figure 5, the average travel distance from home to work, average commute cost and average travel time are shown. The available modes for travel inhibits long-distance travel; therefore, average travel distances and travel costs are also low. Likewise, because travel distances to work are low average travel time for work is less than one hour.

FIGURE 5. Commute Characteristics by distance from Accra

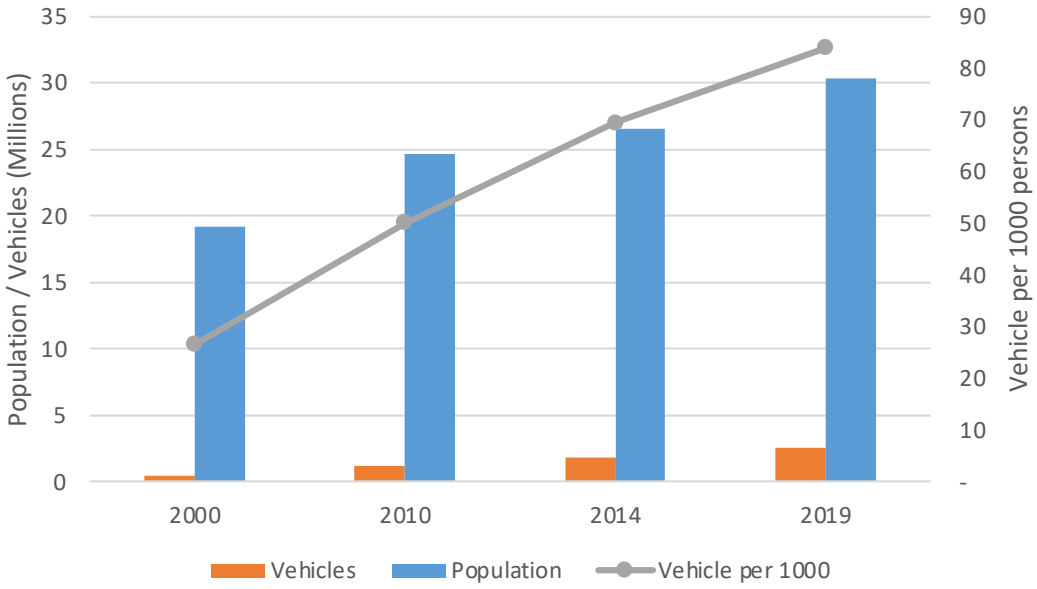


Source: National transport survey, 2007

2.2. Vehicle population: Historical trends

The total number of registered vehicles population in Ghana in 2015 stood at approximately 1,952,564. The Greater Accra Region has the highest number of registered vehicles of about 1,164,942, followed by Kumasi with just 269,689. The remaining regions recorded about 517,933 registered vehicles. The vehicle/population ratio in Ghana is growing steadily; it has grown from about 50 vehicles per 1,000 population in 2010 to about 70 vehicles per 1,000 population in 2015. As per the latest statistics, Ghana is home to over 2,753,833 million vehicles of various types (DVLA, 2021). This is a cumulative figure from 1995 and includes vehicles that are no longer roadworthy or scrapped. In 1996, the DVLA surveyed all road vehicles to obtain the actual stock of road vehicles and recorded a total vehicle population of 247,623. Since then, the official vehicle stock is the year-on-year registration records from 1996 to date. The composition of the vehicle stock is as follows: Motorcycles and Tricycles (28.72%), Private Vehicles up to 2000 cubic capacity (cc) (30.08%), commercial vehicles up to 2000cc (11.32%), Private Vehicles above 2000cc (12.72%), Commercial vehicles above 2000cc (0.26%), Private Buses and Coaches (7.16%), Commercial Buses and Coaches (2.06%), Trucks (5.42%), Articulated Trucks (1.48%) and Others including earthmoving vehicles (0.77%).

FIGURE 6. Population and Vehicle Growth Ghana



Source: Ministry of Transport, 2020

In figure 7, the annual registration of new vehicles in Ghana is shown from the year 2010 till the year 2015. There is a steady growth in the number of vehicles that get registered every year in Ghana. The number has increased from a little less than 170 thousand in 2010 to little less than 300 thousand in 2014. Thus a significant number of new vehicles get added every year, and there is also a steady increase in the new registrations.

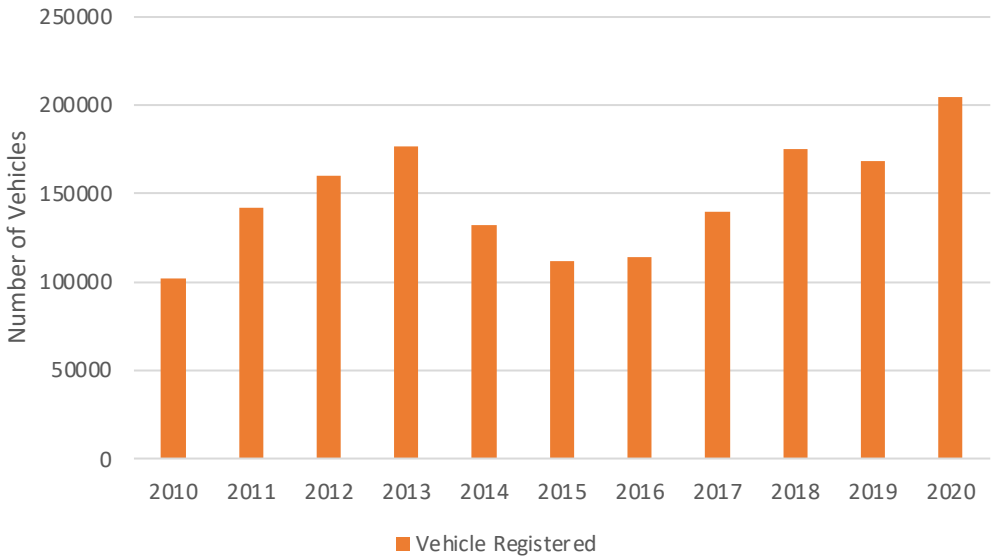
A few local assemblers, including Kantanka Automobile Limited and Volkswagen and a host of others, have indicated their intentions to set up an assembly plant in Ghana. Concerning locally produced vehicles, an Automotive Policy has been developed to provide the necessary framework for assembly and manufacturing capacity in Ghana.

The initial coverage is for new passenger cars, SUVs, and light commercial vehicles, which would include pickups, mini-buses and cargo vans. For policy implementation and effective regulation of incentives, Ghana has categorized auto assembly into Semi-Knocked-Down (SKD), Enhanced SKD, and Completely-Knocked-Down (CKD), based on the qualifying list of local or foreign assembly and Fully-Built-Units (FBUs). Fiscal Incentives have been introduced, including exemption of import duties and related charges on any plant, machinery, equipment, or its parts, waiver of the import duty and domestic levies on imported SKD, Enhanced SKD, and CKD kits, and on Original Equipment components. It is important to note that new and used vehicles imported outside the Auto Programme attract 35% of CIF value as import duty.

Most vehicles in Ghana are imported mainly from Europe and North America, with a few coming from Asia and the Middle East [5] [6]. The legal framework for vehicle importation is governed by the Ghana Customs, Excise and Preventive Service (CEPS) (Management Law) PNDCL 330 of 1993 and the Customs Act, 2015 (Act 891). A new regulation came into effect in April 2020 (Customs Amendment Bill, 2020) which sought to ban the importation of Light-Duty Vehicles older than 10 years as well as salvage vehicles. Implementation of the new framework commenced in October 2020 but has been suspended to allow for further consultation with industry players and stakeholders. Consequently, most vehicles imported into the country are used vehicles (mostly referred to as second-hand) dominated by internal combustion engines running on diesel fuels (28%), petrol (61%), and Liquid Petroleum Gas (11%) [7]. Analysis of data from the Ghana Revenue Authority showed that used vehicles constitute (85.10%) and (20%) of all petrol and diesel Light Duty Vehicles imported into Ghana respectively. With respect to regional distribution, the Greater Accra Region records the highest number of vehicle registration 1,596,611 (57.98%) vehicles out of the total registered vehicles, followed by Kumasi with just 369,191 (13.41%) vehicles.

[5] https://www.ssatp.org/sites/ssatp/files/publications/Toolkits/ITS%20Toolkit%20content/case-studies/accra-ghana.html
[6] Vehicle import Data, Ghana Community Network Services Limited
[7] Vehicle Registration Data, Driver and Vehicle Licensing Authority, 2018

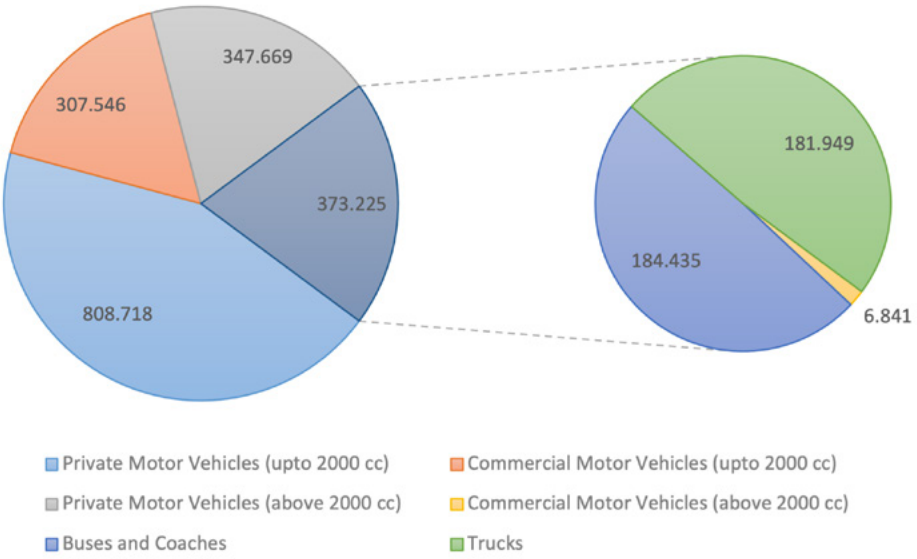
FIGURE 7. Annual Registration of Vehicles



Source: Ministry of Transport, 2020

In Figure 8, vehicle registrations by vehicle type are shown. In the category of vehicles that are below 2000cc, most registered vehicles (65%) are used for commercial purposes; there is also a significantly large (27%) of registered vehicles that have engine sizes larger than 2000cc, and also around 21% registered vehicles are buses and coaches.

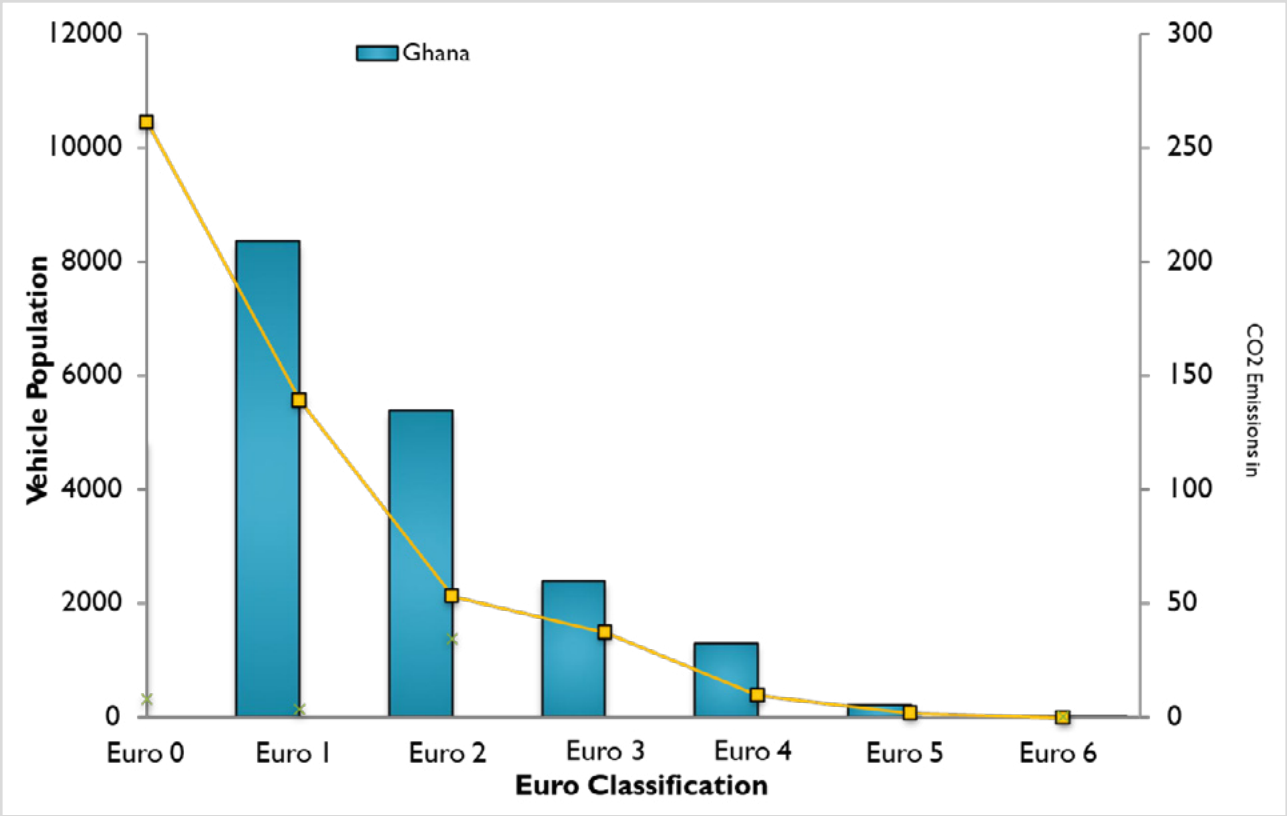
FIGURE 8. Registered Vehicles by engine size



Source: Ministry of Transport, 2020

As stated earlier, there is a huge market for used vehicles in Ghana. Therefore, as shown from figure 9 most vehicles running in Ghana are on relatively old vehicle technology and use either Euro 1 or Euro 2 engines. Some vehicles are of Euro 3 and Euro 4 category engines, but these are small in number.

FIGURE 9. Registered Vehicles Euro Classification



Source: Ministry of Transport, 2016

2.3. Institutional structure and policy frameworks

At the global and regional levels, Ghana is a party to the 2015 Paris Agreement on Climate Change, the United Nations' 2030 Sustainable Development Goals (SDGs), and the African Union Agenda 2063. These protocols and developmental agendas have been ratified into various policies and laws. At the national level, the Coordinated Programme of Economic and Social Development Policy (CPESDP) 2017-2024 provides the enabling framework for accelerated development of Ghana's economy, including improvement in infrastructure and services [8].

The strategic direction of the CPESDP 2017-2024 aims to create "an optimistic, self-confident and prosperous nation, through the creative exploitation of human and natural resources, and operating within a democratic, open and fair society in which mutual trust and economic opportunities exist for all". The policy sets out four broad intervention and programme areas which include:

- Economic development
- Social development
- Environment, infrastructure, and human settlements development;
- Governance, corruption, and public accountability; and strengthening Ghana's role in international affairs.

[8] The Coordinated Programme of Economic and Social Development Policies 2017-2024

The transportation sector fits within the environment, infrastructure, and human settlements thematic area, which prioritizes the development of modern, integrated, and well-maintained transportation infrastructure and services to establish Ghana as the transportation hub within the West African region. Transportation also has links with social development through gender, health, employment and education SDGs (SloCaT, 2018; UN-Habitat, UNEP & SLoCaT 2015). The primary governance document is the National Transport Policy (NTP) (2008) and its immediate successor, the NTP(2020). The policy provides a common framework in which sector Ministries, Departments, and Agencies (MDAs) set out their objectives and demonstrate how their activities will support the national development agenda. NTP(2020) ranked its influence as superficial or coincidental to other ongoing programmes and projects in the transport sector. The institutional framework needed for greater sector coordination to achieve improved inter-sectoral policy formulation and integration of transport modes was weak. Another vital issue identified was the interdependence of the NTP on other non-transport sector agencies such as the land-use planning authorities, the Metropolitan, Municipal, District Assemblies (MMDAs), among others.

These shortcomings combined with the need for stronger collaboration with other non-transport sector agencies and institutions to promote transport development informed the revised transport policy –the NTP of 2020.

At the sectoral level, the national architecture for managing the transport sector has undergone several changes. Before 2017, two-sector ministries existed, namely the Ministries of Transport (MOT) with oversight responsibility for Aviation, Maritime/ Inland Waterways, Railways and Road Transport Services whilst the Ministry of Roads and Highways (MRH) was responsible for the provision of road infrastructure and related facilities. In January 2017, through Executive Instrument 28 (EI. 28), the aviation and railways sectors were carved out of the MOT and established as separate ministries. The transport sector consequently operated with four modal ministries until 2020 when by an Executive Instrument, MOT was once again realigned with the merger of the Ministry of Aviation. The mandate of MOT currently includes maritime and inland water transport, aviation, and road transport services. Among the functions prescribed for the sector are:

- Provide effective leadership and guidance to the transport sector through sound strategic policy formulation, research, statistics and information management, human resource development, general administration and finance.

- Ensure the establishment of a regulatory framework and setting of standards for effective, sustainable management of the sector.

- Promote activities needed to underpin sector standards and policies required to plan and monitor strategic development projects and programmes.

- Ensure the sectoral structure will deliver on the mandate, vision, mission, objectives, and functions in providing critical sector policy strategies and services.

The MOT is assisted by fourteen (14) implementing agencies and departments that provide services, regulations, and infrastructure development in the transport sector. The existing institutional arrangement is fragmented and does not encourage integrated planning and coordination. To support a policy-led and development planning approach for all the modes of transport, two (2) special groups, Transport Sector Working Group (TSWG) and Transport Planning Group (TPG) were established to guide the planning process and ensure coordination and integration between the transport modes. However, meetings of the group have not been regular and in some instances, recommendations and policy advice are ignored or not fully implemented. It is important to stress that integration, stronger collaboration, and coordination would be needed for better planning and effective utilization of resources.

Concerning the road transport services sector, the MOT provides the governance framework, working in close collaboration with the other sector ministries and agencies. For instance, the MOT implements programmes and projects through sector agencies, namely: Driver and Vehicle Licensing Authority (DVLA); National Road Safety Authority (NRSA);

Government Technical Training Centre (GTTC), and two others. The DVLA's mandate includes establishing standards and methods for the training and testing of driver instructors and drivers of motor vehicles, riders of motorcycles and vehicle examiners, issuance of driving license and vehicle registration certificate, and inspection testing and registering of motor vehicles.

The NRSA regulates road transport services, including coordinating, monitoring, and evaluating road safety activities, programmes, and strategies. The GTTC trains artisans for the automobile industry. Other state institutions whose functions impact the transport sector are summarised in Table 3.

TABLE 3. Institutional roles and responsibilities

Institution	Roles
Ministry of Local Government and Rural Development (MLGRD)	MLGRD has the overall responsibility for policy planning, implementation, monitoring and evaluation of the decentralization program of government. It also has the overall responsibility for the regulating urban passenger transport services in the Metropolitan, Municipal & District Assemblies (MMDAs).
Ministry of Environment, Science, Technology and Innovation (MESTI)	MESTI's mandate includes environmental protection through policy formulation and economic, scientific and technological interventions which aim at mitigating any harmful impacts caused by development activities. It plays an important role in setting standards and regulating activities concerning the application of science and technology in managing the environment for sustainable development.
Environmental Protection Agency (EPA)	EPA ensures that the implementation of environmental policy and planning are integrated and consistent with the country's desire for effective, long-term maintenance of environmental quality. It ensures the environmentally sound and efficient use of both renewable and non-renewable resources and guides development to prevent, reduce, and as far as possible, eliminate pollution and actions that lower the quality of life.
Ghana Private Road Transport Union (GPRTU) & Ghana Road Transport Coordinating Council (GRTCC)	GPRTU and GRTCC are the main umbrella bodies responsible for all private and informal road transport operators. They represent the interests of road transport operators, especially in negotiating with Government for transport tariffs and assistance in the acquisition of vehicles.
Greater Accra Passenger Transport Executives (GAPTE)	GAPTE is an inter-MMDA coordinating body established with the legal mandate to plan, regulate and coordinate urban passenger transport activities in the Greater Accra Metropolitan Area (GAMA). It also facilitates the implementation and operationalization of the Bus Rapid Transit (BRT) system.
Ghana Revenue Authority (GRA)	GRA ensures the collection of Import Duty, Import Value Added Tax (VAT), Export Duty, Petroleum Tax, Import Excise and other taxes, levies and fees.
Ministry of Trade and Industry (MOTI)	MOTI is mandated to formulate and implement policies for the promotion, growth and development of domestic and international trade and industry. It is also the lead policy advisor on trade, industrial and private sector development.
Ghana Standards Authority (GSA)	GSA is responsible for maintaining acceptable standards for product and services and sound management practices in industries and public institutions.
Motor Traffic and Transport Department (MTTD)	MTTD is responsible for enforcement of road traffic regulations and enforcement arrangement.
National Petroleum Authority (NPA)	NPA is responsible for the implementation and enforcement of standards which is aimed at ensuring that petroleum products meet the required standards.

At the local level, the Local Government Service Regulations, 1961 (LI 1961), Local Government Act, 1993 (Act 462) and the revised Local Governance Act 2016 (Act 936) are the primary governance documents for MMDAs.

Among the many functions prescribed under these Acts are the regulations and provision of omnibus transport services. The Act requires the setting up of Transport Departments in all the MMDAs. However, not all the MMDA's have fully functional transport departments. The regulation of passenger transport services was virtually absent until the Ghana Urban Transport Project (GUTP) was introduced through a World Bank facility. Under the project, MMDAs in the Greater Accra and Greater Kumasi areas were supported to set up Departments for Transport to address institutional gaps and other lapses in the road transport services sector. Their main task was to plan, regulate and coordinate urban passenger transport activities in participating local assemblies. In GAMA, the Greater Accra Passenger Transport Executive (GAPTE) was established as a body corporate with a mandate that includes:

- Collection, analysis, and modelling of transport data for planning and operating urban transport systems
- Development of operating standards for operators of passenger transport services
- Development of requirements for establishing passenger service standards and passenger information centres
- Setting up of a passenger transport research process for continuous improvement of passenger transport services

The primary mandate of GAPTE is to mainstream transport planning activities within the participating MMDAs into the national development planning system. However, the activities of GAPTE have primarily been constrained by the inadequate regulatory assistance from the relevant MMDAs to ensure effective enforcement of public transport bye-laws and other legislation regulating passenger transport services.

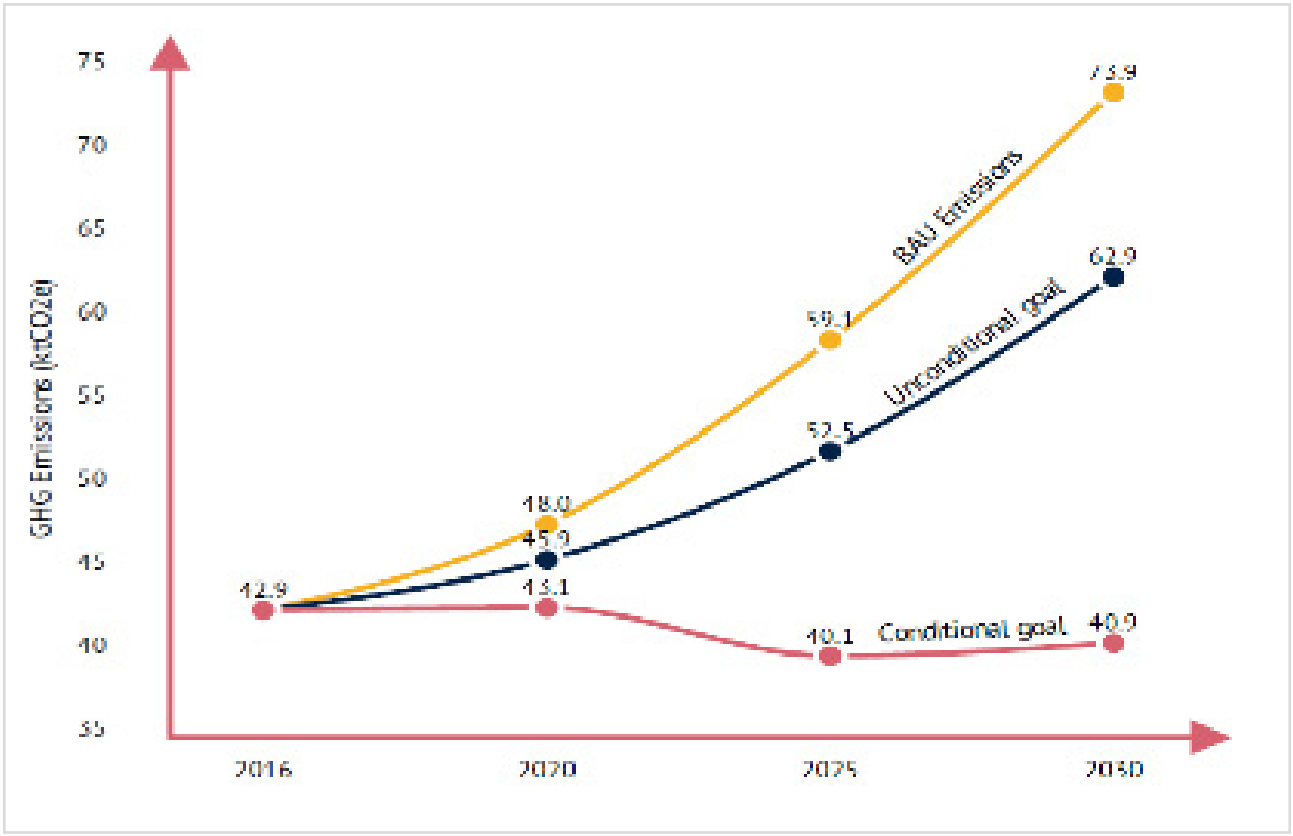
The structure of these institutions and operational criteria affect the performance of the transport sector. The multi-level relationships between national policies and transport sector policies, central national agencies and local authorities, and local authorities and transport service providers present potential conflict zones especially concerning the issues of mandate and functions of the various stakeholders.

2.4. GHG emissions from the transport sector

Closely tied to the rising vehicle stock is the substantial growth in the energy sector, contributing 35.6% of emissions in 2016. Transport is the predominant source of greenhouse gas in the energy sector, accounting for 47.7% of emissions. Vehicle emissions contributed to more than 7.2 MtCO2e emissions in 2016, representing 17% of overall emissions. Ghana's 3rd national communication reports a significant upward trajectory of emissions over the past two decades. The main drivers for the increase in transport emissions are the continued growth in the number of used vehicles and over-reliance on low-capacity passenger vehicles with poor servicing and maintenance, along with the use of sub-standard fuels.

In its nationally determined contribution (NDC), Ghana committed to a 15% reduction in Greenhouse Gas (GHG) emissions by 2030 from the business-as-usual scenario. This is expected to reduce total national GHG from the projected 74 MtCO2e to 63 MtCO2e (Figure 10). However, with technology and financial support that can scale up mitigation actions such as renewable energy use, reducing import of high fuel consumption vehicles and promoting sustainable mass transportation, the emissions can be brought down to 41 MtCO2e and below emissions in 2016 (see Figure 10).

FIGURE 10. GHG Emissions projection from 2016 to 2030



Source: GFEI (2018)

Other key response programs have focused on developing and implementing measures to reduce petroleum consumption and equivalent carbon emissions from the transport sector and discourage the importation and use of high-fuel-consumption vehicles. Although there are a few policies in place that relate to fuel economy, import taxation, overaged penalty and differential tax based on vehicle displacement, and low Sulphur in fuels initiatives have in some ways influenced vehicle mix. Ghana has, over the years, seen an improvement in the fuel economy for mostly imported Light-Duty Vehicles (LDVs) (see Table 4). A study by GFEI (2018) revealed that imported diesel-powered LDVs tend to have better fuel economy (7.0 L/100km) compared to petrol-fuelled vehicles (7.3 L/100km).

Also, CO_2 emissions decrease with the corresponding improvement in fuel efficiency of vehicles, with petrol-powered LDVs having better CO_2 emissions reduction than diesel-fuelled vehicles.

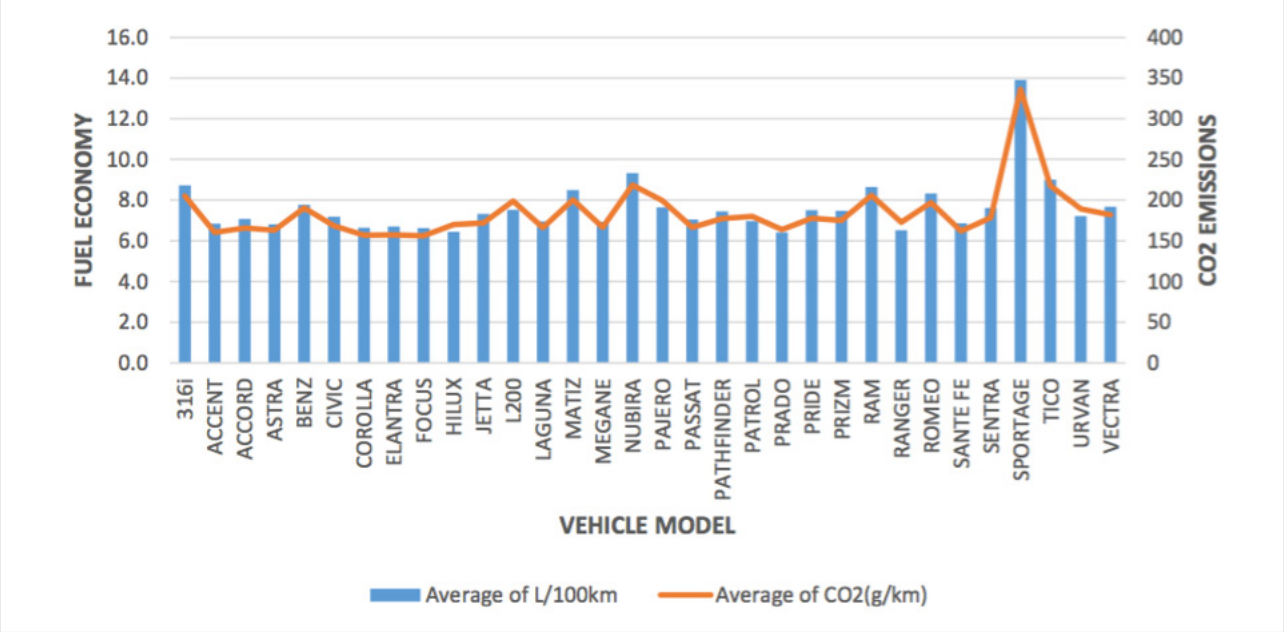
TABLE 4. Average fuel efficiency and CO2 emissions of LDVs in Ghana

YEAR	Average age LDV's (Years)	Average fuel economy (L/100km)	Average CO2 emissions (g/km)
2005	5.7	7.4	180
2006	5.1	7.3	177
2007	4.5	7.4	182
2008	4.4	7.4	181
2009	4.4	7.5	182
2011	4.1	7.3	178
2012	4.6	7.1	173
2013	4.5	7.0	171
2014	4.6	7.1	170
2015	5.1	7.0	166
2016	5.0	6.9	162

Source: GFEI (2018)

In terms of fuel consumption, CO_2 emissions, and engine displacement, the most fuel-efficient imported diesel and petrol LDVs have an engine displacement of 2501-3000cc and 1501-2000cc respectively, whereas the most efficient CO_2 emitter of imported diesel and petrol LDVs have an engine displacement of 2001-2500cc and 2501-3000cc respectively. Figure 11 shows the average fuel economy (L/100km) and CO_2 emissions by popular vehicle models.

FIGURE 11. Average fuel economy (L/100km) and CO2 emissions by popular models



Source: GFEI (2018)

2.5. Air Quality in Cities

In cities of Sub Saharan Africa, one of the highest air pollution levels (measured in terms of PM2.5) in the world have been recorded, often exceeding the WHO prescribed target for annual average PM2.5 concentrations of 35 µg /m3 (Anenberg et al., 2019). However, data on air pollution levels in countries is limited due to the absence of air quality monitoring capacity (Amegah and Agyei-Mensah 2017). In Ghana, air quality monitoring is often limited to only a few locations, with most being centred in the country's capital and data from Environmental Protection Agencies (EPA) is often not readily accessible to the public (Sewor & Obeng, 2021).

Over the years, due to the low standards for fuels in Ghana and old vehicles, vehicular emissions have posed a grave threat to human lives. Fuels sometimes contain sulphur levels 2000 times more than the EU and USA acceptable standards. As part of measures to improve fuel standards, in 2014 the maximum specification for sulphur content in diesel was reduced from 5000ppm to 3000ppm and subsequently revised to 500ppm for refineries (to be further reduced to 50ppm or lower) and a maximum of 50ppm sulphur for imports. Such measures coupled with the successful elimination of lead in gasoline are expected to improve fuel economy, engine performance, and local roadside air quality and further accelerate Ghana's transition to ultra-low sulphur fuels with a maximum of 10 ppm of sulphur. A combination of tax, vehicle options, and fuel efficiency policy will be very instrumental in increasing fuel efficiency and reducing emissions. Therefore, the introduction of electric mobility is one of the viable options that should be championed to reduce transport-related emissions.

Ghana Urban Air Quality Project (GHAir) was established in May 2019 with the overall goal of bridging the air pollution data and epidemiologic research gap in Ghana. The project currently has deployed low-cost sensors, a mixture of PurpleAir sensors, Clarity nodes, RAMPs, and Modulair-PM, in five metropolitan areas of Ghana, namely Accra, Tema, Cape Coast, Takoradi, and Kumasi (Sewor & Obeng, 2021). The infrastructure for air quality monitoring will help monitor the impacts of electric mobility.

2.6. Projections and future plans for urban transport

Going forward, Ghana's vision for the transport sector aims to provide an "integrated, efficient, cost-effective and sustainable transportation system responsive to the needs of society, supporting growth and poverty reduction and capable of establishing and maintaining Ghana as a transportation hub of West Africa" (GoG, 2020, p. 38).

Thus, under the National Infrastructure Plan (NIP), the government wants to upgrade the current underperforming transport infrastructure to a "typical High and Upper Middle-Income country" (GoG, 2017, p. 57). This is in recognition of the relationship between the quantity and quality of transport infrastructure and the level of economic development (GoG, 2020). To this end, specific Modal Master Plans have been proposed to improve urban transport infrastructure under the NIP initiative for GAMA and Kumasi. The Greater Accra Master Plan (GAMP), for instance, was prepared with the technical support of the Korean Government through KOICA to address GAMA's urban transport needs and improvement from 2015 to 2035. Table 5 presents a snapshot of the ongoing project in Accra.

TABLE 5. Infrastructure projects under the Greater Accra Master Plan

Improvement Item	Short-term	Mid-term I	Mid-term II	Total
BRT (length)	Adenta-CBD, Amasaman-CBD	Motorway Kasoa-CBD	Ashaiman-Ringroad Achimota-Labadi	6 routes
	49.9km (24.9km)	61.4km	56.7km	168.3km(24.9km)
Arterial Bus (length/bus)	Line 2-1, 2-2 Line 3-1, 3-2	Line 1, 2-3 Line 4-1, 4-2	Line 4-3, C-1, C-2, Line C-3	12 lines
	71.5km / 158(85)	122.6km / 177	98.3km / 146	292.4 / 478(85)
Hub Terminal	(Amasaman, Ofankor) Adenta, Madina, 37 Lorry	Kasoa, Sowutuom Community 1, Sakaman	Ashaiman, Circle, Kaneshie, 37 Lorry (Achimota)	13 hub terminals (3)
Transfer Facility	5 facilities	3 facilities	3 facilities	11 transfer facilities

Source: GoG, 2017

Several important infrastructure projects are ongoing or have recently been completed, including the construction of the bypass and the widening of the Lake Road in Kumasi, and the Kwame Nkrumah, Kasoa, and Pokuase interchanges in Accra. Nevertheless, essential road links are still missing or have reached their maximal capacity, and the existing road network remains vulnerable to seasonal floods. As a way of keeping faith in the policy objective of revamping the transport infrastructure of the country, generally, the year 2020 was declared as the "Year of Roads" to pay particular attention to road infrastructure (Citi Newsroom 2019; Graphic Online, 2019). However, the Covid-19 pandemic hit Ghana in 2020, thereby slowing down the government's activities. Understandably, public health was paramount, and it seems the government's immediate concern was to address the inadequate health sector infrastructure. The government has made good its intention to prioritise road infrastructure by declaring 2021 as a continuation of the Year of Roads policy objectives (GhanaWeb, 2021). In this regard, safe last mile connectivity and a combination of the different vehicle modes that provide door-to-door connectivity should also be developed as it enhances women's mobility.

Additionally, it has been widely recognised that electrification of the transport sector is one of the several technological trajectories that can address some of the environmental issues associated with the growth in vehicles and travel, oil demands, and climate change impacts. Ghana made commitments in the fight against climate change through its Intended Nationally Determined Contribution (INDC) in 2015. Specific targets concerning the urban transport sector included: increase the number of trips by public transportation by 10% in the 4 major cities; sustainable mass transportation modes (rail and bus transit system); reduce travel time by at least 8 minutes per trip by public transport; decrease traffic congestion levels. The first target was accomplished, through the Ghana Urban Transport Project (GUTP), with the establishment of high QBS, as part of the BRT initiative, on the Amasaman, Adenta, and Kasoa corridors - Ayalolo services. However, it is bedevilled with poor ridership and unsustainable financial challenges. It is estimated that the development of a full BRT can reduce emissions by 1.63MtCO2 by the year 2040 when combined with other climate change mitigation measures (GoG, 2015b). The electrification of the QBS and deployment of electric buses in Accra can accelerate the achievement of this target as well as the NDC target (-15% relative to BAU). Coupled with this, the QBS when developed to a full BRT system can potentially minimize traffic congestion in Accra thereby contributing to the New Urban Agenda on improving transport and mobility infrastructure systems and consequently enhance efficiency, connectivity, accessibility, health, and quality of life of urban dwellers (UN-Habitat, 2015).

The utilization of electric mobility in Ghana is still at the infant stages of development. The Government is considering the introduction of tax exoneration for electric vehicles as part of plans to promote a technology shift from fossil fuel-based vehicles and by so doing enable the transition to low emissions transportation. In this regard, the government is on the move to secure high-occupancy electric buses for urban transport, through the Green Climate Fund (GCF) and other Development Partners. These actions have occasioned inter-sectoral collabora-

tion and industry partnership including a pilot installation of Electric Vehicle (EV) charging systems (e.g. A&C Mall in East Legon, and Stanbic Heights, Airport City).

This initiative, however, requires further investments to conduct comprehensive engineering and commercial studies into the effects of the EV charging system on current electricity distribution networks, the energy consumption rate of different charging systems, installation at filling stations, charging cost, etc. Such efforts demonstrate the government's commitment towards developing an EV policy and market readiness and implementation framework that can operationalize electric mobility and make a significant contribution to the NDC target. Consequently, the private sector and some local startups have also responded positively by taking initiatives to reduce the barriers to adoption and boost the EV market in Ghana. Such initiatives and projects include:

- SolarTaxi: assembles electric motorcycles, leases electric vehicles, and provides EV passenger services at affordable prices;
- Kantanka automobile Ltd.: currently constructing lithium powered EVs for private and commercial use;
- Great Walls Motors Ora 1 (aka Black Cat): has both motor and battery pack EVs for private and commercial use;
- Accraine: specializes in the supply, installation and servicing of electric vehicles;
- Arke Technologies: retrofits EVs and operates an EV conversion school and workshop;

Some individuals are also using imported and/or retrofitted electric vehicles (Graphic online, 2019).

Ghana's intensified efforts toward the deployment of electric vehicles should consider leveraging and scaling up some of these ongoing projects and possibly extend to include other projects such as the Ghana Climate Innovation Center (GCIC), a technology hub designed to help over 100 local clean technology businesses develop and commercialize innovative solutions to climate change. Also, given that electric buses are becoming cheaper than diesel-run buses, the introduction of electric buses into the QBS in Accra can be an innovative effort to revolutionize sustainable urban transportation. It is worth adding that although some plans exist to improve air quality and promote sustainable mass transport including the introduction of electric vehicles (EVs) and alternative fuels in vehicles, the regulatory and implementation framework is not clearly defined. For example, in 2015 vehicle import duties and value-added tax (VAT) was revised to cover high capacity buses, which hitherto was exempt from import duty (CET Act of 2015, Act 905). This revision has disincentivised current efforts to promote and encourage the use of high-capacity buses for public transport.

Also, rather than supporting vehicles with lower engine displacement, as they are often more efficient, the Act imposes 10% import duty on vehicles with engine capacity of above 1500 to 1900 cc, which was previously applied to vehicles above 2000 cc. Mindful of this, there should be a clear policy direction specifically with respect to the application of import duties and taxes on EVs (as these have no engines) and other energy-efficient vehicles to facilitate their penetration, uptake, and use.

3. Electric Mobility Priorities in Ghana technology suppliers

3.1. Decision Context: Country aims and expectations

As a first step in prioritising EVs, the decision context was established. The study adapted and conceptualized the decision context as the economic, political, social and technological environment surrounding the decision. For emphasis, other related categories such as financial, institutional, environmental and climate change were included in the decision context to reflect Ghana's national development framework. The decision-making process entailed identifying clear objectives that are specific, measurable, attainable, realistic, and timely. The objectives defining the decision context was thus framed to take account of Ghana's climate change and sustainable development agenda.

The objectives for the prioritisation process was established in two steps. First, the consultant did a comprehensive desk review of documents on climate change, development priorities, and national/sectoral strategies and plans. It is worth noting that these objectives have, to some extent, already been determined by decision-makers in the national or sectoral strategies and plans. Second, the consultant did extensive stakeholder mapping, producing an all-inclusive list of relevant stakeholders who mattered (see Appendix 2). The objectives established were discussed with the relevant stakeholders and steering committee members for comments and evaluation. The results of this process were further finalized together with UNEP DTU.

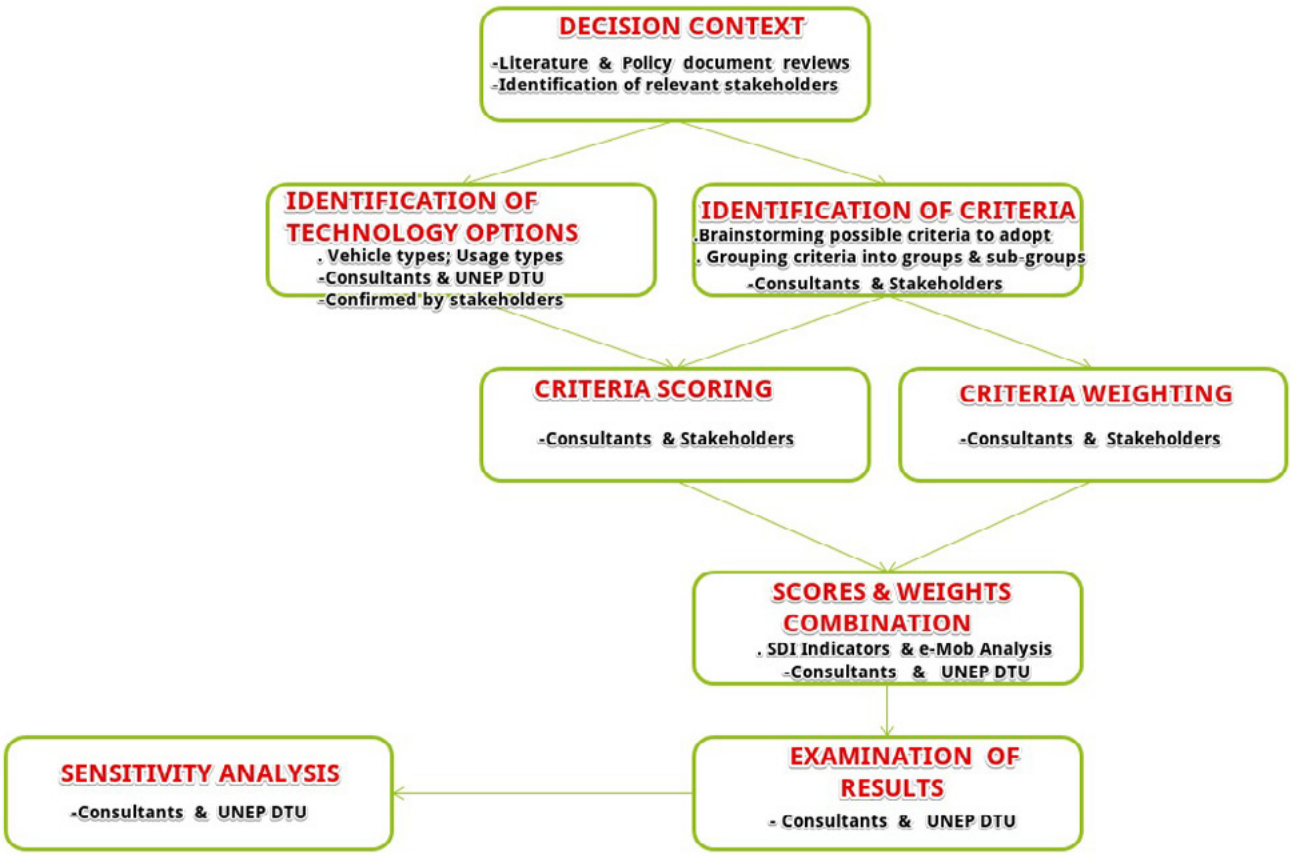
Electric Mobility (e-mobility) is expected to deliver a full spectrum of mitigation outcomes with the potential to spur a paradigm shift in mass and sustainable urban transport in major cities in Ghana as e-mobility offers low to zero tailpipe exhaust emissions. As a result, it is estimated to contribute substantially to Ghana's ambitious GHG mitigation actions and ensure better air quality consistent with the Paris Agreement. Specifically, e-mobility is expected to deliver multiple results in the following areas: GHG emission reduction, improvement in local pollutants (avoided NOx and PMs), improvement in fuel economy, and above all, facilitate the transfer of low carbon technology.

The uptake of e-mobility has been slow in Ghana. Therefore, Ghana's e-mobility agenda would have to be delivered through a range of supportive government policies, private sector partnerships, and investments from international development partners. Policies to overcome ownership cost and technical barriers associated with electric vehicles (EVs) vis-à-vis the internal combustion engine vehicles (ICEVs) are as important as the enabling operational environment required for cheap and clean electricity, the rollout of public charging infrastructure and stations, and emission mitigation. Such policy interventions are critical to the penetration and adoption of e-mobility and can potentially drive other related development in the urban transport landscape. However, being a developing country, the resources are limited, and it is vital to direct the investment in a direction which delivers the highest benefits.

3.2. Methodology for Prioritisation

Formulating electric mobility policy necessitates a range of methods and stakeholder consultations to address cost, benefit, and local context issues related to government budgets, policy scenarios and instruments, and support ecosystems that promote public acceptance.

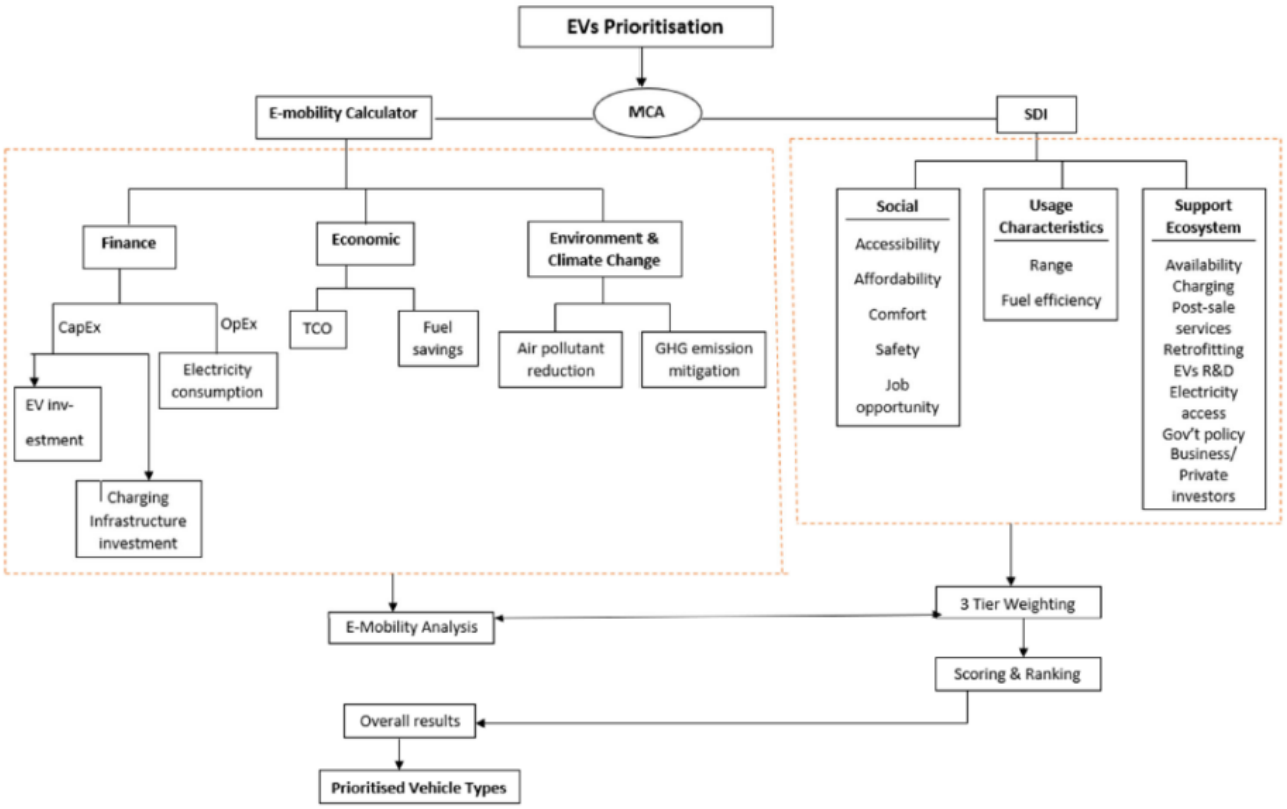
FIGURE 12. Steps adopted in the Multi-Criteria Assessment



The multi-criteria assessment (MCA) methodology was adopted for prioritizing EVs in Ghana. MCA is an analytical tool commonly used for decision-making, including ranking options or short-listing options and providing a scale of preference for a limited number of options. MCA allows mixed methods, i.e. both quantitative and qualitative criteria. The MCA process, in general, involves eight steps (Figure 12). It entails a combination of criteria valued in monetary and non-monetary terms. The social, environmental, technical, institutional, economic, and financial criteria are considered. MCA provides a structured framework for comparing mitigation technologies across multiple criteria. Importantly, given that MCA is a value-judgement based system, the framework was adopted to reflect a well-balanced judgement of all the relevant stakeholders and developed through a consultative process.

The MCA methodology applied for the current project had two core components: (1) UNEP e-mobility calculator (E-MOB) and (2) Sustainable Development Impacts (SDI). Figure 13 provides a flow chart of how these two components were applied. The E-MOB calculator, developed by the UN Environment Programme, was used to quantitatively analyse the potential of saving energy, greenhouse gas and air pollutant emissions and money through a shift to electric vehicles. Presently, there are three distinct calculators. They include E-MOB calculators designed for Motorcycles (which was adopted and adapted for the analysis on 2-Wheelers and 3-Wheelers); Light-duty vehicles (which was adopted and adapted for the analysis on personal cars and taxis) and Buses (which was adopted and adapted for the analysis on Trotros and Buses) in Ghana. Appendix 1 illustrates the data requirements and sources for the E-MOB. The SDI measures specific socio-economic benefits and challenges that accrue to the adoption of EVs. Specifically, the SDI data was sourced through surveys with selected relevant stakeholders.

FIGURE 13. Flow chart illustrating the MCA methodology process



3.3. Options for EVs in Ghana in terms of vehicle categories and user types

This second step of the MCA aims to identify the options of mitigation technologies that were evaluated and assessed. The output of this step is six identified EV categories: 2W, 3W, Car, Taxi, Trotro and Buses. The consultant did a thorough and up-to-date desk review of existing studies on climate change and low carbon strategies and actions, development priorities, and national/sectoral strategies and plans to identify the EV options for prioritization. The list of identified vehicle categories was discussed with relevant stakeholders. Based on feedback from experts, the identified list of EV categories was refined and further categorized into usage types: i.e. public and private transport modes (see Table 6).

TABLE 6. Identified vehicle categories for prioritizing EVs in Ghana

Private	Public
2 Wheeler(2W)	Taxi
3 Wheeler (3W)	Trotro
Car	Bus

The consultant prepared technology fact sheets (flashcards) to provide the stakeholders with essential data and information on each identified EV option (See flashcards in Appendix 4). During the engagement meetings, the consultant presented fact sheets or flashcards about key figures and features of the identified vehicle types. The flashcards contained infographics on both conventional vehicles and EVs for comparison purposes. In addition, they provided a baseline scenario and a 10-year projection for the six (6) identified vehicle types (2W, 3W, Car, Taxi, Trotro, and Bus). The data for the conventional vehicles were based on parameters from the transport fare model adopted by the Ministry of Transport (MoT) and transport operators in fixing transport fares in Ghana. Data from the American Auto Association (AAA) was used for the EVs. The assumptions about the model and input data for the flashcards on ICEVs and EVs are shown in Appendix 3. The 10-year total cost of ownership projection flashcards showed that overall EVs are cheaper to run and maintain than conventional vehicles. Stakeholders/experts provided feedback on the flashcards that informed the revised version.

3.4. Criteria (Attributes) for prioritisation of EVs in Ghana

Criteria are the measures of performance by which the six identified vehicle options were evaluated and judged. The criteria against which the vehicle options were evaluated were comprehensive to enable a complete evaluation; however, mutually exclusive to avoid duplication. The meaning of the criteria and the implied trade-offs were explained to the Steering Committee, experts and stakeholders. The criteria were derived from the objectives identified in Step 1, which mainly focused on prioritizing EVs for Ghana in transport-related emissions mitigation and mass and sustainable transport to foster national and sectoral development priorities.

The criteria were categorised at three levels. At level one, three criteria categories were identified, further divided into sub-categories at level two and into parameters at level three. The criteria used and the sources of data are shown in Table 7. These sub-divisions afforded stakeholders an understanding of how the objectives are translated into evaluation criteria. The criteria were also selected and categorised based on the national development agenda, considering the needs and objectives set for the transport sector.

TABLE 7. Criteria used for prioritizing EVs in Ghana and data sources

Criteria Categories (L1)	Criteria Sub-categories (L2)	Parameters (L3)	Method /Data Sources
Cost & Financing	Capital expenditures (CapEx)	EVs investment requirement (e.g. acquisition of vehicles; knocked down parts; depots etc)	Transport Fare Model, MoT
		Charging infrastructure investment requirement	eMob Cal
	Operating expenditures (OPEX)	Electricity consumption	eMob Cal
Benefits	Economic	Total Cost of Ownership (TCO)	eMob Cal
		Fuel savings	eMob Cal
	Environmental	Air pollutants (PM, NOx) reduction	eMob Cal
	Climate	GHG emissions (i.e. CO2) mitigation	eMob Cal
	Social	Accessibility	Survey
		Affordability	Survey
		Comfort	Survey
		Safety	Survey
		Personal Security	Survey
		Job opportunities	Survey
Local Context	Usage characteristics	On road Vehicle stock	DVLA
		Vehicle trip length (Range i.e trip time before next charge)	Transport Fare Model, MoT
		Fuel efficiency per passenger km	eMob Cal
	Supporting Ecosystem	Local availability of EV models	Survey
		Easiness of EV Charging	Survey
		Local post sales services	Survey
		Local assembly & supply of EV model	Survey
		Local retrofitting of ICEVs to Evs	Survey
		EVs R&D and Technical skills	Survey
		Quality of road and accessibility	Survey
	Local stakeholders' acceptance	Government's preference	Survey
		Businesses/ Private investors (i.e. OEMS, Service Providers; Associations)	Survey
		Local consumers	Survey

3.5. Criteria Scoring

3.5.1. Attribute Values

The attribute values for different options against different criteria defined in Table 7 were done using quantitative and qualitative methods. The quantitative approach was used for criteria for which calculations were made using the eMob Cal or the Transport Fare model. The qualitative approach relied on surveys for estimating attribute values for the following sub-categories as shown in Table 7: social (six items in all), supporting eco-systems (seven items in all), and local stakeholders' acceptance (three items in all).

The survey questionnaires for qualitative methods were designed in consultation with UNEP DTU and piloted first with a few selected participants. The survey questionnaire was revised for clarity and flow based on respondents' feedback. Participants were asked to rank/score the six-vehicle categories: 2W, 3W, Car, Taxi, Trotro, Buses, using a scale of 1 to 6, with 1 being the 'most preferred option' and 6 the 'least preferred option' per the set criteria/parameters. Appendix 7 contains the final survey tool adopted for six social parameters. Appendix 9 includes the survey tool for seven parameters for supporting eco-systems and three parameters for local stakeholders' acceptance. The list of stakeholders who participated in the two qualitative surveys is provided in Appendix 8 and 10.

3.5.2. Value Functions

Value functions convert all the attribute values on a scale of 0 to 100 to allow comparison across criteria and allow to combine the scores across different criteria into an overall score for each option. Two different value functions were used for quantitative (done using eMob calculator and Transport Fare model) and qualitative indicators (collected using stakeholder surveys).

Primary data obtained from the stakeholder surveys on the qualitative indicators were extracted from Google forms and saved in Excel spreadsheets for further analyses. Table 8 indicates the value function used to convert the ranking given by stakeholders into a standardized score from 0 to 100. For example, if transport mode A is scored 1st on a parameter, and mode B is scored 2nd for the same parameter, it is assumed that mode A has scored 100% while mode B scored 83% on that parameter.

TABLE 8. Value function for scoring the SDI parameters

Position	Score	Score on a scale of 0 to 100 (%)
1st (Most preferred)	1.00 (6/6)	100
2nd	0.83 (5/6)	83
3rd	0.67 (4/6)	67
4th	0.50 (3/6)	50
5th	0.33 (2/6)	33
6th (Least preferred)	0.17 (1/6)	17

Regarding the quantitative attributes estimated using the E-Mob calculator, the value function used to convert the absolute values into scores was stated thus:

When the preferred value is higher

$$Score = \frac{100-17}{X_{max}-X_{min}} \; x \; (X_{\square} - X_{max}) + 100$$

When the preferred value is lower

$$Score = \frac{17-100}{X_{max}-X_{min}} \; x \; (X_{\square} - X_{max}) + 17$$

Where: X_{max} = most preferred value for a mode
X_{min} = least preferred value for a mode

3.6 Criteria Weighting

A stakeholder engagement meeting was organized virtually via Zoom to assign weights to the Criteria categories (L1), Sub-categories (L2) and Parameters (L3). A survey tool was designed and mounted on Google forms (See Appendix 5), and the link to the forms was posted in a Zoom chat box for the benefit of the stakeholders. The questions were explained to survey participants through interactive sessions. These experts, drawn from knowledgeable industry and policy experts in the transport and related sectors (See Appendix 6 for the experts), filled the survey questionnaire on the Criteria categories (L1), Sub-categories (L2) and Parameters (L3 for prioritising EVs. The participants first discussed and confirmed the Criteria categories (L1), Sub-categories (L2) and Parameters (L3), and secondly, assigned a three-tier weightage to the three different criteria levels. The output is presented in Table 9.

TABLE 9. Criteria weights of the various criteria

Criteria Categories (L1)	L1 Weightage	Sub-categories (L2)	L2 Weightage	Parameters (L3)	L3 Weightage
Cost & Financing	49%	Capital expenditures (CapEx)	55%	EVs investment requirement (e.g. acquisition of vehicles; knocked down parts; depots etc)	56%
				Charging infrastructure investment requirement	44%
		Operating expenditures (OPEX)	45%	Electricity consumption	100%
Benefits	30%	Economic	28%	Total Cost of Ownership (TCO)	53%
				Fuel savings	47%
		Environmental	24%	Air pollutants (PM, NOx) reduction	100%
		Climate	28%	GHG emissions (i.e. CO2) mitigation	100%
		Social	20%	Accessibility	17%
				Affordability	24%
				Comfort	13%
				Safety	16%
				Personal Security	13%
				Job opportunities	17%
Local Context	21%	Usage characteristics	31%	On road Vehicle stock	29%
				Vehicle trip length (Range i.e trip time before next charge)	33%
				Fuel efficiency per passenger km	38%
		Supporting Ecosystem	37%	Local availability of EV models	14%
				Easiness of EV Charging	16%
				Local post sales services	21%
				Local assembly & supply of EV model	14%
				Local retrofitting of ICEVs to Evs	12%
				EVs R&D and Technical skills	11%
				Quality of road and accessibility	12%
		Local stakeholders' acceptance	32%	Government's preference	36%
				Businesses/ Private investors (i.e. OEMS, Service Providers; Associations)	31%
				Local consumers	33%

In the first step, the participants assign a weight totalling 100% to the criteria categories at Level 1: cost and financing, benefit, and local context. The second step involved assigning weight (totalling 100%) to the sub-categories (Level 2) of the respective criteria categories that were weighted in the first step. Finally, the third step entailed giving weights to the various parameters (Level 3).

3.7. Results and Sensitivity Analysis

3.7.1. Attitude of stakeholders for EVs

The qualitative views of participants were sought regarding plans by the Ghanaian government to promote electric vehicles for the country. The results are illustrated in Figure 14. Participants (see Appendix 8 for the participants) agreed that this was a good idea and overwhelmingly endorsed the policy. The participants believed that EV adoption would serve the nation well in terms of helping overcome dependence on fossilized fuels (23.4%) and improving the environment (22.1%). A handful of respondents (1.3%) indicated that being seen driving in an electric vehicle was a sign of personal accomplishment (Figures 15).

FIGURE 14. Attitudes towards EVs adoption by the government

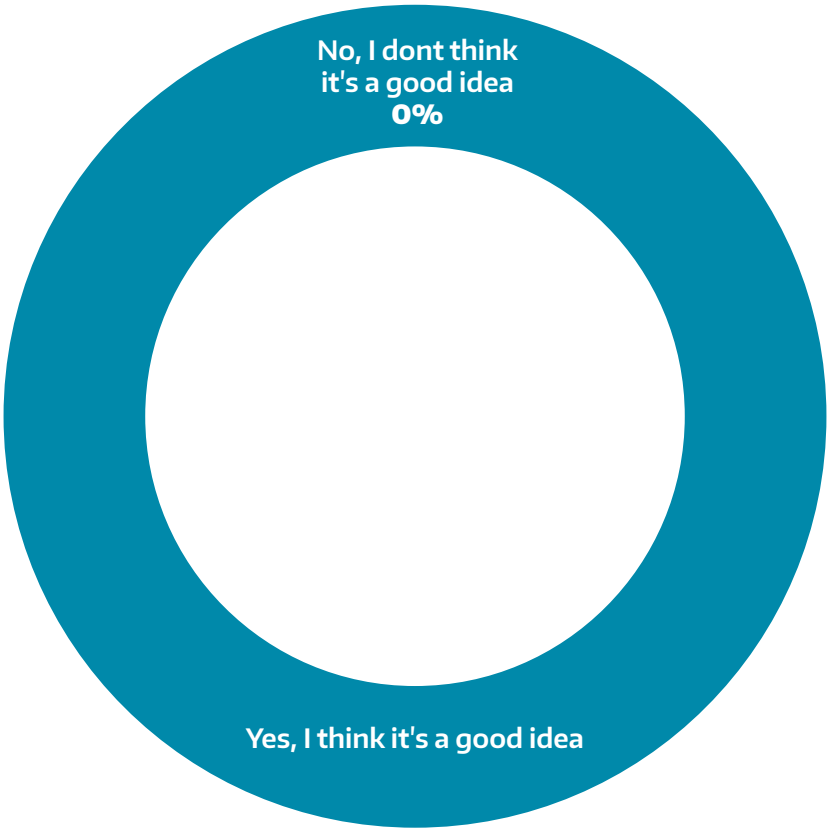
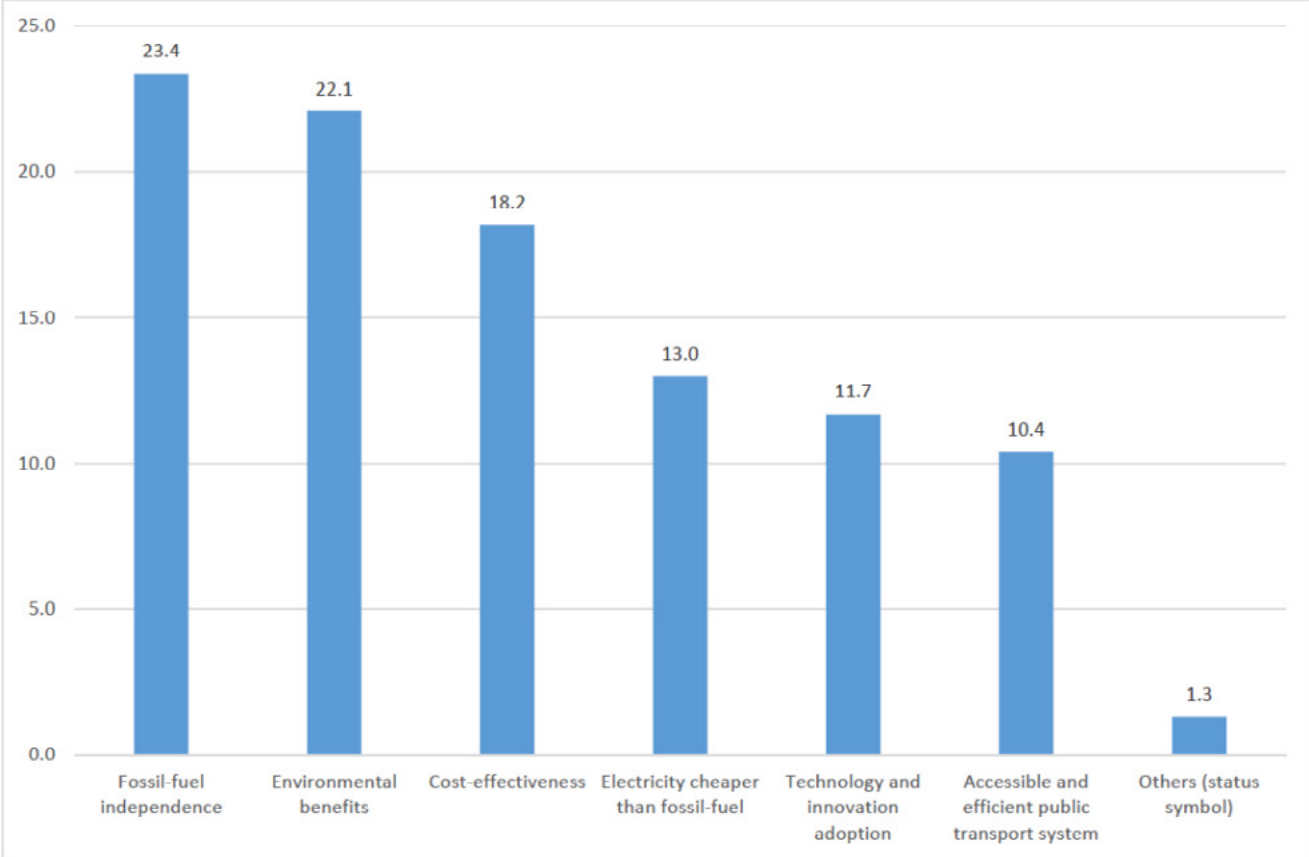


FIGURE 15. Key themes that explain the massive support for EVs adoption in Ghana (Top Panel - Graphic and in % terms)



3.7.2. Priorities for EVs

The priorities for EVs are presented here based on scores obtained for both qualitative and quantitative indicators. We start with scores for qualitative indicators followed by quantitative and then the overall score.

Table 10 shows the score for SD indicators for the various EV modes based on how surveyed participants perceive their overall potential for achieving sustainability in the transport sector. In terms of providing equal access and affordability, Trotro ranked the highest and was closely followed by bus. However, the bus was ranked highest for the remaining parameters, including comfort , safety and security. This suggests that adopting a bus for the EV policy will assure commuters of a comfortable, safe and secured travel experience. In the case of private transport car was the highest scorer on all indicators.

TABLE 10. Aggregate Scores for SDI

Modes	Bus	Trotro	4w-Taxi	Car	3W-Personal	2W-Personal
Access	1533	**1714**	1334	**1351**	731	621
Affordability	1633	**1648**	1301	**883**	848	835
Comfort	**1751**	1148	1500	**1515**	799	570
Safety	**1733**	1332	1383	**1484**	864	587
Security	**1749**	1365	1401	**1450**	765	571
Job opportunities	**1533**	1515	1367	869	914	**1085**
Total	9932	8722	8286	7552	4921	4269
Percent	22.7	20.0	19.0	17.3	11.3	9.8

In the case of local context-related indicators (Table 11), for public transport vehicles, it was 4W Taxi that had the highest scores with bus and Trotro getting almost equal scores. In the case of private vehicles, cars were given the highest score.

TABLE 11. Aggregate Scores for Local Context

Modes	Bus	Trotro	4w-Taxi	Car	3W-Personal	2W-Personal
Local availability	616	734	**865**	**1133**	501	70
Local Retrofitting	618	631	**917**	**967**	848	553
Local post sales services	568	683	**933**	**1017**	682	733
Easiness of EV charging	567	516	**767**	903	863	**1000**
Evs R& D	868	**932**	899	**1018**	481	352
Electricity Access	**1084**	963	768	**802**	546	387
Government policy	1066	**1081**	902	**733**	514	320
Businesses/ Private investors	718	898	**1018**	**817**	631	584
Local assembly & supply of EV model (q9)	618	631	**917**	**967**	848	553
Local consumers (q10)	**1233**	963	758	**802**	480	304
Total	7956	8032	8754	9159	6394	5487
Percent	17.4	17.5	19.1	20.0	14.0	12.0

The analyses for quantitative indicators show that buses have the highest values in terms of the cumulative costs savings, fuel savings, fuel efficiency and GHG reduction in the public transport modes (Table 12). In case of private transport vehicles the cars had the highest values for cumulative costs savings, fuel savings, fuel efficiency, air pollution and GHG reduction. However both buses and cars had highest investment requirements which is something to consider for implementation.

TABLE 12. Attribute values for quantitative indicators

Indicator (L3)	Unit	Bus	Trotro	4w-Taxi	Car	3W-Personal	2W-Personal
EVs investment requirement	US $	320,000	95,000	36,000	36,000	3,388	2,730
Charging infrastructure investment requirement per vehicle	US $	80,000	80,000	4360	805	54	54
Maintenance cost of vehicle per passenger km of electric vehicle	US $ /100 pkm	0.4	0.6	2.4	4.8	0.3	0.3
Cumulative Cost Savings EMOB Scenario	million US $	39,701	23,547	10528	9,540	512	8,984
Fuel savings cumulative EMOB Scenario	million Lge	32,328	23,514	15,259	7,230	242	1885
Air pollutants (PM) reduction cumulative EMOB Scenario	tons	3,305	1,709	15,259	7,230	242	1885
GHG emissions reduction cumulative (till 2050)	thousand ton CO2	89,914	65,298	36,184	19,034	783	6,106
On road Vehicle stock in 2020	thousand	243	41	308	1,156	83	754
Driving Range		250	250	350	350	60	60
Fuel efficiency per passenger km of electric vehicle	Kwh/100 pkm	1.9	2.5	4.5	11.3	5	5

The overall result from the Multi-Criteria Assessment, which incorporates scores and weights is presented in Table 13. Among the various transport modes used for public transport, the bus emerged as the overall preferred option with an aggregate score of 70.11. On the other hand, among the modes used for personal mobility, the car has the highest aggregate score of 55.64. These outputs of the prioritisation were presented to the Steering Committee, experts and stakeholders across the related sector (see Appendix 11) for validation at a workshop organised by the Ministry of Transport on 7 July 2021.

TABLE 13. Prioritized transport modes for EV adoption in Ghana

Usage Type	Modes	Overall Score
Public	**Bus**	70.11
	4W-Taxi	69.71
	Trotro	65.08
Personal	**Car**	55.64
	2W-Personal	49.55
	3W-Personal	47.24

4. Barriers for EVs

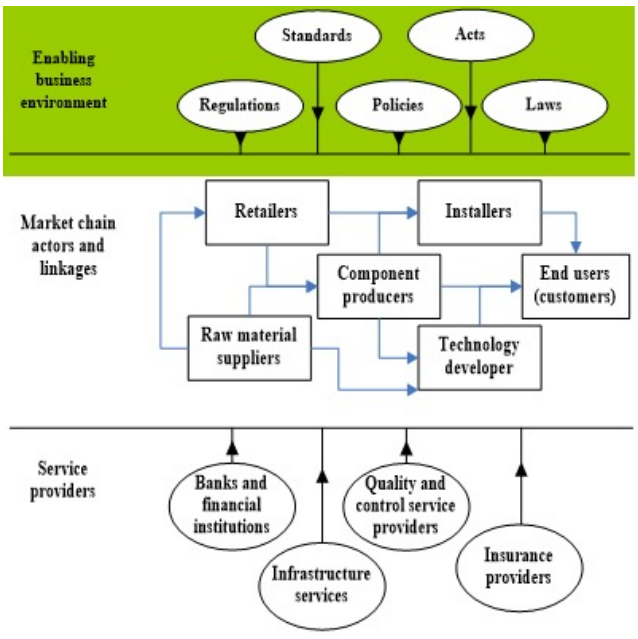
Electric mobility is gradually gaining attention in Africa. In Ghana, although e-mobility has great potential to unlock investment opportunities and innovation for clean, safe and reliable urban transport, EVs are still not attractive due to a wide variety of barriers.

4.1. Methodology for Barrier Analysis

4.1.1. Introduction

Electric vehicles (EVs) are considered a market good (Nygaard & Hansen, 2015). Thus, in identifying and analysing barriers for such goods, a market mapping framework, as illustrated in Figure 16, is used to identify the players in the market chain, enabling the business environment and service providers.

FIGURE 16: Market mapping framework adopted in the study



Generally, the idea of barriers identification and analysis of market goods is premised on the fact that "some form of participatory approach and stakeholder consultation is recommended to strengthen the understanding and identification of pertinent barriers and to improve the appropriateness of barrier removal measures. This may include written feedback, bilateral discussions between consultants and main decision-makers, and the use of questionnaires, all of which may be combined with stakeholder workshops."(Nygaard & Hansen, 2015, p.16-17)

4.1.2. Framework for Analysing Barriers and Enabling Measures

In this particular study, the Consultant began with a desk study of policy documents and relevant academic literature to identify and enumerate "the primary reasons why the [EV] technology is not currently in widespread use, and why neither the private nor public sectors have invested significantly in it" (Nygaard & Hansen, 2015, p.17). In addition, the Consultant reflected on and incorporated some key points highlighted by participants at the Prioritization Workshop organized at the Ministry of Transport. The barriers were categorized appropriately under various sub-headings. These were: economic and financial, social (including awareness/usability/information), technical, infrastructure, policy, regulatory and institutional barriers. These barriers may be common, but they are also uniquely contextual. The steps followed for barrier analysis are detailed below

Desk review

The initial step in identifying and analysing barriers and their mitigating measures was an extensive review of existing studies and reports to identify key issues, challenges and enablers that promote EVs uptake. This review revealed a number of pertinent factors such as financial, market, socio-cultural, operational, policy, and institutional potential implementation barriers. Lessons learned from the reviews informed the identification and contextualization of the barriers and determining the lacuna in policies and mitigating measures to overcome the barriers.

Stakeholders interviews

The second step comprised preliminary consultations and engagements with stakeholders to identify and

contextualise key potential barriers and enablers. This process informed the development of the interview guide (Appendix 9), which was later revised, piloted with a few participants and finalised for deployment. This was done in close consultation with our partners at UDP. Afterwards, attempts were made to contact the stakeholders who were categorized under: (a) national policy actors and regulators; (b) donors and (c) end users or consumers of electric vehicles. Face to face and Zoom interviews were held with available stakeholders and experts. Overall, 17 in-depth interviews were conducted to represent a cross-section of the categorised stakeholders. They included EV manufacturers, policymakers, regulators and related institutions, technical experts, potential consumers and users, early adopters (hybrid EV users), and transport operators and unions. Each interview lasted between 30 minutes and one hour. See Appendix 12 for a list of stakeholders interviewed.

Market Surveys on Barriers & Enablers to EV adoption

Market surveys involving 1507 participants were undertaken in three most urbanized localities which represent the three (3) broad ecological zones of Ghana. These are: Accra (n=705), representing the southern sector; Kumasi (n=502), representing the middle sector and Tamale (n=300), representing the northern sector of the country respectively (see Figure 17).

FIGURE 17. A map of Ghana showing the three ecological zones for the market survey on EVs.

These urbanized locations were purposively selected due to the high population growth and rising levels of motorization in recent decades, as discussed earlier in section 2. For instance, Accra and its contiguously built-up area, GAMA, is home to about 5 million inhabitants. In addition, Accra hosts about 60% of the Ghana's registered vehicle population (Hesse and Ofosu, 2014). In addition, all five (5) currently available electric vehicle charging outlets are located in the city. These are found at the Kempinski Hotel Gold Coast City, Palace Shopping Mall, and the ANC Shopping Mall. The rest are located at the Stanbic Heights and the Total Service Station on Liberation Road (See Appendix 13).

Due in part to growing disposable incomes and urban sprawl, Kumasi and Tamale are equally fast motorizing. Hence their inclusion in this study. Appendix 14 illustrate the geographical distribution of study sites in Accra, Kumasi and Tamale, where participants were randomly selected for the market surveys. In Appendix 15, an overview of selected participants, including gender, age, education, marital status, and employment status in given. The rest are income, city of residence, household size, housing type and assets owned.

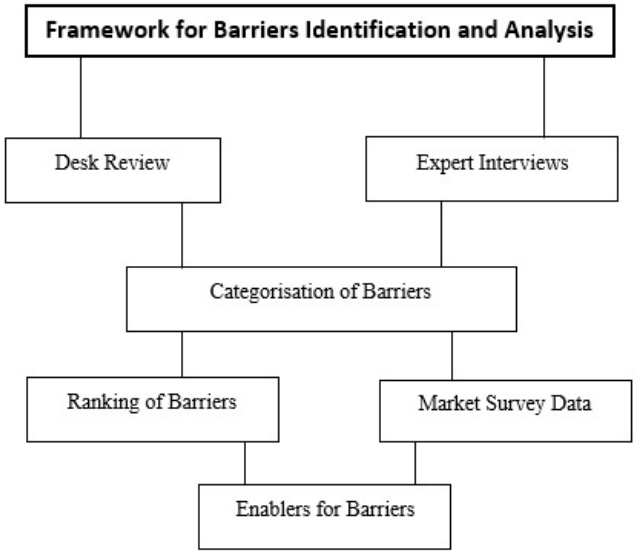
Categorising, weighting and ranking barriers

After data collection, the analytical process involved classifying the barriers into categories and ranking them. Five categories of barriers were identified: (1) social, (2) technical, (3) economic/financial, (4) policy/regulation/institutional, and (5) infrastructure. The identified barriers were refined through further consultation with experts. In total, 22 barriers were identified and these were grouped under the five major categorized barriers. The multi-criteria decision method (MDCM) was employed in the various stakeholder elicitation and decision-making processes and ranking of the barriers. We adopted the weighted sum method (WSM), and analytical hierarchy process (AHP) multi-criteria approaches to ensure that throughout the stakeholder engagement process, the decisions made are consistent, inclusive and unbiased. This adopted approach has been used for the context of renewable energy penetration (see Painuly 2001).

The WSM was used to estimate the priority and percentage weights for the categorised barriers and their sub-categories. Afterwards, the AHP approach was used to rank the barriers. The AHP is one of the pop-

ular methodologies used to estimate subjective judgment while making decisions or ranking factors and barriers. It is a decision-making model that analyzes the hierarchical structure of a research problem based on the subject matter under consideration. The hierarchical tree was formulated considering the 22 barriers within their respective classifications (i.e., five categories). This step decomposed the decision-making problem into a hierarchical structure.

FIGURE 18. Consolidated flow chart



Comparative values were obtained from the expert interviews to rank the identified and categorized barriers. Thus, based on the experts' opinions, the scores and weights for each category of barriers and specific barriers within each category were estimated. The process was constantly re-evaluated to increase the accurateness and persuasiveness of results. For better transparency and appreciation of the framework for analysing barriers and enablers, the consolidated flow chart is presented in Figure 18. A consumer preference surveys (Market Survey) was combined with the stakeholder analysis to examine and better understand the uptake of electric vehicles.

4.2. Economic and financial barriers

ICEVs enjoy an economic advantage, which increases consumer resistance to purchasing EVs, which are typically priced higher. This price differential is recognized as a major barrier against the uptake of EVs. The high purchase price of EVs in Ghana is largely attributed to the high import duties, vehicle tax, etc. Since it is difficult to categorise EVs under the current HS codes, they are often classified as hybrid under luxury vehicles. For example, the import duty of a 2008 Toyota Camry LE model is GHS 17,974.66 (US$ 2,986.52) compared to a 2008 Toyota Camry Hybrid, which is GHS 28,873.13 (US$ 4,797.32). Other economic factors, such as battery replacement cost, charging installation cost, and access to credit, are considered disadvantageous to EVs' acceptance. The government needs to provide different kinds of financial incentives to create a competitive market for EVs. The economic barriers will be addressed, to a certain extent, through such incentives. This report identified four economic barriers that can potentially inhibit the diffusion of EVs in Ghana.

4.2.1. Higher Purchase Price

Stakeholders and the public view the higher purchase price of EVs as a major concern. Manufacturing costs are higher because EV is an emerging technology, hence, they have a higher market price than ICEVs. Subsidizing EV purchase will promote their uptake and scale up. Notably, PHEVs tend to be even costlier due to the complexity of their dual operations. The initial prohibitive purchase cost, as a barrier, featured prominently in the market survey interviews, as captured in the sampled comments below:

> "Charley, honestly, I don't think I will have such money to buy an electric vehicle.
> My income overtime even till pension cannot buy the EV cars. My finances are not too good"
>
> (A 47-year-old Management Accountant, Accra)

> "The electric cars are meant for the rich. Even in the Developed World, it is not everyone can afford it"
>
> (A 30-year-old Engineer at the DVLA office, Tamale).

> "Initial price of this car is very expensive. I could keep the balance for other better things if I were to buy a fuel or diesel [ICE] car".
>
> (A 49-year-old car spareparts dealer, Kumasi).

4.2.2. Battery Replacement Cost

The battery life of an EV is limited to between eight and ten years, and users have to bear the cost burden of its replacement. Stakeholders pointed out that the cost of the battery accounts for a significant proportion of an EV's total purchase price. This cost serves as another key barrier against EV uptake. Selected comments from the market surveys shed further light on the extent to which the anticipated high battery costs may inhibit the wide scale adoption of EV:

> "I have used my fuel [ICE] car for about 7 years now and I haven't gotten any major problem with the car. So, I usually spend less on maintenance every year. With the electric vehicle, it is very likely for the battery to spoil just as my mobile phone's battery. I have
>
> replaced the battery 3 times this year because the least mistake you make in charging, it can damage the battery. The battery too will be quite expensive"
>
> (A 41-year-old Technical Officer, Kumasi).

> "I can't buy an electric car because all batteries (even phone batteries) have battery health. Thus, if my EV's battery health is reduced it wouldn't be able to drive me on a long distance"
>
> (A 44-year-old man at Adum, Kumasi)

4.2.3. Higher Electricity Price for Charging

EVs utilize electrical energy to run compared to ICEVs, which use petrol or diesel. Stakeholders and potential users are sensitive to the installation and charging cost, thus, a higher electricity price reduces the uptake and demand for EVs. The daily operation cost of an EV is mainly dependent on the electricity price for charging the EV and, therefore electricity prices should be affordable to influence potential EV users to purchase EVs. Aside cost, the quality and reliability of electricity supply is also an important concern raised by both stakeholders and the surveyed public. Institutions in charge of generation, transmission and distribution should work collaboratively and innovatively to address broader energy challenges to guarantee reliable and sustainable electricity supply. These sentiments are captured in the comments from some potential users of EV in the following comments:

> "You said it will be cheaper to charge EVs as compared to what I will be spending onfuel. Do you know how much I pay as light bill [electricity charges] every month? Some of us are doing illegal connections, but we are still not finding it easy paying the electricity bills. The EV will make our light bills go up even more, so I won't buy it".
>
> (A 35-year-old man in Saabonjida, Tamale).

> "So what will happen if the battery runs down at a place where there is notlight[electricity] to charge it? How long can the electric car last?"
>
> (A 40-year-old car mechanic around Kaladan Park in Tamale).

> "Do we have enough power for these cars looking at all the struggles' homes and businesses are going through to get stable power?"
>
> (A 32-year-old tutor, Accra)

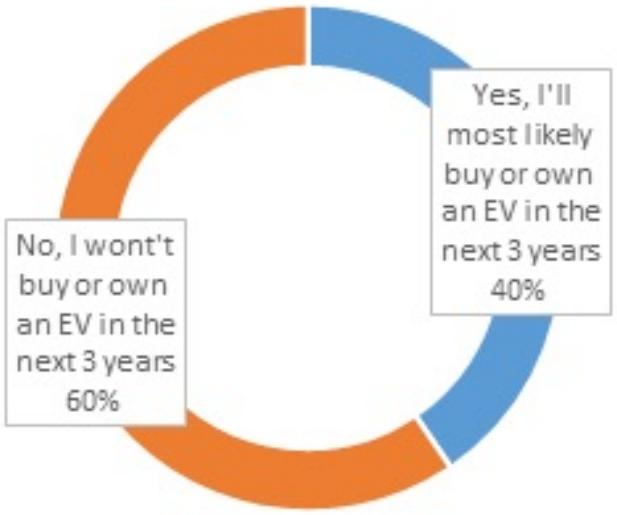
> "We have intermittent power supply which is not supporting the local economy currently. How is the government going to make sure that these cars will be sustainable and won't be a burden to us?"
>
> (A 51-year-old man at Asafo, Kumasi)

4.2.4. Lack of Credit Access for EVs

Expectedly stakeholders in the private sector are hesitant to invest in new technologies as they typically pose some measure of risk and, therefore, policy makers, banks and related institutions can play a vital role by facilitating the purchase of EVs via subsidized interest rate credit mechanisms for potential users. Difficulty in obtaining credit access due to a weak or absent credit mechanism serves as a major barrier against the diffusion of EVs. Transport operators and businesses within the transport sector recounted the role played by past governments and some financial institutions in supporting newly introduced buses for public transport and intimated that same consideration should be extended to EV penetration and deployment.

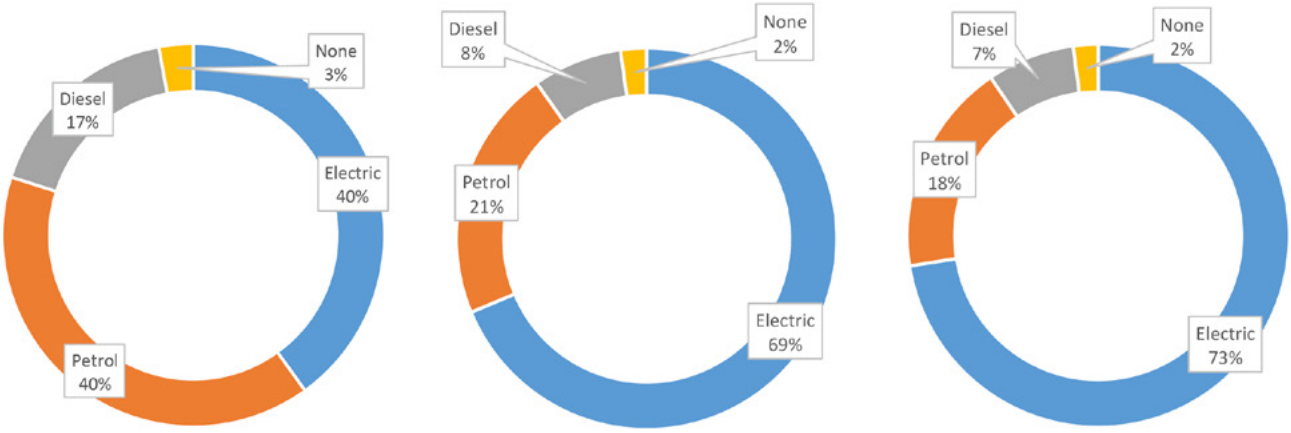
Results from the market survey highlight the extent to which financial and economic challenges may impede the widespread adoption of EVs in the immediate to the near future. As high as 60% of survey participants said they may not buy or own an EV in the next 3 years (see Figure 19).

FIGURE 19. Willingness to buy/own an EV in the immediate future



Indeed, when shown the initial purchase cost and total cost of ownership, as well as the performance indicators for three different cars of the same make and model but with different energy sources (i.e. diesel, petrol and electricity), participants were divided regarding the choices they will make under various conditions. As seen in Figures 20a, under purely "market conditions" (i.e. where customers are expected to choose based on their own financial resources and taste preferences), most participants said they would opt for either petrol- or electric-powered version of the hypothetical car. Interestingly, when policy interventions (Figure 20b) such as "no parking fees", "no tolls payment" and "priority driving lanes" are introduced as incentives only for the electric-powered model, the percentage share for participants wanting to own an electric car goes to 69%, up from 40% under the former scenario. In Figure 20c, the stated preference to buy or own electric cars goes up by a whopping 73%. This was when participants were introduced to policy and fiscal intervention benefits for the EV model such as "soft loans at 15% per annum to be paid in 8 years". While the petrol and- diesel-powered cars attract 24% interest rate per annum; and "no payment of import duty, VAT charges and NHIL levies" while the other two internal combustion car models are slapped with 20%, 12.5% and 2.5% respectively of these afore-mentioned taxes.

FIGURE 20. Preference for car modes under different conditions



a) under "Market Conditions"

b) under "Policy Intervention Conditions"

c) under "Fiscal & Policy Intervention Conditions"

4.3. Policy, regulatory and institutional barriers

In Ghana, EVs are regarded as a relatively new technology compared to CVs. The lack of a policy framework for EVs is considered by various stakeholders as a key concern. Any proposed policy framework should be consultative and inclusive of all relevant stakeholders, including policymakers, manufacturers, users, transport operators, and other related institutions. The government can implement different policies to encourage the uptake of EVs, including awareness creation, tax exemption and incentives, and long-term goal-based planning. Stakeholders intimated that purchase subsidies alone might not be enough to increase EV adoption without an effective policy package (that includes adequate infrastructure, operational framework etc.) and political will. This emphasizes the need for a comprehensive policy framework that integrates economic (such as subsidies and tax exemption), technical (such as workshops and expertise) and infrastructural (charging systems and stations) considerations. This report identified three key policy barriers against the uptake of EVs in Ghana.

4.3.1. Lack of Long-Term Planning and Goals

Given that EV acceptance is still in its nascent stage in Ghana, the government's lack of long-term planning and goal setting is considered an important policy barrier. Government should connect the uptake of EVs at the national level to their respective sustainable development visions. Linking long-term planning of the transport sector with development goals could facilitate quicker EV uptake and scale-up. Appropriate legislation geared toward the provision of an adequate number of charging networks, government procurement strategies, environmental awareness, subsidized purchasing, among other policies, should be included in long-term plans and goals for accelerated EV uptake.

4.3.2. Absence of an Annual Tax Exemption Policy

Vehicle owners pay mandatory annual vehicle and roadworthiness taxes. Given that EVs pollute less than fossil fuel powered vehicles, the government should consider removing such environmental and pollution-related taxes. Providing tax benefits to EV users could help the diffusion of EVs over their conventional counterparts. Currently, Ghana does not exempt EV owners from such taxes.

4.3.3. Absence of Awareness Creation about EVs

The diffusion of any new technology can be accelerated by providing potential users with the necessary information about the technology. Educational programs, advertisements, and media communications play a crucial role in the diffusion of EVs. Designing and implementing awareness-raising campaigns is important to promote the acceptance of EVs in Ghana. Such campaigns are likely to reduce consumers' hesitation about purchasing EVs. As EVs are new to Ghana, this report considers the absence of awareness raising as a policy barrier against the uptake of EVs. The above-mentioned policy deficits create mistrust among potential end users towards the real motives of the state in pushing for the transition to EVs. These sentiments are illustrated in the selected views from end users across the country, as follows:

> "You yourself, do you believe in what the Energy Commission is saying? It's all lies. Where is the excess capacity and we are suffering [from] power outages?"
>
> (A 45-year-old transport manager at Kintampo Station, Tamale.

> "I won't purchase an EV because, initial policies may favour us in the meantime. However, at the long run these policies would go against us and we would regret buying them"
>
> (A 67-year-old man at Roman Hill, Kumasi)

> "I also don't believe our leaders are going to do all of these incentives you are talking about. They are all liars".
>
> (A 37-year-old teacher at Cantonments, Accra).

> "We have intermittent power supply which is not supporting the local economy currently. How is the government going to make sure that these cars will be sustainable and won't be a burden to us?"
>
> (A 51-year-old man at Asafo, Kumasi)

4.4. Infrastructure barriers

In the transportation sector, the lock-in possibility is fairly high for new technologies such as EVs, which are reliant on the available infrastructure for charging. This implies that the absence of sufficient infrastructure creates a negative network externality

for the uptake and deployment of EVs. Stakeholders are of the view that the construction of the relevant infrastructure, such as charging stations and repair maintenance workshops, should be undertaken by the government, private sector and vehicle manufacturers. Below is a discussion of the key infrastructure-related barriers identified.

4.4.1. Lack of Charging Stations

A sufficient number of charging stations is a prerequisite for EV diffusion. The insufficient number of charging networks (all the five stations are concentrated in Accra) has been recognized as a limiting factor for consumers to use EVs. The public and private sectors are reluctant to invest in charging stations as the number of EV users is still insufficient and, similarly, potential EV users hesitate from purchasing EVs due to the insufficient number of charging stations. The private sector is expected to respond to market needs, and the current fuel stations can be redesigned to install charging stations. The charging stations should be operationalized similar to the current fueling stations to reduce concerns of transport operators and users.

4.4.2. Long Charging Time

Long charging time affects travel time. There are different types of charging systems. Driving range and battery capacity have a direct bearing on charging time. Inadequate space at fuel stations to accommodate vehicles is likely to prolong waiting time at charging stations. In terms of booster charging, stakeholders estimated an average recharge time of between 5-10 mins for private cars and 20-45 mins for buses. This implies that standards should be put in place to ensure that fast-charging systems are deployed.

4.4.3. Unreliable Power Supply

Power should be available at all times to support the charging of EVs. Stakeholders indicated that even though Ghana has excess capacity in terms of electricity generation, disparities in electricity distribution and irregularities in access across the country should be carefully considered. Bearing in mind the country's industrialization drive. The power supply should be sustainable, reliable and affordable to all EV users. The charging infrastructure should have a backup plan to ensure a reliable power supply.

4.4.4. Lack of Repair and Maintenance Workshops

Stakeholders and potential EV users are concerned about the insufficient support centres or workshops for EV repair and maintenance. Further, EV-related repair and maintenance procedures can be complicated, and there are concerns about inadequate expertise and trained mechanics available to fix such issues when they arise.

4.4.5. No Domestic Industry

EV adaptation is closely linked to local vehicle production facilities. Consumers' confidence in EVs can increase provided users are assured that their complaints will be resolved should their vehicles develop a fault. Notably, Ghana does not have a domestic EV production industry and, therefore, this lack of local industry can be viewed as an infrastructural barrier.

Evidence gathered from the user survey interviews, as presented below, throw more light regarding how Ghanaians perceive the limited infrastructure as a major impediment for their decision to procure and use an EV:

> "We can only afford these cars if we have constant power supply to support our businesses so they should fix the power supply before they work on the electric vehicles"
>
> (39-year-old trader in Kumasi)

> "I know these EV's are working well in parts of Europe because they are prepared for it. I don't see us having all that which is needed including the expertise to work on the car when there is fault, availability of spare parts, charging infrastructures and even a sustainable electricity. I will buy one [an EV] when these things are visibly available"
>
> (A 36-year-old tutor, Accra)

> "I can work with my car for 16 hours when the fuel tank is fully filled. With this electric vehicle, however, I would have to park and charge for some minutes before I continue my work. As they say, "time is money". There is no way you can convince me that charging, a vehicle will take less than 5 minutes but filling my fuel tank [at the fuel stations] takes less than 5 minutes"
>
> (A 37-year-old trotro driver, Kumasi).

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

4.5. Technical barriers

Technological advancements in the vehicle industry play a critical role in emission reduction and the energy efficiency of vehicles. The lack of standardization, limited availability, inadequate model choices, and performance issues are important factors for the acceptance and diffusion of EVs. Since EVs are relatively new technologies compared to internal combustion engine vehicles (ICEVs), their quality can be compromised by technical constraints at the manufacturing stage. In this report, the key technical barriers identified for Ghana are explained below.

4.5.1. Limited Range (One-Time Travel Distance at Full Charge)

Range anxiety is one of the major user concerns for EVs. EV batteries must be charged for the vehicle to run and their storage capacities determine the distance that can be traveled on a single charge. Users who do not need to travel long distances for their daily routines (especially intra-city) are likely to show more interest in EVs. Those who need to travel long distances (inter-city) have to plan their journey well to avoid range anxiety. Thus, limited range is considered as an important technical barrier.

4.5.2. Lack of Evidence on Reliability and Performance

Considering that EVs are a relatively new technology compared with ICEVs, potential users tend to be concerned about their technological performance, which tend to increase their unwillingness to use EVs. Lack of performance is likely to affect user perceptions of BEVs, while system stability is an important detrimental factor against acceptance and the increased deployment of EVs. Stakeholders indicated that ample evidence in relation to reliability and performance should be promoted through piloting schemes taking cognizance of local context issues including weather.

4.5.3. Limited Battery Life

EVs run on the power provided by charged batteries. Yet, the typical warranty for an EV battery, improved more recently, lasts between eight and ten years. After this battery life period, battery replacement should be borne by the user. The batteries are also sensitive to overcharging, which poses a problem for EV users. Limited battery life requires frequent replacements, which is a major burden on EV users.

4.5.4. Fewer EV Models

EV uptake is influenced by the limited number of design models. Generally, a wider range of car models tend to appeal to a broader consumer segment. Stakeholders are concerned about the limited EV model availability which poses a core challenge as it restricts users' choices. The EV technology is still emerging and the limited production of different EV models will be overcome as the EV market opens up. The EV manufacturing industry and related institutions through research and development should make advancements in the production of EVs.

The views from stakeholders concerning the technical barriers facing EV adoption were further echoed by the potential end users of EV, as captured in the comments below:

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

> "All these advantages of the electric vehicles are good and nice, but I haven't seen anyone using some in this country, So, I would like to see someone try the electric vehicle and know how it works by evidence"
>
> (A 46-year-old taxi driver, Kumasi).

> "Even if I want to purchase an EV, I will only do that after it has become common and popular and everyone is seen using it"
>
> (A 43-year-old electronics shop owner at Osu, Accra).

4.6. Social barriers

Given that EVs are new to Ghana, concerns relating to social barriers including awareness, safety etc cannot be overlooked. Social factors, particularly consumer understanding of the attributes of EVs, are recognized as important consideration for EV users. The communication of related information is crucial in this regard. Social barriers may pose obstacles equivalent to technical factors with regard to the adoption of EVs. Consumer knowledge, experience, environmen-

tal considerations, and perceived quality of EVs influence consumers' decision to purchase EVs. This report considers the following three social barriers against EV deployment in Ghana.

4.6.1. Lack of Knowledge on EVs

Complete information and knowledge on EVs can allay fears and misconceptions and address market failure concerns. Providing the right information is crucial to aid the transition towards EVs. Currently, there is limited understanding of and knowledge on EVs among the relevant stakeholders and cross-section of the public who were engaged. Potential users' awareness of the benefits of EV, financial incentives, infrastructure availability, and potential fuel-related savings are likely to be essential factors influencing the acceptance of EVs. Notably, this barrier is limited to the provision of general information to improve knowledge about EVs for potential users. This does not consider the users' understanding of the product quality of EVs, which is discussed below.

4.6.2. Limited Understanding of the Quality and Safety of EVs

Potential consumers' perceptions of the quality and safety of EVs has a great influence on their decision to purchase EVs. It was noted that uninformed or misinformed consumers are likely to be unwilling to purchase EVs. Actual versus perceived product quality limitations, such as those related to performance and reliability, range capacity, and other technical issues, were highlighted to potentially create a perception gap among potential EV users. Thus, conscious efforts should be made to keep the public informed about the quality of EVs, as this particular social factor serves as a prerequisite for their acceptance and uptake.

4.6.3. Lack of Environmental Awareness about EVs

Emission reduction is one of the key advantages of using EVs. However, stakeholders and the public are mostly uncertain about the emission reduction potential of EVs, as most of them are environmentally unaware of the harm caused by greenhouse gas emissions due to the use of ICEVs. Environmental awareness regarding EVs enhances the deployment of EVs. Since EV is relatively new in the Ghanaian market, more efforts should be geared towards EVs' environmental benefits and fuel-cost savings. Sampled opinions of interviewed Ghanaian as presented below, highlight social concerns about EV adoption:

"The fumes from [ICE] cars do not have any negative effect on climate change. However, it is written in the Bible that in the end times difficult time like what we are experiencing will come. Seas will go beyond their boundaries, and these are all happening. The climate will come back to normal if we change our wicked attitudes.

(A 47-year-old trader at Adum, Kumasi)

"Climate change is a natural occurrence; God decides if it will rain or not. That's why most predictions about the weather are inaccurate. The adoption of an EV can do nothing to make the weather better"

(A 34-year- old car sprayer, Kumasi)

"[Handling} electricity is dangerous, and so when there is a problem with any ware in the car, it can shock you and kill you. So, I will not use it [EV] not to talk of recommending it to a friend". (A 40-year- old staff of Tamale sub-Metro, Tamale).

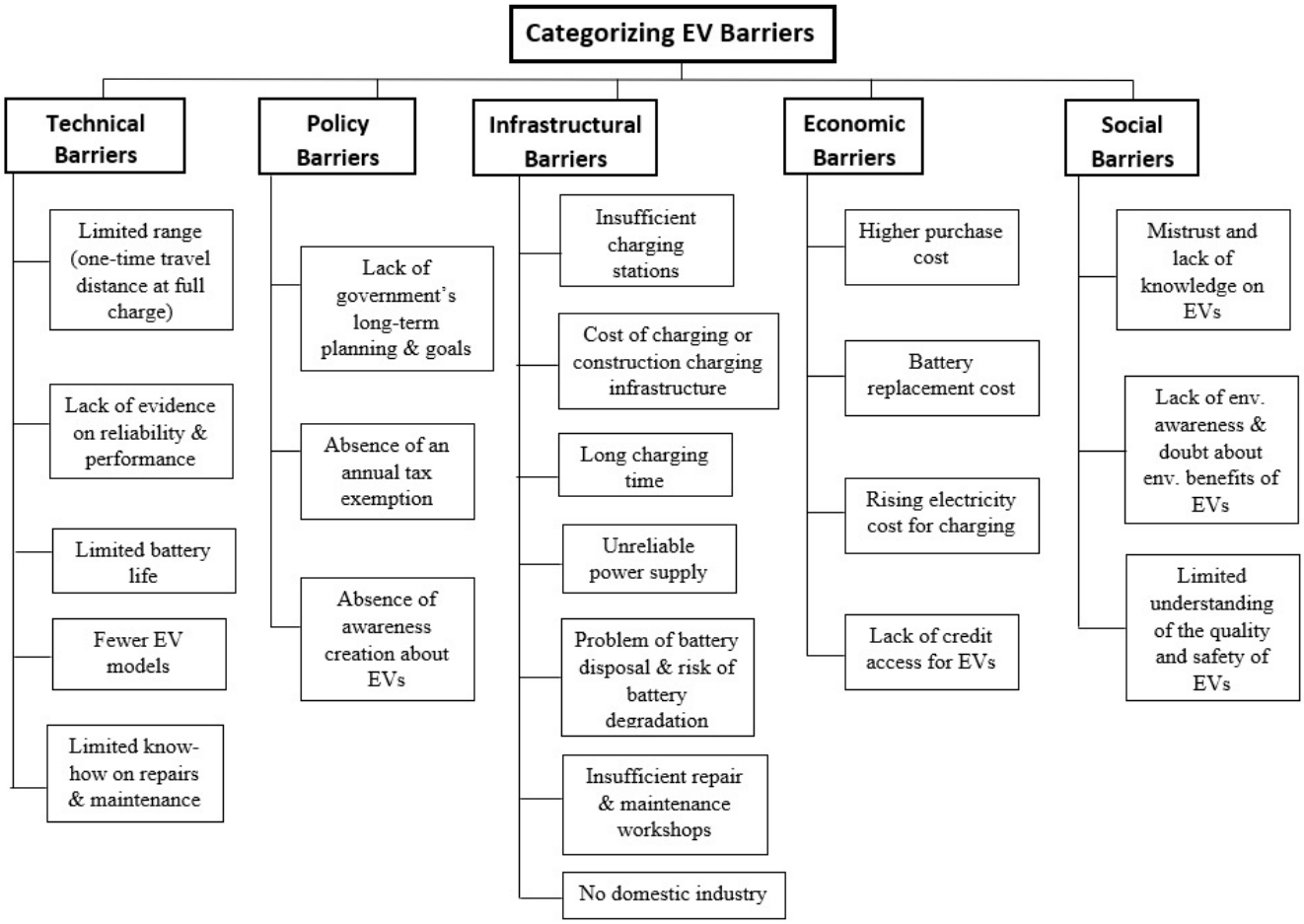
"As for me, I think that a brand-new petrol or diesel car with good exhaust equally emits fewer polluting gases into the atmosphere. In my view, the [EV] car really doesn't have any advantage over other cars [ICEs] in terms of promoting a cleaner air"

(A 46-year-old human resource manager, Kumasi).

4.7. Ranking EVs Barrier Categories

The results of the barrier analysis are summarised in Figure 21.

FIGURE 21. Hierarchical tree for ranking EV Barriers in Ghana



A ranking analysis was further done of these across the five categorised barriers (Table 14). Economic barriers was ranked as the most crucial barrier (33.3%) against EV deployment in Ghana, followed by infrastructure barriers (26.7%), technical barriers (20.0%), policy, regulatory and institutional barriers (13.3%), and social barriers (6.7%). Notably, the economic, infrastructure, and technical barriers are not significantly different in terms of weight, which means that all three categories pose significant challenges. The results show that, while social barriers pose a challenge, they have a minimal effect on the uptake and diffusion of EVs compared to the other four barrier categories.

TABLE 14. Categories of barriers ranking for electric vehicle use.

Barrier Categories	Priority Weight	Priority Weight (%)	Rank
Policy Barriers	0.4	13.3	4th
Infrastructure Barriers	0.8	26.7	2nd
Economic Barriers	1.0	33.3	1st
Technical Barriers	0.6	20.0	3rd
Social Barriers	0.2	6.7	5th

4.7.1. Ranking within categories

The ranks of the barriers within each category, in terms of their percentage weights, were estimated. The analysis shows that in terms of the technical barriers limited range (namely, one-time travel distance with a fully charged battery) is ranked first (33.3%), which implies that the greatest technical obstacle to EVs uptake in Ghana relates to the driving range (see Table 15). Range is a major concern, especially when it comes to intercity travel. Transport operators, for example, expect EV buses to have the capacity to travel from Accra to Kumasi without any charging constraints. The limited range was followed by limited battery life (26.7%), lack of technical know-how on repairs and maintenance (20.0%), lack of evidence on reliability and performance (13.3%), and fewer EV models and types (6.7%).

TABLE 15. Technical barriers ranking

Technical Barrier	Priority Weight	Priority Weight (%)	Rank
Policy Barriers	1.0	33.3	1st
Infrastructure Barriers	0.4	13.3	4th
Economic Barriers	0.8	26.7	2nd
Technical Barriers	0.2	6.7	5th
Social Barriers	0.6	20.0	3rd

Additionally, the results show that within the policy barriers category, lack of government long-term planning and goals is estimated to be the most important barrier (50.0%) highlighted by the stakeholders, followed by the absence of annual tax exemption policy (33.3%) and absence of awareness creation about EVs (16.7%) as shown in Table 16. This finding is not unexpected as the majority of the stakeholders pointed out the need for an EV policy to regulate and streamline the operational framework for EV deployment.

TABLE 16. Policy barriers ranking

Policy Barrier	Priority Weight	Priority Weight (%)	Rank
Lack of government long-term planning and goals	1	50.0	1st
Absence of an annual tax exemption	0.6	33.3	2nd
Absence of awareness creation about EVs	0.3	16.7	3rd

Moreover, the higher purchase price is ranked as the most crucial economic barrier (40.0%) against EV uptake in Ghana, followed by the battery replacement cost (24.01%), lack of credit access (12.14%), and higher electricity price for charging (9.02%), as indicated in Table 17. Expectedly and as earlier indicated, the higher upfront cost is a deciding factor that influences EV purchase. Even though this cost will be offset in the long run by other running and maintenance costs, many potential users cannot afford it due to their disposable income. This makes credit facilities, tax waivers etc critical in the successful deployment of EVs in Ghana.

TABLE 17. Economic barriers ranking

Economic Barrier	Priority Weight	Priority Weight (%)	Rank
Higher purchase price	1.0	40.0	1st
Battery replacement cost	0.8	30.0	2nd
Risk of rising electricity price for charging	0.3	10.0	4th
Lack of credit access for EVs	0.5	20.0	3rd

Likewise, with regards to the infrastructural barriers, the analysis shows that a quarter of the stakeholders ranked the lack of or insufficient charging stations as the most significant obstacle (25.0%) against EV deployment in Ghana, followed by insufficient repair and maintenance workshops (27.80%), unreliable power supply (17.9%), cost of charging or installing charging infrastructure (14.3%). Even though it is expected that the private sector will respond to EV penetration in the market by developing the necessary charging infrastructure, stakeholders strongly pointed out that government should support this process by providing the necessary regulatory and operational framework. The remaining barriers were ranked in the following descending order: absence of domestic industry (10.7%), long charging time (7.1%) and battery disposal and degradation (3.6%) as shown in table 18.

TABLE 18. Infrastructural barriers ranking

Infrastructural Barrier	Priority Weight	Priority Weight (%)	Rank
Lack of (or insufficient) charging stations	1.0	25.0	1st
Cost of charging or constructing charging infrastructure	0.6	14.3	4th
Long charging time	0.3	7.1	6th
Unreliable power supply	0.7	17.9	3rd
The problem of battery disposal and risk of battery degradation	0.1	3.6	7th
Insufficient repair and maintenance workshops	0.9	21.4	2nd
No domestic industry	0.4	10.7	5th

In terms of social barriers, the analysis shows that stakeholders and users understanding of the quality of EVs is the most influential barrier (50%), followed by lack of knowledge about EVs (33.3%), and lack of environmental awareness and doubts about environmental benefits of using EVs (16.7%) as indicated in Table 19. This finding is not surprising particularly due to the limited understanding/awareness, and misconceptions about how EVs work and related safety concerns.

TABLE 19. Social barriers ranking

Social Barrier	Priority Weight	Priority Weight (%)	Rank
Mistrust and lack of knowledge on EVs (e.g. safety)	0.7	33.3	2nd
Lack of environmental awareness and doubts about benefits of EVs	0.3	16.7	3rd
Limited understanding of the quality of EVs	1.0	50.0	1st

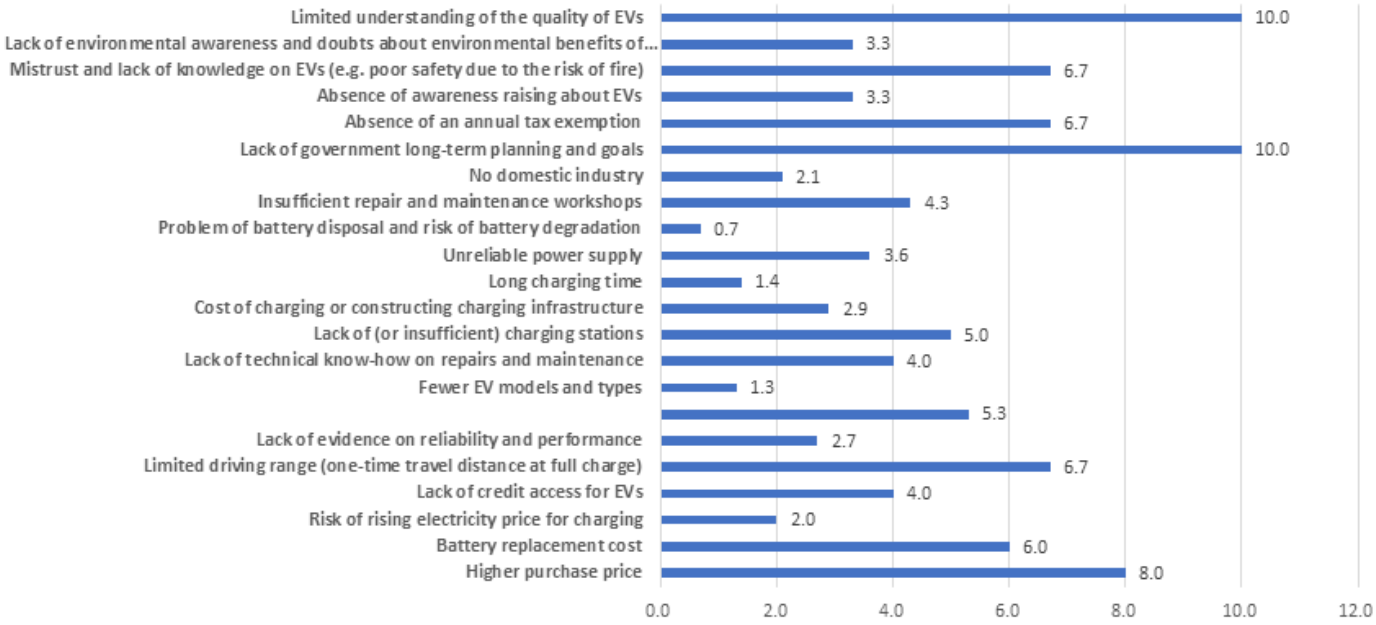
4.7.2. Overall ranking

The overall weight of the barriers was calculated by multiplying the priority weight of each category with the relevant priority weight of the barrier within that category. The overall weight of the barriers and their sub-categories is presented in Table 20 and Figure 20. The results show the degree to which each barrier inhibits EV acceptance and diffusion in Ghana. Limited understanding of the quality of EVs (10.0%), lack of government's long-term plans and goals (10.0%), and higher purchase price (8.0%) were ranked as the top three barriers, followed by limited driving range (6.7%), lack of annual tax exemption (6.7%), mistrust and lack of knowledge on EVs (e.g., poor safety) (6.7%), battery replacement cost (6.0%), limited battery life (5.3%) and insufficient charging stations (5.0%). The results further indicate that insufficient repair and maintenance workshops (4.3%), lack of technical know-how on repair and maintenance (4.0%), lack of credit access for EVs (4.0%), unreliable power supply (3.6%), lack of environmental awareness and doubts about environmental benefits of EVs (3.3%), and absence of awareness creation about EVs (3.3%) are moderate level barriers. In addition, the overall ranking results indicate that the absence of ample EV models is the least important barrier (1.3%), followed by long charging time (1.4%), rising electricity price for charging (2.0%), no domestic industry (2.1%), lack of evidence on reliability and performance (2.7%), and costs of charging and installing charging infrastructure (2.9%).

TABLE 20. Weightages adopted for ranking various categories of barriers

Barrier Categories (L1)	Barrier sub-Categories (L2)	L1 Weightage	L2 Weightage	Final Weightage
Economic	Higher purchase price	33.3	40	8.0
	Battery replacement cost		30	6.0
	Risk of rising electricity price for charging		10	2.0
	Lack of credit access for EVs		20	4.0
Technical	Limited driving range (one-time travel distance at full charge)	20	33.3	6.7
	Lack of evidence on reliability and performance		13.3	2.7
	Limited battery life		26.7	5.3
	Fewer EV models and types		6.7	1.3
	Lack of technical know-how on repairs and maintenance		20	4.0
Infrastructure	Lack of (or insufficient) charging stations	26.7	25.0	5.0
	Cost of charging or constructing charging infrastructure		14.3	2.9
	Long charging time		7.1	1.4
	Unreliable power supply		17.9	3.6
	Problem of battery disposal and risk of battery degradation		3.6	0.7
	Insufficient repair and maintenance workshops		21.4	4.3
	No domestic industry		10.7	2.1
Policy	Lack of government long-term planning and goals	13.3	50.0	10.0
	Absence of an annual tax exemption		33.3	6.7
	Absence of awareness raising about EVs		16.7	3.3
Social	Mistrust and lack of knowledge on EVs (e.g. poor safety due to the risk of fire)	6.7	33.3	6.7
	Lack of environmental awareness and doubts about environmental benefits of EVs		16.7	3.3
	Limited understanding of the quality of EVs		50.0	10.0

FIGURE 22. Overall ranking of barriers (weight in percentages)



5. Recommended policies and market readiness framework

The barrier analysis discussed in the preceding section has significant implications for government, EV manufacturers, transport operators, users, and other related stakeholders interested in introducing EVs and exploring solutions to navigate the barriers that militate against EV adoption and use in Ghana. The results of the barrier analysis reveal that infrastructural, policy, economic, and technical barrier categories present significant challenges compared to social barriers. It further indicates that the top two ranked categories of barriers had similar weights, which shows that, while the origins of the barriers are diverse, it is crucial to address them concurrently to ensure successful EV deployment in Ghana. Thus, adopting an all-inclusive and integrated approach, rather than focusing on a specific barrier, must be the end goal.

5.1. Economic and financial measures

The economic barriers against EV diffusion in Ghana are the most important barrier. The experts' opinions revealed that EVs' relatively high purchase price was ranked as the highest in this category, followed by battery replacement cost, lack of credit access, and risk of rising electricity price. Notably, purchase waivers and subsidies would provide a competitive edge to EVs over ICEVs. In addition, battery replacement cost and credit access mechanisms need to be considered. The risk of rising electricity prices for recharging EV batteries was shown to be the lowest-ranked barrier. This is expected as currently the price of electricity for charging EV is low compared to diesel and petrol for ICEVs. Key fiscal measures and economic instruments include:

- **Tax waivers and tax holidays for electric vehicles, batteries and charging units.** Tax waivers and tax holidays for import duties and other vehicle taxes can help bring down the upfront capital costs. These could, however, be progressively reduced since battery costs have shown a downward trend and are expected to go below a price of US $ 100 per Kwh in future.
- **Special electricity (energy) tariff for EV vehicles**: Electricity tariffs vary depending on where we charge, e.g., at home or a public charging point. There is also a tendency to charge vehicles in the evening when people return from work. This can create a surge in electricity demand at the residential end in the evening. Differentiated and subsidised tariff systems for EV charging (e.g. from 10 pm to 6 am) could lower EVs' operating costs and balance the demand simultaneously.

In order to offset lost revenues to the government as it implements the aforementioned fiscal measures, it is recommended that the tax waivers and holidays should be strategically done within a specified amount of time, say between 2 and 5 years. This is to attract a sizeable and critical proportion of EV consumers. Subsequently, the government can remove those incentives and halt the tax breaks. The government may then be better positioned to recoup the incomes lost during the break by re-imposing taxes on EV consumers and products, which would have become widely accepted.

Furthermore, there are several carbon market platforms, including the Chicago Climate Exchange (CCX), the European Energy Exchange (EEX), European Climate Exchange (ECX), just to name a few. Ghana may register and benefit from selling off its carbon credit surpluses from EV adoption to other high GHG emitting countries. The profits may be used to offset incomes lost during the tax holidays and/or to provide further subsidies on EVs to promote the transition to renewable transportation. Overall, electric vehicles are expected to create viable economic benefits, including job creation, reduced trade deficits, reduced cost of oil imports etc.

5.2. Institutional framework, policy and regulatory measures

Policy barriers were ranked as the fourth most important barrier category. Stakeholders emphasized the need for the Ministry of Transport to develop an EV policy that promotes and regulates EV use in Ghana.

The results show that the government's long-term plan and goals are the most critical policy-related barrier affecting EV use. Various policy instruments would be needed to promote EV usage based on specific government plans and goals. Such policies would include tax exemption and awareness creation. Policies on tax exemption and waiver and awareness creation will play a supporting role in deploying EVs in Ghana. For instance, tax exemption will significantly reduce the price of EVs and increase their uptake.

EVs are a disruptive technology, and therefore to create an ecosystem for EVs, an integrated approach is needed covering different ministries and a mix of policies and regulations that should include:

- **Review of the Harmonised System (HS) Customs code**: to facilitate proper estimation of import duties and related issues of registration. The current practice whereby the HS codes tag EVs as hybrids act as a disincentive to EV importation and use. Thus, the Ghana Revenue Authority (GRA) customs division must work closely with the Driver and Vehicle Licensing Authority (DVLA) to address this challenge.

- **Standardisation, licensing and certification**: chargers, charging systems and charging installation should be regulated by Energy Commission, Ghana Standards Authority and allied agencies.

- **Research and capacity development**: EV modules and curriculum should be developed and rolled out through the Technical, Vocational Education and Training (TVET)

- **Dealing with power outages**: Electricity supply infrastructure and meter monitoring systems should be improved to minimize power cuts (frequency and duration). To this end, the adoption of Geographic Information Systems and the Meter Management System (MMS) platforms are seen as steps in the right direction to promptly monitor power outages for redress and enhance user experience.

- **Renewable electricity for charging and battery storage energy system for energy security**: EV adoption has a dual advantage of taking up the supposed excess energy capacity and opening the market for renewable energy companies to enter the market and augment power generation to support the charging of EVs. EVs can reduce CO_2 emissions only when the electricity comes from renewables, nuclear, etc. Regulations that incentivise the use of renewables for EV charging should be promoted. Further SMART grids should be planned for the future that allows EVs to provide storage and grid stabilisation services.

- **Close collaboration among partnering ministries and agencies**: There should be close collaboration among the Ministry of Transport, Ministry of Finance, Energy Commission and Environmental Protection Agency in promoting the transition to green technologies. Specifically, these ministries should collaborate and register Ghana's Electric Drive Initiative to generate revenue from the nation's carbon sales.

- **Attract funding for promoting EV uptake**: Energy Commission's SUNREF project to support retrofitting of ICEVs to EVs should be promoted and scaled up

- **Overaged vehicles importation** regime should be reviewed

The emergence of EVs has already created a lot of interest in Ghana. Some oil marketing companies are considering retooling and redeveloping fuel filling stations to include EV charging facilities. A charging station with a solar component is coming at the Kotoka International Airport. DVLA is also considering installing setting charging facilities at their testing stations. Other private charging station initiatives are also coming up. Therefore, there is an urgent need for policy, standardisation, and certification guidelines to guide EVs' charging systems, installation, and use. MoT should work closely with the Ministry of Energy to carry this forward.

5.3. Infrastructural measures

Infrastructural barriers were ranked as the second most important barrier. EVs are a relatively new technology, so EV manufacturers, private businesses, transport operators, and users are unlikely to invest in EVs unless the supporting infrastructure exists. Thus, the government should work closely with the relevant stakeholders to facilitate the development and maintenance of the required infrastructure, including charging, battery handling etc. Among the seven barriers listed in the infrastructure category, the lack of (or insufficient) charging stations was ranked the highest, followed by inadequate repair and maintenance workshops, unreliable power supply, the cost of charging, no domestic

industry, and long charging time. The results indicate the high importance of charging stations and service and maintenance compared to the other barriers. Thus, government intervention and partnerships with the private sector toward infrastructure creation are crucial to overcoming barriers and promoting EV diffusion. The following enablers should be considered:

- **Installation of private (home) charging systems**: solar energy dependent charging installations should be encouraged.

- **Installation of multiple public charging points**: at fuel filling stations, parking spaces, street-side parking lots, office parks, service stations and depots should be promoted to reduce charging waiting time.

- **Installation of inter-city charging points**: to support mobility between major urban centres. Specifically, major highways along the coast and along the central corridor from Accra through Kumasi to the northern parts of the country should be targeted for public charging outlets. In addition, strategic partnerships with major oil marketing companies are encouraged to install EV charging outlets at existing filling stations along these highways. Further to this, EV charging outlets can be installed at major rest stops like Linda Dor and the Paradise Resort in the Eastern region, and elsewhere on these important highways for charging EVs.

- **Fast chargers, connectors, and charging systems**: should be made available in the market at designated rest stops along national highways and prices regulated.

- **Backup power systems** for charging stations to deal with power outages. Solar panels should be harnessed to provide power backups to the national grid

- **Battery swapping, recycling and end-of-life disposal systems**

Finally, to improve the attractiveness of EVs, city governments can think of ways of giving an advantage to EVs in traffic. For example, contraflow bus lanes whereby EV buses use the opposite direction of the surrounding lanes, especially during peak hours, to promote scheduled bus services and minimize traffic. This should be done in the short term as the government works toward exclusive and dedicated bus lanes as part of the bus rapid transit (BRT) system in the long term to support efficient, reliable and sustainable transport.

5.4. Technical measures

Technical barriers were ranked as the third most important barrier category. The findings show that experts and stakeholders continue to have doubts about the technical performance of EVs and the expertise required to repair and maintain EVs. Within the technical barriers category, the issue of the limited range was ranked as the most crucial barrier, whereas the lack of different models was ranked the lowest. Increasing the number of charging stations can reduce the limited range problem. The results also revealed that limited battery life and lack of evidence regarding EV reliability and performance were the second and third barriers in the technical category, followed by lack of evidence on reliability and performance. Thus, the results emphasize the need for these technical issues to be resolved to encourage people's willingness and uptake of EVs in Ghana. The key enablers could include:

- **Range**: EVs with a longer range should be encouraged, especially for long-distance travel. Some EV models have a range of 580 miles (about 930kms); this could be used for inter-city mobility.

- **Continuous training and skill development**: of local auto-mechanics (fitters), electricians, garage operators (Certification of Garages)

- **Low carbon technology transfer**: development of local skills (artisans, operators, garage)

- **Retrofitting ICEVs to EVs**: Local start-ups that convert ICEs to EVs on a limited scale should be identified and supported to bring down the final cost to the end-user.

5.5. Social Measures

Social barriers were considered the least important, as the stakeholders considered these barriers to be less critical than the other challenges. Within the social barrier category, consumer understanding of the quality of EVs was ranked as the most important, followed by the lack of knowledge regarding EVs and the lack of environmental awareness and benefits. The results reveal that the average potential user is likely to be uninformed about the advantages of using EVs and their quality and actual performance. Hence, it is recommended that information about EVs be publicly

disseminated to heighten consumer understanding and awareness. Other key recommendations include:

- **Procuring, piloting, and testing EVs** to demonstrate their quality, safety, performance, and reliability with the country. For example, this could be piloted with STC and Ayalolo buses on a few selected corridors (intra-city and inter-city) as part of the BRT system.

- **Adding EVs to government vehicle fleet**: Ministries, departments and agencies should be encouraged to procure a share of their fleets as EVs.

- **Roadmap on EV awareness creation and campaigns**: The roadmap for EV deployment and implementation should encapsulate broad grassroots consultation and validation engagements. Information sharing about EVs should be done in a democratised manner to ensure inclusivity. This could be done in multiple ways, including:

    - Easy-to-read leaflets, handouts, and brochures in English and the local dialects

    - Media engagements and advertisements: using both print and electronic media (radio, television, social media)

5.6. Measures for development of local industry

Stakeholders unanimously supported the need to develop the domestic industry for EVs. In this regard, the current Ghana Automotive Development Policy for ICEVs could be a reference point, whereby the local companies such as Kantanka and multinational companies including Toyota, Hyundai, VW etc. that are already manufacturing or locally assembling vehicles are encouraged and supported to retool and adapt their assembling plants to develop EVs quickly. Moreover, the government should put the necessary operational framework to attract end users, especially new EV manufacturers and assemblers, to venture into the EV market. Key measures to develop the domestic industry include:

- **Adapting the Ghana Automotive Development Policy**: to operationalise and promote the development of a local industry for EVs.

- **Assembling plant establishment**: this should be done bearing in mind and incorporating the operational framework of the automotive development policy.

In summary, the overall weights presented in Figure 4.4 point to the higher purchase price, lack of government long-term planning and goals, limited understanding of the quality of EVs, lack of knowledge on EVs, limited range, absence of tax incentives, and insufficient charging stations as the top-ranked barriers against the deployment of EVs in Ghana. Therefore, based on the preceding, it is evident that the top-ranked barriers should be prioritized and addressed first.

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Appendix

APPENDIX 1. Data sources employed in the E-MOB Calculator

Input data	Source
Projections for gross domestic project (PPP)	International Monetary Fund World Economic Outlook Database, April 2018 Url: http://www.imf.org/external/datamapper/datasets/WEO
Projections for population	United Nations Population Division. Url: (https://esa.un.org/unpd/.../WUP2014.../ WUP2014-F18- Total_Population_Annual.xls
Estimated Vehicle stock	Driver and Vehicle Licensing Authority (DVLA)
Estimated Vehicle sales	Driver and Vehicle Licensing Authority (DVLA)
Technology share	Assumption
Economic growth 2023 - 2030	Based on GACMO Model used for Fourth National Communication
Economic growth 20-1-2050	Assumption
Annual mileage	ADB Model
Loadfactor	Proposed by UNEP
Technical lifetime	CO2 GEF Manual
Share electric driving PHEV	Proposed by UNEP
Tested FE gasoline ICE	GEF CO2 manual
Tested FE diesel ICE	GEF CO2 manual
Tested FE CNG ICE	Proposed by UNEP
Tested FE gasoline hybrid	Proposed by UNEP
Tested FE gasoline PHEV	Proposed by UNEP
Tested FE BEV	Based in Yutong manual
Annual FE improvement gasoline ICE	Proposed by UNEP
Annual FE improvement diesel ICE	Proposed by UNEP
Annual FE improvement gasoline hybrid	Proposed by UNEP
Annual FE improvement gasoline PHEV	Proposed by UNEP
Annual FE improvement gasoline BEV	Proposed by UNEP
FE gap factor	Proposed by UNEP
Benchmark scenario	Consultant
E-mob scenario	Consultant
Vehicles prices	Transport fare model adopted by the Ministry of Transport (MoT) and transport operators in fixing transport fares in Ghana. For the EVs, data from the American Auto Association (AAA) was used.
Vehicle maintenances	Based on 30% the maintenance cost of a conventional bus and two battery replacements
Electricity CO2 footprint	First BUR of Ghana https://unfccc.int/files/national_reports/non- annex_i_parties/ biennial_update_reports/application/pdf/ghnbur1.pdf
Fuel cost	http://www.eia.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history. html
	https://www.globalpetrolprices.com/Ghana/
	IEA India Energy Outlook
Vehicle emisssion standard	Roadmap for Promotion of Cleaner Buses in Accra, Ghana https://wedocs.unep.org/ handle/20.500.11822/31213
Fuel quality standard	Roadmap for Promotion of Cleaner Buses in Accra, Ghana https://wedocs.unep.org/ handle/20.500.11822/31213

APPENDIX 2. A list of relevant stakeholders in the transport sector of Ghana

No	Stakeholder groups	Stakeholders
1	Public/Para Transport Companies	Metro mass Transit Limited
		GAPTE
		Intercity STC
		Agate Transport Services Ltd
		VIP Jeone Transport
		OA Transport
		GH-Express Transport
2	National / Regional / Local Authorities	Ministry of Transport
		Ministry of Roads and Highways
		Driver and Vehicle Licensing Authority
		Ministry of Trade and Industry
		Ministry of Energy
		Energy Commission
		Ministry of Environment, Science, Technology & Innovation
		Ghana Standards Authority
		Environmental Protection Agency
		The city of Accra (AMA); the city of Kumasi (KMA)
		Land Use and Spatial Planning Authority?
		Ministry of Finance
		Customs, Excise and Preventive Service (CEPS of GRA)
		MLGRD Urban Development Unit
3	OEMs (i.e. vehicle companies, maintenance)	Kantanka Automobile Ltd
		Volkswagen Ghana Limited
		Universal Motors Ghana Limited
		CFAO Ghana
		Toyota Company Ghana Limited
4	Service providers (Private and small-scale operators (also informal), energy companies)	Electricity Company of Ghana, POBAD International
		Solar Taxi (Arnold Amoateng Anokye, the operations manager of Solar Taxi Limited, + Jorge Appiah (Kumasi Hive)/DEXT Technologies/ CEO Ghana Tech Lab
		ORA 1
		Arke Technologies of Ghana
		Orient Energy
		Accraine Ghana

No	Stakeholder groups	Stakeholders
5	Associations	Ghana Road Transport Coordinating Council
		Ghana Private Road Transport Union (GPRTU)
		Ghana Automobile Association
		African Association of Automotive Manufacturers (AAAM)
		Ghana Association of Garage
		Progressive Transport Owners Association (PROTOA) (i.e. Taxi Associations)
		Okada association(s);
		Digital taxis (Uber, Bolt, Yango)
		Abossey-Okai Spare Parts Dealers Association
		Ghana Automobile Distributors Association
6	Academia/ Research	University of Ghana (CUMS)
		Sunyani Technical University (Faculty of Engineering)
		Accra Technical University
7	Multilateral Agencies / Donors	UNEP / UNDP
		World Bank
		SECO
		AfDB
		JICA

APPENDIX 3. Assumptions and data input for flashcards on ICEVs and EVs

Assumptions and data input for the flashcards

The data for the conventional vehicles (commercial) was based on parameters from the Transport Fare model adopted by the Ministry of Transport (MoT) and transport operators.

For EVs – data from the American Auto Association (AAA) was used. The AAA estimates that EVs are 33-34% cheaper to run and maintain than ICEVs.

The following parameters have been used in estimating the cost build up for ICE and Electric Vehicles for the flashcards.

For Commercial Transport ICEs and EVs

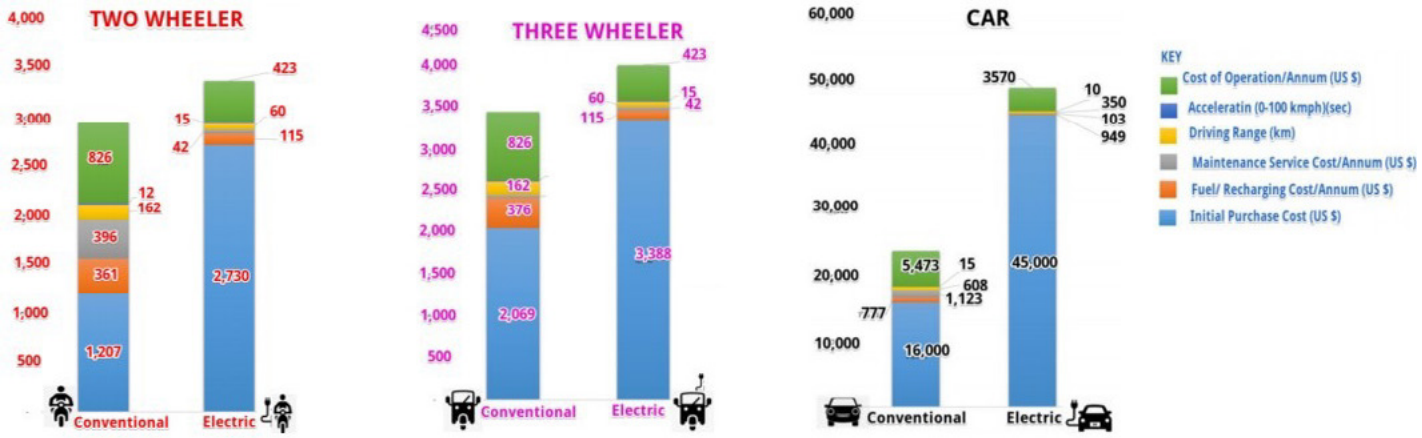
- Average trip distance is estimated at 8.5km for shared taxis, 17.2km for tro-tros, 27km for medium-sized buses and 207km for intercity buses. This is in conformity with the Transport Fare Model adopted by Transport Operators for the determination of fares.
- Shared taxis make an average of 14 trips/day translating into 119km/day and 35,700km/ year on a 240 days working cycle
- Trotros make an average of 14 trips/day translating to 240km/day and 72,000km/ year on a 240 days working cycle
- Fuel consumption for Taxis is estimated at 283.33 litres/months
- Fuel consumption for trotros is estimated at 1,200 litres/months
- Maintenance cost is also estimated using output of the Transport Fare Model for all categorises (taxis, trotros and buses)
- Cost of charging is estimated at US$1.14/100km based on US$0.064/kwh. This cost also takes into consideration the range and the kms to be covered before recharge
- American Auto Association estimates 34% less in terms of annual cost of operation of EV as compared to ICE

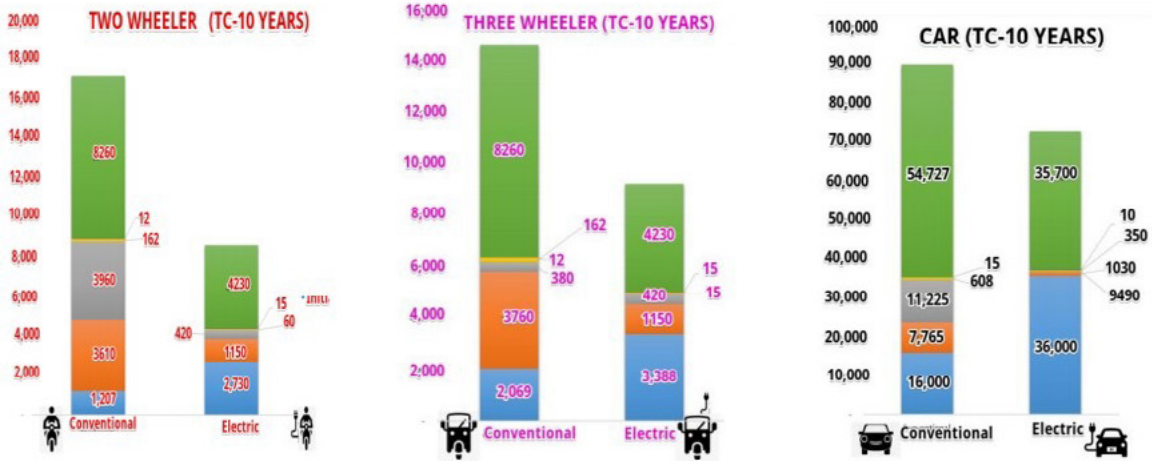
For Private Transport ICEs and EVs

- Trip distance is estimated at 17.2km in conformity to tro-tro operations at an average of 2 trips per day
- Total trip distance is 857.14km/ month and 10,285.71km per year
- Fuel per months is estimated at 85.71 litres
- Cost of charging is estimated at US$1.14/100km based on US$0.064/kwh. This cost includes 2 trips/day and the range after a single charge

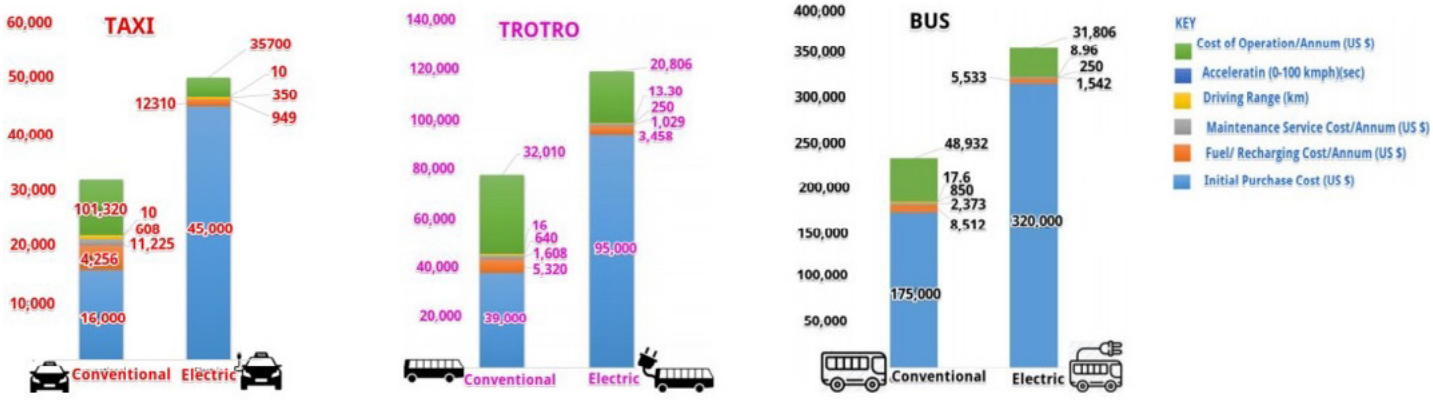
APPENDIX 4. Flashcards displaying Total Cost of Ownership for Personal and Public modes of transport

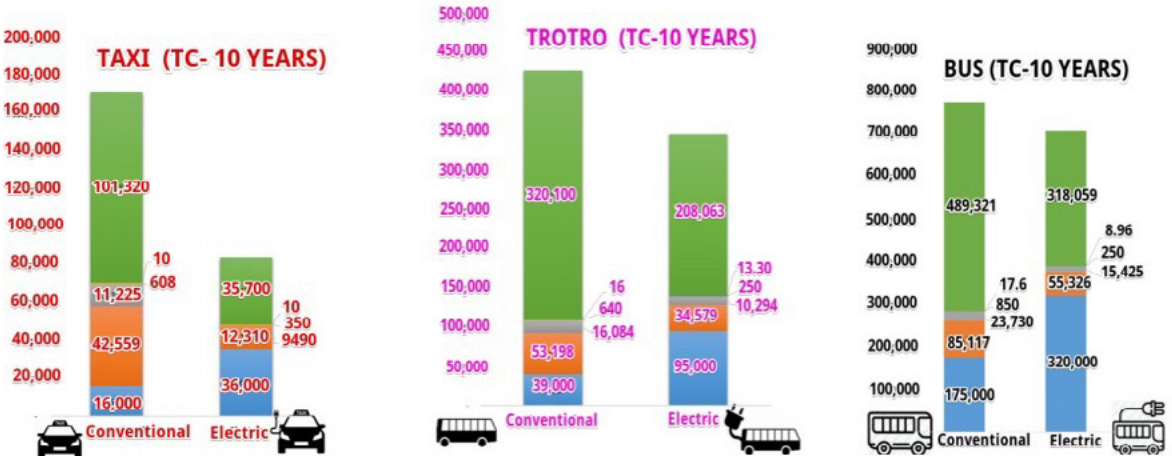
TOTAL COST OF OWNERSHIP (TCO) IN US ($) FOR CONVENTIONAL & ELECTRIC PERSONAL MODES





TOTAL COST OF OWNERSHIP (TCO) IN US ($) FOR CONVENTIONAL & ELECTRIC PUBLIC MODES





APPENDIX 5. **Survey tool used for prioritising and weighting of criteria adopted for the scoring of attributes**

Preamble: The Ministry of Transport is collaborating with the Environmental Protection Agency and Climate Technology Centre to develop an Electric-Mobility Policy, incorporating Implementation of Framework for the Deployment and Scale-Up of Electric Vehicles (EVs) in Ghana. This maiden exercise is aimed at developing Priorities and Weights of specific parameters in the Multi-Criteria Analyses.

Your response is being solicited in your official capacity/representative for your organization. The responses will be anonymized and greatly appreciated. The survey is expected to last 35 minutes.

* Required

Email *_____

1. **How do you rank the following categories over 100%?**

☐ Cost & Financing*_____ ☐ Benefits*_____

☐ Local Context*_____

2. **How do you rate the following cost and financing sub Categories over 100%?**

☐ Capital expenditures (CapEx) *_____

☐ Operating expenditures (OPEX) * _____

3. **How do you rate the following Capex Parameters over 100%?**

☐ EVs investment requirement (e.g. acquisition of vehicles; knocked down parts; depots)*_____

☐ Charging infrastructure investment requirement* _____

4. **How do rate the following benefits to be derived from EV adoption over 100%?**

☐ Economic*_____ ☐ Environmental*_____

☐ Climate*_____ ☐ Social*_____

5. **How do you rate the following economic Benefits over 100%?**

☐ Total Cost of Ownership (TCO) *_____ ☐ Fuel savings*_____

6. **How do you rate the following social benefits over 100%?**

☐ Accessibility* _____ ☐ Affordability*_____

☐ Comfort* Safety*_____ ☐ Personal Security*_____

☐ Job Opportunities*_____

7. How do you rate the following local context sub categories over 100%?

☐ Usage characteristics* _____ ☐ Supporting Ecosystem* _____

☐ Local stakeholders' acceptance* _____

8. How do you rate the following local context usage characteristics

☐ On road Vehicle stock* _____

☐ Vehicle trip length (Range i.e trip time before next charge) * _____

☐ Fuel efficiency per passenger km* _____

9. How do you rate the following local context supporting ecosystem over 100

☐ Local availability of imported EV models* _____

☐ Local post sales services* _____ ☐ Easiness of EV Charging* _____

☐ Local assembly & supply of EV model* _____

☐ Local retrofitting of ICEVs to EVs* _____

☐ EVs R&D and Technical skills* _____

☐ Quality of road and accessibility* _____

10. How do you rate the following local context local stake holder's acceptance over 100%?

☐ Government's preference* _____

☐ Businesses/ Private investors (i.e. OEMS, Service Providers; Associations) vested interests* _____

_____ ☐ Local consumers' interests* _____

11. Name of organization being represented * _____

12. Your Name and Position in Organization * _____

APPENDIX 6. A list of stakeholders who participated in scoring of attributes adopted in the MCA process

No	Name	Organisation	Designation
1	Daniel Essel	Ministry of Transport	Principal Planning Officer
2	Manish Daryanani	Stallion Motors Ghana Automobiles Industries Ltd.	Business Head: Sales & Marketing
3	Robert Kwadwo Nyarko	Ministry of Roads and Highways	Assistant Planning Officer
4	Ing. John Awuku Dzuazah	Intercity STC Coaches Limited	Deputy Managing Director
5	Ing. David Yarboye Tackie	Metro Mass Transit Limited	Technical Manager
6	Emmanuel Ohene-Yeboah	Ghana Road Transport Coordinating Council	General Secretary
7	Foster Gyamfi	Ministry of Finance	PrincipalEconomic Officer
8	Edward Agbodjan	Ministry of Transport	Principal Planning Officer
9	Atsu Akpakli	Ghana Private Road Transport Union	
10	Eric Addison	Driver and Vehicle Licensing Authority	Manager, Vehicle Inspection
11	Ebenezer Amankwaa	University of Ghana	Consultant
12	Ernest Agyemang	University of Ghana	Consultant

APPENDIX 7. Survey tool adopted for social indicators from EVs adoption

Preamble: The Ministry of Transport is collaborating with the Environmental Protection Agency and Climate Technology Centre to develop an Electric-Mobility Policy, incorporating Implementation of Framework for the Deployment and Scale-Up of Electric Vehicles (EVs) in Ghana. This exercise is aimed at mapping the Sustainable Development Impacts of selected social indicators emanating from EVs adoption for the country. Your response is being solicited in your official capacity/representative for your organization. The responses will be anonymized and greatly appreciated. The survey is expected to last 45 minutes.

* Required

Email *_____

1. The government plans to promote the use of Electric Vehicles in Ghana. Do you think this is a good idea?*

☐ Yes, I think it's a good idea ☐ No, I don't think it's a good idea

2. If 'Yes' to Question 1, what is/are your main reason(s) for the preferred choice? Select as many as applies to you.

Check all that apply.

☐ EVs have major benefits for the environment

☐ EVs are cost-effective in the long run

☐ I am interested in trying out new and innovative technology

☐ EVs will enable accessible and efficient public transport system

☐ EV cars are classier

☐ EVs will make us less fossil-fuel dependent

☐ I understand the price of electricity for driving EVs is cheaper than oil

☐ Other _____

3. **Which of the vehicle types should government prioritize for promoting EVs adoption if we want to significantly improve ACCESS FOR ALL Ghanaians, including the poor, aged, women, children, differently abled persons etc?***
CRITERION 1: ACCESSIBILITY DEFINITION: 'Accessibility' is defined as readily available and easily accessible transport service.
Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will offer the most access for all" and '6th' means "vehicle type will offer the least access for all"
NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

4. **Which of the vehicle types should government prioritize for promoting EVs adoption if the focus is on AFFORDABILITY FOR ALL citizens, including the poor, aged, women, children, differently abled persons etc? ***
CRITERION 2: AFFORDABILITY DEFINITION: "Affordability' is the ability to make all necessary journeys at all times to work, school, health, other social services, etc without having to curtail/sacrifice other essential activities due to a person's low disposable income.
Based on your knowledge of how much transport in Ghana presently costs (i.e. whether as passenger fares for commuting by commercial transport or fuel and maintenance costs etc. for personal car users), Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will offer the most affordable service for all" and '6th' means "vehicle type will offer the least affordable service to all"
NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

5. **Which of the vehicle types should government prioritize for promoting EVs adoption if the focus is on COMFORT OF THE TRANSPORT SERVICE FOR ALL, including the poor, aged, women, children, differently abled persons etc?** *

CRITERION 3: COMFORT DEFINITION: "'Comfort' includes on-board features and user experiences such as enough space/leg room, ability to relax, minimal noise, less heat, ability to do extra activity such as reading/browsing

Using your knowledge of how the various transport modes in Ghana presently offer comfort as your benchmark, which of the vehicle types should we prioritize for EV adoption with the view to ensuring comfort for commuters?

Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will offer the most comfortable service for all" and '6th' means "vehicle type will offer the least comfort to all" NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

6. **Which of the vehicle types should government prioritize for promoting EVs adoption if the focus is on SAFETY OF TRANSPORT SERVICE FOR ALL, including the poor, aged, women, children, differently abled persons etc?** *

CRITERION 4: SAFETY DEFINITION: 'Safety' is measured in terms of harm, injuries that may arise from road crashes.

On the basis of how safe the various transport modes are perceived to be currently in Ghana, Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will offer the safest service for all" and '6th' means "vehicle type will offer the least safe service to all"

NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

7. **Which of the vehicle types should government prioritize for promoting EVs adoption if the focus is on SECURED TRANSPORT SERVICE FOR ALL, including the poor, aged, women, children, differently abled persons etc?** *
CRITERION 5: SECURITY DEFINITION: 'Security' is measured to include protection against thefts, and burglaries etc. According to your perception of how the present transport modes promote and ensure personal security to its users, Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will offer the most secured service for all" and '6th' means "vehicle type will offer the least secured service to all"
NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

8. **Which of the vehicle types should government prioritize for promoting EVs adoption if we want to significantly improve JOB OPPORTUNITIES to Ghanaians?** *
CRITERION 6: JOB OPPORTUNITIES DEFINITION: 'Job opportunities' include livelihood for drivers, bus conductors/'mates', depot/workshop mechanics; etc.
According to your perception of job creation opportunities associated with the present transport modes, Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will offer the most job opportunities for all" and '6th' means "vehicle type will offer the least job opportunities".
NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

11. **Name of organization being represented** *_____

12. **Your Name and Position in Organization** *_____

APPENDIX 8. A list of stakeholders who participated in the survey on social indicators for EVs adoption

No	Name	Position in organization
1	Thomas Kankam Adjei	NDC Project Coordinator
2	Busi Khaba	Head of Public Policy Sub-SaharanAfrica
3	Jessica Poku	Ghana Country Manager
4	Omotola Odeyemi	Public Policy (West Africa)
5	Doris Edem Agbevivi	Energy Commission (Project Coordinator, Electric Initiative)
6	Daniel Essel	Deputy Director
7	Manish Daryanani	Vice President
8	Deyegbe Godwin Rajiv	Head of Technical Support, National Technical Lead. Toyota Ghana Company Ltd.
9	Abisola Odukoya;	Regulations and Public Policy WA.
10	Robert Kwadwo Nyarko	Assistant Planning Officer. Min of Roads and Highways
11	Ing. John Awuku Dzuazah	Deputy MD, Technical & Engineering Services, STC
12	Ing. David Yarboye Tackie	Technical Manager. Metro Mass Transit
13	Emmanuel Ohene-Yeboah	General Secretary. GRTCC
14	Joseph Baffoe	Ag Director
15	Ebenezer Amankwaa	Lecturer, UG.
16	Foster Gyamfi	MOFEP
17	Gyimah Mohammed	Head of Climate Change
18	Edward Agbodjan	Prin. Min of Transport
19	Dominic Hotor	Researcher-University of Ghana
20	Francis Andorful	GIS Expert-University of Ghana
21	Peter Mensah	Researcher-University of Ghana
22	Martin Oteng-Ababio	Head, Geography Department-UG

APPENDIX 9. Survey tool used for generating feedback on supporting eco-systems and local stakeholders' acceptance concerning EVs adoption

Preamble: The Ministry of Transport is collaborating with the Environmental Protection Agency and Climate Technology Centre to develop an Electric-Mobility Policy, incorporating Implementation of Framework for the Deployment and Scale-Up of Electric Vehicles (EVs) in Ghana. This exercise is aimed at mapping the Supporting Eco-systems for EVs adoption for the country. Your response is being solicited in your official capacity/representative for your organization. The responses will be anonymized and greatly appreciated. The survey is expected to last 30 minutes.

* Required

Email *_____

1. **In view of your knowledge of the existing sales outlets (e.g. showrooms and garages) in Ghana where vehicles may be made available for sale, which of these vehicle types will readily be easier to obtain on the market?** *
   Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will be easiest to access on the local market" and '6th' means "vehicle type will be most challenging to access on the local market"
   NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

   Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

2. **Which of these vehicle types will be the easiest to retrofit/convert from petrol & diesel to electric and sold locally, bearing in mind our existing local resources?** *
   CRITERION 2: RESOURCES DEFINITION: "Includes investors, vehicle designers and engineers, knocked down parts assembly plants, available networks to outsource car parts from existing OEMs; showrooms to sell finished product. Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will be easiest to retrofit locally" and '6th' means "vehicle type will be most challenging to retrofit locally
   NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

   Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

3. **Which of these vehicle types will be the easiest to provide local post-sales services, bearing in mind our existing local resources?** *
CRITERION 3: RESOURCES DEFINITION: "'E.g. companies helping with the installation process (such as computer software), support regarding warranty service, training, or repair and upgrades and regular maintenance. Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will be easiest to provide post-sales services locally" and '6th' means "vehicle type will be most challenging to provide post-sales services locally" NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

4. **Which of these vehicle types will be most convenient to charge?** *
CRITERION 4: CHARGING CONVENIENCE REMARKS: Keep in mind that 1. Vehicles can be charged; 2. Faster charging requires higher power rating devices (moving from single phase to 3 phase to DC charging); 3. Larger the battery size (in Kw) needs more time to charge & 4. Charging happens when vehicle is stationary therefore you need a parking place. Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will be the most convenient to charge" and '6th' means "vehicle type will be most challenging to charge"
NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

5. **Which of these vehicle types should government focus on in a bid to promote innovative research and development projects for EVs?** *
CRITERION 5: R&D REMARKS: projects include policy & strategies to improve battery storage systems, electric motors, power electronics, and vehicle charging infrastructure. Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will be the easiest to promote R&D" and '6th' means "vehicle type will be most challenging to promote R&D" NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

6. **Which of these vehicle types will help in improving electricity access?** *
REMARKS: Keep in mind that vehicle batteries can help in integrating roof top solar energy, thereby improving access to electricity. Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will provide the most access to electricity" and '6th' means "vehicle type will least provide access to electricity" NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

7. **If government wants to introduce incentives/subsidy to promote sustainable transport, which of these vehicle types should government's policy focus on?** *
Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will be the most preferred option to receive government incentives" and '6th' means "vehicle type will be the least preferred option to receive government incentives"
NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

8. **Which of these vehicle types will business/private investors be interested to introduce to the market?** *
Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will be the easiest to introduce to the market" and '6th' means "vehicle type will be the most challenging to introduce to the market"
NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

9. **Which of these vehicle types will be the easiest to assemble and sold locally, bearing in mind our existing local resources?** *
CRITERION 6: RESOURCES DEFINITION: "Includes investors, vehicle designers and engineers, knocked down parts assembly plants, available networks to outsource car parts from existing OEMs; showrooms to sell finished product. Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will be easiest to retrofit locally" and '6th' means "vehicle type will be most challenging to retrofit locally" NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE.

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

10. **Which of these vehicle types will consumers be interested in utilizing the most when introduced to the country?** *
Please rank the vehicle types from 1st to 6th, where '1st' means "vehicle type will receive the most interest among consumers" and '6th' means "vehicle type will be receive the least interest among consumers"
NB: Rank all the modes from the 1st to the 6th position. PLEASE DO NOT REPEAT THE SAME POSITION TWICE PER MODE

Mark only one oval per row.

	1st	2nd	3rd	4th	5th	6th
2W-Personal	◯	◯	◯	◯	◯	◯
3W-Personal	◯	◯	◯	◯	◯	◯
Car	◯	◯	◯	◯	◯	◯
4W-Taxi	◯	◯	◯	◯	◯	◯
Trotro	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯

11. **Name of organization being represented** *_____

12. **Your Name and Position in Organization** *_____

APPENDIX 10. A list of stakeholders who participated in the survey on supporting eco-systems and local takeholders' acceptance concerning EVs adoption

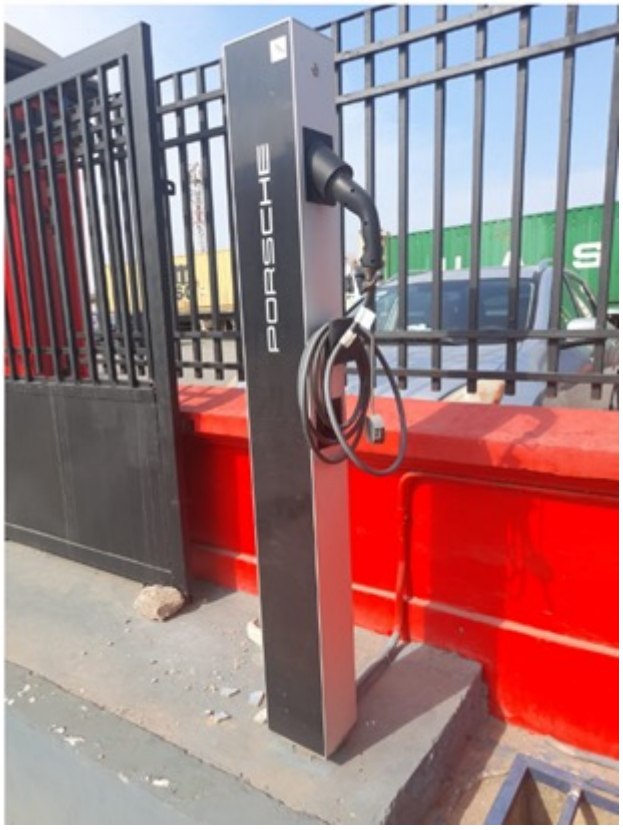
Name	Position in organization
Jessica Poku	Ghana Country Manager
Doris Edem Agbevivi	(Project Coordinator, Electric Initiative) Energy Commission.
Daniel Essel	Deputy Director
Godwin Rajiv Deyegbe	Head of Technical Support, National Technical Lead. Toyota Ghana Company Ltd.
Ing. John Awuku Dzuazah	Deputy Md, Technical & Engineering Services, STC.
Emmanuel Ohene-Yeboah	General Secretary. GRTCC
Joseph Baffoe	Ag Director. EPA
Ebenezer Amankwaa	Lecturer, UG. Consultant
Ernest Agyemang	Lecturer, UG. Consultant
Edward Agbodjan	Min of Transport
Dominic Hotor	Researcher-University of Ghana
Lord Awusi	MOT
Macmillan Prentice	
Francis Kodjo Kudjordjie	
E. Boateng	
Charles Annan	GAPTE
Thomas Adjei	NDC Project Coordinator

APPENDIX 11. A list of Steering Committee Members and Stakeholders who participated in the Validation Workshop at the Ministry of Transport, Accra

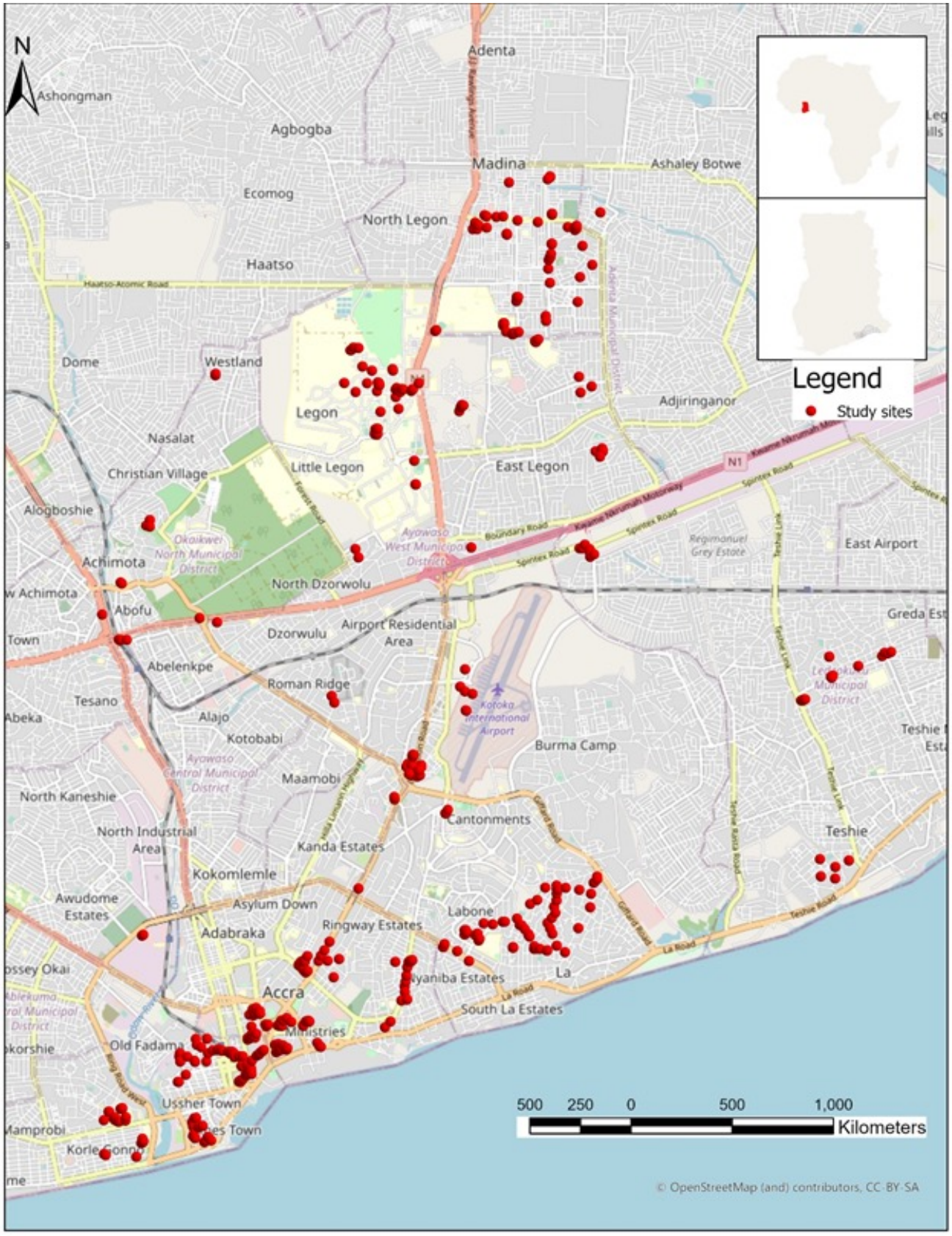
No	Name	Institution
1	Doris Edorm Agbevivi	Energy Commission
2	Charles Annan	GAPTE
3	Benjamin Nimako	MMTL
4	Millicent Elorm Kumah	MOT
5	Lord Awusi	MOT
6	Edward Agbodjan	MOT
7	Raymond E. Ofori	MLGDRD
8	Joseph Baffoe	EPA
9	Deyegbe Godwin Rativ	TOYOTA
10	Mavis Tei	MOT
11	Dr. Eben Amankwaa	Consultant
12	Kyekyeku Oppong Boadu	National NDC Project Consultant
13	Ing John Awuku Dzuazah	STC
14	Edward Hoffmann	Co-operative Transport
15	Emmanuel Ohene-Yeboah	GRTCC
16	Dr. Ernest Agyemang	Consultant
17	Foster A. Gyamfi	MOF/NDA
18	Ezekiel A Azuure	Ministry of Energy
19	Mohammed Munzamil	LUSPA
20	Beverlyn Adoah	MOT
21	Juliana Ohenewaa Ofosu	MOT
22	Nana Ama Birago Appau-Gyekye	MOT
23	Andrews Gzowoda	MOT
24	Irene Jones-Nelson	MOT
25	Nana Nimako Bresiama	GPRTU
26	Nana Ampofi Ananni	GPRTU
27	Godfred Abulbire	GPRTU
28	Amin Abdul-Rahaman	MOT
29	Ernest Obeng	MRH
30	Joseph Sackey	GH Express
31	Irene Messiba	MOT
32	Sagoe Mabel	MOT
33	Daniel Essel	MOT
34	Prosper Amewode	MOT

APPENDIX 12. List of Stakeholders consulted for Barrier Analysis

APPENDIX 13. Publicly installed EV charging outlets at the ANC and Palace Malls, Accra



APPENDIX 14. Survey locations in Accra, Kumasi and Tamale



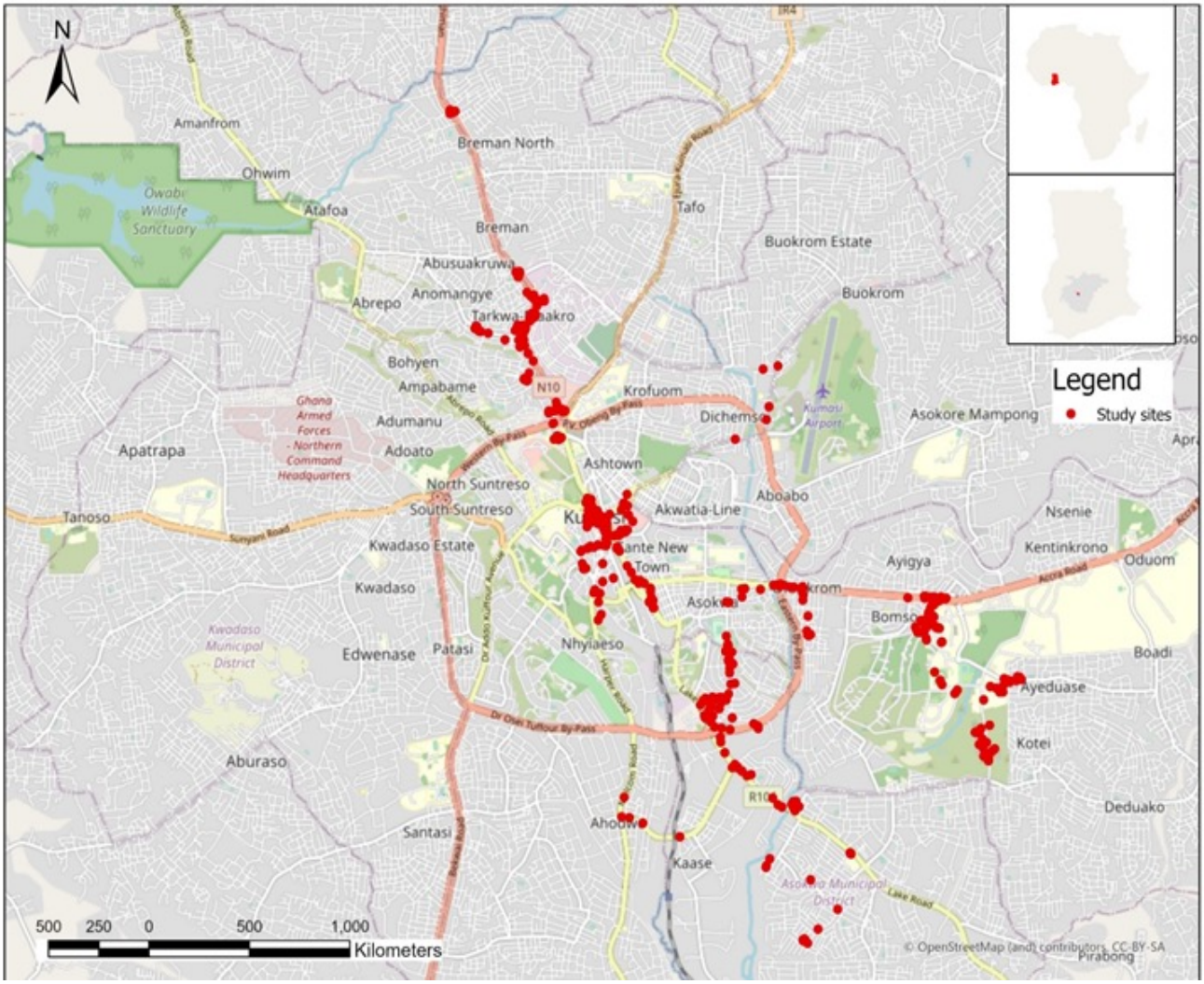


Figure b A map of Kumasi showing study sites

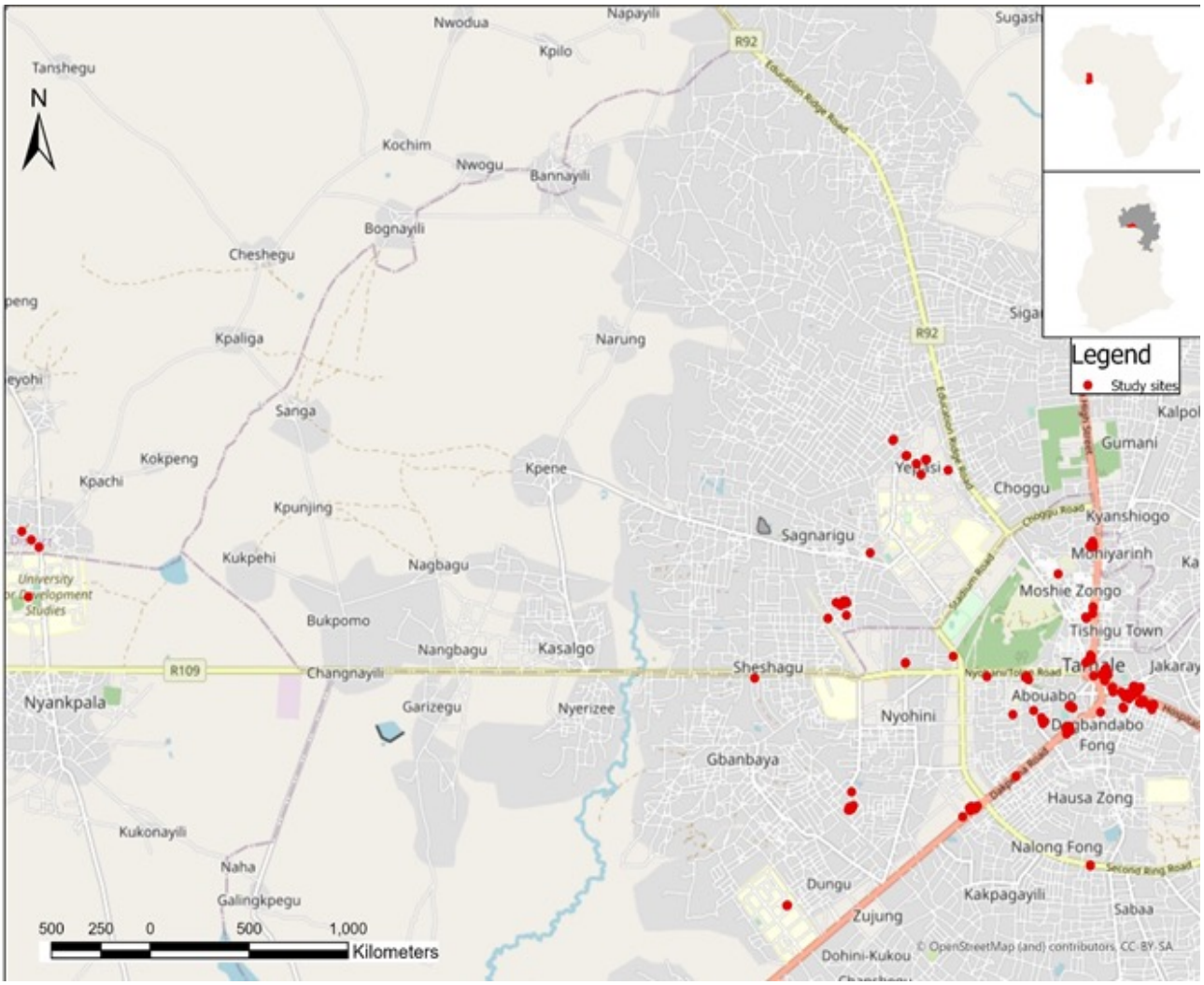


Figure c A map of Tamale showing study sites

APPENDIX 15. Overview of survey participants (N=1507)

Item	Category	Frequency	Percentage
Gender	Male		
	Female		
Age groups	18-24		
	25-39		
	40-54		
	55+		
Education	No formal education		
	Primary		
	JSS/JHS/Mid. School		
	SSS/SHS		
	VOC,/Tech./Commercial		
	Tertiary		
Marital status	Single, never married		
	Married		
	Married, with children		
	Divorced/Widowed		
	Co-habiting		
Employment	Formal sector (i.e. Senior staff, n=416; Junior staff, n=323)		
	Informal sector		
	Student		
	Retired		
Income category	< 1500 GHS		
	1500 - 3000 GHS		
	3001 - 4500 GHS		
	4501 GHS & above		
	Prefer not to say/student/unemployed		
City of residence	Accra		
	Kumasi		
	Tamale		
Household size	Alone		
	1-3 persons		
	4-6 persons		
	Above 6 persons		

Item	Category	Frequency	Percentage
Housing type	Traditional house		
	Single room (e.g. shares toilet, bathroom and kitchen with other non-family members) in a compound house		
	Single room self-contained (i.e. you have your private toilet, bathroom, and kitchenette) in the unit		
	Chamber &hall (i.e a bedroom & living room) but shares toilet, bathroom & kitchenette with other non-family members		
	Chamber and hall self-contained (i.e. bedroom and living room) with private toilet, bathroom & kitchenette		
	Detatched/ Semi-detatched/ Self-contained (2 or 3 bedrooms, walled, gated)		
	Apartment/ Flat		
	Townhouse (i.e. two to three level houses which have a shared wall in between)		
Assets owned	Portable electronic devices (i.e. Mobile phone, n=1479; Laptop, n=848)		
	Home appliances (i.e. LCD TV, n=1294; Air conditioner, n=433)		
	Personal means of transport (i.e. Car, n=608; Motorcycle, n=360; Bicycle, n=445)		